CYSTOSCOPY AND UROGRAPHY

BY

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SECOND EDITION. REVISED AND ENLARGED.

WITH 297 ILLUSTRATIONS IN THE TEXT
AND 14 COLOURED PLATES.

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PREFACE TO THE SECOND EDITION

NINE years have passed since *Cystoscopy* was first published. Encouraged by the kindly reception accorded to the previous issue I have undertaken the preparation of a second edition. The text has been carefully revised throughout, and to it much new material has been added. Six fresh chapters are presented. Three of these concern urography. The ever-increasing recognition of the value of urography and the advances made in this field have called for additional space to be allotted to it. The three new chapters concern Pelvic Resorption, Excretion Urography, and Pyeloscopy. The title of the book has been altered in view of the greater space given to urography. The other new chapters deal with Fistula of the Bladder, Funnel-neck Deformity of the Bladder, and Congenital Abnormalities of the Kidney and Ureter. The second-mentioned of these contains much subject-matter which appeared in the author's presidential address to the Section of Urology of the Royal Society of Medicine (October, 1934). The last-mentioned was originally designed for a different object, and this accounts for the inclusion of a certain amount of detail which is possibly outside the strict scope of cystoscopy and urography. As, however, a full description of congenital abnormalities of the upper urinary tract is not easily come by, and as a complete picture is essential to a proper understanding of the subject, the original form has been allowed to stand.

Into many other chapters extra matter has been introduced. Thus a section on urography in renal tuberculosis finds a place in Chapter VI, an account of purpura in Chapter XV, and in the chapter on the prostate a description of endoscopic prostatic surgery is given, whilst further considerable additions will be found in Chapters IX, X, XIII, XX, etc.

Of the 181 figures in the previous edition 25 have disappeared, but 141 new illustrations find a place, making a total of 297. The coloured plates are also increased from 12 to 14 by the addition of *Plates V* and *IX*. All the new drawings, with the exception of 18 acknowledged below, are by Miss Dorothy Davison. The high quality of her work is self-evident, but I cannot sufficiently praise her excellent draughtmanship, patience, and meticulous care.

The extensive nature of the revision, and the large number of half-tone illustrations which have been added, has suggested a change in the format—the book is now printed on art paper, and, with the exception of the coloured plates, all the figures are incorporated in the text.

For *Figs.* 278–282 I am indebted to *Surgery, Gynecology and Obstetrics.* They were originally used to illustrate an article by Dr. F. Traut, and are examples of the beautiful art of Max Brödel. The *British Journal of Urology* has kindly lent me *Figs.* 283, 284, 288, and 289, all taken from articles by the late Dr. Lee Brown ; and also *Fig.* 287, from one by Mr. Duncan Morison. *The Lancet* has obliged me with the loan of blocks for *Figs.* 207 and 277, both from an article by myself which appeared in that journal, whilst the Royal Society of Medicine has been good enough to lend me the blocks of *Figs.* 149 and 150, together with the figures for Chapter XVI, all these figures being from a personal contribution.

Mr. Duncan Morison has read through the chapter on Resorption and Mr. Schranz the section on the resectoscope, and each has obliged me with helpful criticism. To the latter I am likewise indebted for the drawings from which *Figs.* 163 and 234 were prepared. Mr. Kenneth Watkins, when working in my department, prepared the specimens from which *Figs.* 91 and 217 were drawn. Once again I have freely consulted articles in various journals too numerous to be separately acknowledged.

Finally, to my publishers I again accord my warmest thanks for their unsparing and sound workmanship, their close attention to detail, and for their willingness to gratify my every whim.

JAS. B. MACALPINE.

Manchester,
March, 1936.

PREFACE TO THE FIRST EDITION

Believing that there is a real need for a book on cystoscopy, I have attempted the task. It is several years since I conceived the idea, and my first care was to provide myself with an artist to draw cystoscopic pictures. Having trained such an artist to the point where he was starting to become useful to me, I lost his services through ill health. A few of his drawings are reproduced herein, and a few more of his less mature efforts have been redrawn by Mr. W. Thornton Shiells, of London. Unable to face the training of a fresh draughtsman, I approached Mr. Thornton Shiells, who kindly consented to travel to Manchester periodically; cases of interest were collected for him, and I have enjoyed a fair amount of fortune in being able to call up suitable material on the occasions of his visits. Though I do not feel that the cystoscopic circles reproduced in this work call for any apology, it is nevertheless certain that if I had been fortunate enough to have my artist within easy call, I should have had a larger selection of drawings from which to choose. I am greatly indebted to Mr. Thornton Shiells for his unfailing cheerfulness in making so many long journeys, and for his capable work.

There are a large number of surgeons whose opportunities for using the cystoscope do not recur with sufficient frequency to make them skilled in its employment. Their mistakes are usually trifling, yet are sufficient to make shipwreck of their attempts. In the hope of helping these I have entered into much detail when describing the technique of cystoscopy, and it is possible that I have been over-anxious to be explicit.

I am indebted to Mr. Cyril Nitch and Mr. Jocelyn Swan for the loan of several pyelograms, and to Drs. Hyman, Gilbert Thomas, and Hinman, of the United States of America, for the use of *Figs.* 64, 66, and 67 respectively. Messrs. Williams and Wilkins have kindly permitted me to copy *Fig.* 66. For the loan of the blocks of *Figs.* 93 and 94 I have to thank Mr. Canny Ryall and Mr. Henry Kimpton. Mr. E. D. McCrea has read through the text carefully, and has offered helpful criticism. To Mr. Schranz, of the Genito-Urinary Manufacturing Co., I have read several chapters on the cystoscope, and from him have received valuable assistance, particularly in the section on the optical apparatus. To him also I am indebted for the drawings from which *Figs.* 4 and 117 were prepared. The Genito-Urinary Manufacturing Co. have kindly lent me many of the electros appearing in this work, whilst Messrs. Down Bros. have supplied *Figs.* 57, 122, and 127, and Messrs. Allen and Hanburys *Fig.* 42. Finally, to my publishers I gratefully acknowledge my indebtedness for their unfailing courtesy and for the great energy and thoroughness which they have thrown into the production of my book.

In preparing the text I have consulted works on cystoscopy by Nitze, Casper, Ringleb, Pilcher, Marion and Heitz-Boyer, and Papin, and works on pyelography by Braasch and Papin. Articles in various journals, too numerous to be separately acknowledged, have also been referred to.

The historical section derives largely from Nitze's text-book, and the arrangement of Chapter V was suggested by that of the corresponding chapter in Marion and Heitz-Boyer's work.

The first section of Chapter X has previously been published in a slightly different form in the *British Medical Journal.*

J. B. M.

Manchester,
April, 1927.

COLOURED PLATES

CYSTOSCOPY

CHAPTER I.

HISTORICAL.

"EVEN from earliest times clinicians have been dissatisfied with the simple examination of the body surface, and have been ambitious to inspect those hollow viscera which are accessible. For this purpose special instruments became necessary. To the ancient Hebrews the use of vaginal specula was known, whilst expanding rectal specula were amongst the surgical instruments discovered in Pompeii. Nevertheless, for a long time such examinations remained limited to cavities communicating with the exterior of the body by wide orifices, such as the mouth, vagina, and rectum. In no case does one find any reference to an attempt to inspect deep-lying cavities like the bladder until comparatively modern times."*

Fig. 1.
Bozzini's cystoscope.
(*Redrawn from the original.*)

The first attempts at the illumination of the bladder date back as far as 1804, when Bozzini, of Frankfurt, constructed a long tube which he passed down the urethra. The extra-vesical end of this tube fitted on to a box containing a candle as a source of illumination. At the back of the box the observer's eye was placed, and a partition was so arranged as to shade the light of the candle from his eye. Such was the first primitive cystoscope (*Fig.* 1).

In 1826 Segalas introduced a cysto-urethral speculum which received little attention, but a more successful attempt was made by Désormeaux, a French surgeon, who is sometimes referred to as 'the father of cystoscopy'. In 1853 he demonstrated his 'endoscope' to

* Free translation from Nitze's *Lehrbuch der Kystoscopie*, 2nd ed., Berlin, 1907.

the Parisian Academy, and in 1865 published his work, *De l'Endoscopie et de ses Applications au Diagnostic et au Traitement des Affections de l'Urèthre et de la Vessie.*

The instrument made by Désormeaux was more complicated than its predecessors. Its source of light was a gas lamp, and the rays from this, collected by a lens, were reflected by a plain mirror into an endoscopic tube which passed into the urethra and bladder. The observer's eye was placed behind a hole in the mirror. It had, in fact, many points in common with our modern anterior urethroscope. The limitations of this instrument are obvious. The light could never be adequate to give a decent picture of the vesical wall; and even if such a picture could be obtained, only a small portion of the fundus of the bladder could be brought into view. Various other investigators, however, thought it worth while to use and develop Désormeaux's 'endoscope'. Their efforts were directed mainly to the improvement of the illumination. Thus Cruise, of Dublin, and Furstenheim, of Berlin, substituted petroleum for the gas, whilst Stein adopted magnesium wire. In all cases, however, they followed Bozzini and Désormeaux in that they relied on an external source of light reflected down an endoscopic tube. Their results were necessarily poor, and their instruments did not come into general use. One investigator, however, showed originality. Bruck in 1867 attempted to illuminate the bladder by placing in the rectum a lamp containing platinum wire, which he rendered incandescent by means of an electric current, and around which he ran a current of water to avoid burning the rectal mucosa. This he used in combination with a urethral endoscopic tube, hoping by transillumination to obtain sufficient light to investigate the condition of the bladder. His method also was a failure. In these days of superior instruments it is interesting to look back sympathetically at the primitive attempts of these pioneers, and to realize how keenly they felt the necessity of obtaining a view, however imperfect, of the interior of the viscus.

Matters stood thus in 1876 when Nitze took up the problem. His work culminated in the invention of a cystoscope which in its essentials is the instrument in use to-day. From the commencement he foresaw that no advance was possible so long as external illumination was used, and that a light must be carried into the bladder itself exactly "as one takes a lamp into a room in order to light it". At that time, of course, the Edison lamp had not been invented and Nitze had to devise a lamp himself. After many experiments he selected platinum wire rendered incandescent by the electric current as the most suitable source of illumination. It occupied little room, and was thus easily introduced into the bladder on the end of the cystoscope. By it a clear and strong white light could be obtained.

Against these advantages was to be placed the fact that it generated intense heat, which would prohibit its use if it could not be controlled. At first Nitze tried to cool the lamp with a current of air, but this proved unsatisfactory; later he had resort to water-cooling. Two tubes ran throughout the length of the instrument and served to carry water to the beak where the lamp was situated (*Fig.* 2). This method, though clumsy, proved fairly efficient. Nevertheless, the lamp remained the chief source of difficulty right up to the time when the Edison lamp was invented and adopted for use with the cystoscope. Nitze was constantly working to improve his lamp and his methods of cooling it. The one which he ultimately devised was contained in a metal case whose window was made of a piece of thinly scraped goose quill. Inside this there was a glass bulb containing the platinum, and between the glass and the goose quill water circulated to cool the lamp. This remarkable lamp, says Nitze, was wonderfully efficient and durable, though the platinum wire frequently fused at the critical moment.

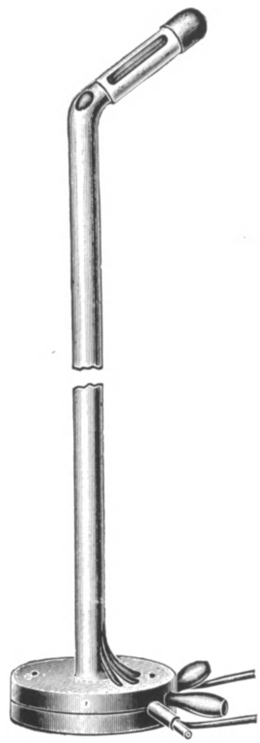

Fig. 2.—Nitze's first cystoscope. Optical system terminal. Platinum filament lamp. Note water-cooling system. (*Redrawn from the original.*)

It was of little value to have introduced a light into the bladder if a larger part of the vesical wall could not be brought into view, for hitherto only that portion of the viscus which lies directly opposite the end of the tube could be seen (*see Fig.* 14). The examination would therefore have to be limited to a portion of the fundus and trigone of the bladder. The solution of this problem came suddenly one day when Nitze was doing some microscopical work in Dresden. Whilst changing the eye-piece of a microscope he held it up to the window to see if it was clean, and through it received the small inverted image of a neighbouring church tower. The problem was solved. With the assistance of a Dresden instrument maker he worked out a lens system which he introduced into the interior of his cystoscope. This had the effect of increasing the field of vision and of bringing the object closer to the eye of the observer. Even so, only that portion of the bladder lying opposite the internal meatus could be inspected. The instrument was, in fact, a direct cystoscope.

The next stage consisted in the introduction of a prism at the end of the shaft. One aspect of the prism looked out through a window cut in the side of the tube and its hypotenuse acted as a mirror to reflect the beams down the tube. By this means a mirror picture of the whole of the bladder wall was obtained. In order to make it as perfect as possible Nitze left Dresden for Vienna, where he collaborated with the well-known surgical instrument maker, Leiter. The first models produced in that city are known as the Nitze-Leiter cystoscopes. In 1879 he demonstrated his inventions to the Vienna Medical Society, where they received much approbation. However, the clumsiness of the lighting system and its water-cooling apparatus prevented the instrument from coming into common use, even amongst the specialists of the day.

The following year, 1880, saw the invention of the Edison lamp. Nitze immediately realized that therein lay the salvation of his instrument, but he had to wait until 1886 before it was found possible to construct a lamp sufficiently small and delicate for his purpose. Then the complicated platinum wire with its water-cooling apparatus disappeared, and the carbon filament lamp solved the last and greatest of Nitze's difficulties. The instrument thus completed was the same in principle as the one we use to-day; details have been altered and improved, and additions have been made to it, such as irrigating parts, provision for ureteral catheterization and intravesical operating, etc., but the fundamentals of the optical and lighting apparatus remain.

Thereafter the number of practitioners of cystoscopy rapidly grew, many of them anxious to add to the new diagnostic method. Nitze himself participated fully in the subsequent progress and improvement of his instrument and its equipment, and was responsible for the invention of many of the accessories, such as operating parts, hot wire snares, modifications of ureteric catheters, and the like.

CHAPTER II.

THE CYSTOSCOPE.

NUMEROUS varieties of cystoscope have been described, but all come under one of two headings : *direct* or *indirect.*

We have seen in the previous chapter that the first cystoscopes were of the direct pattern, and that the indirect type evolved from these at a later date by the insertion of a prism in the optical apparatus. A few surgeons still prefer the direct cystoscope, generally in the form of a simple endoscopic tube. Such are Luys in France, and Kelly and Wolbarst in America. The sphere of usefulness of these instruments is limited to female urology. The large majority of surgeons, however, now use the indirect instrument, as a more extensive and efficient inspection of the bladder is provided thereby. As the present writer has little experience of direct cystoscopy, and the coloured drawings in this book have been made with the aid of the indirect instrument, the direct forms will not be described. Any who are interested in the subject are recommended to consult Wolbarst's translation of Luys' volume on urethroscopy and cystoscopy, in which a description of the various forms of direct cystoscope can be found.

Advantages of an Irrigating Model.—Modern cystoscopes are almost invariably of the irrigating pattern, and in them the telescope containing the optical parts is separable from the sheath. When the former is removed the latter is converted into a catheter capable of serving for irrigation of the bladder. This obviates the passing of more than one instrument for both preparation and examination. It also makes it possible to change the vesical medium in the middle of an examination without removing the instrument, which is advantageous when a bladder bleeds freely, or when large quantities of pus are rapidly thrown into the bladder, either from the kidney or from the vesical mucosa, or from some other source, such as, for instance, a diverticulum, or when débris is shed from the surface of a papilloma during diathermy. In all these cases the medium becomes turbid, and it is convenient to be able to change it quickly without removing the instrument. When the urethra bleeds on instrumentation it becomes almost imperative to use an irrigating cystoscope, for then clots of blood foul the prism window during introduction and obscure the field. In the irrigating instrument the telescope can, when thus soiled, be easily withdrawn, cleaned, and re-inserted, whereas the removal of the whole instrument is time-consuming and painful. Furthermore, the prism probably becomes fouled again on re-insertion, so that even then a satisfactory examination cannot be obtained.

DESCRIPTION OF THE INDIRECT OR PRISMATIC CYSTOSCOPE.

(Examination Model.)

The cystoscope is divisible for purposes of description into two main portions: (I) *A Sheath containing the irrigating and lighting arrangements* (*Figs.* 3*a*, 4); (II) *A Telescope containing the optical system* (*Fig.* 3*b*).

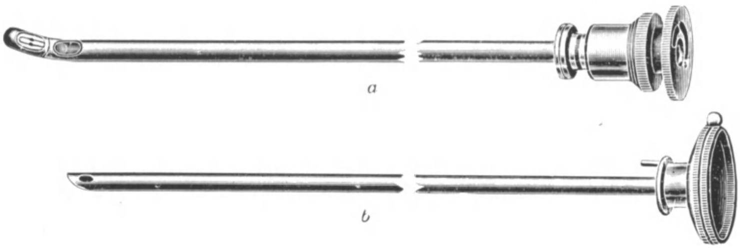

Fig. 3.—Examination cystoscope, irrigating pattern. *a*, Catheter or sheath with lighting apparatus; *b*, Telescope.

I. THE SHEATH, WITH ITS IRRIGATING AND LIGHTING ARRANGEMENTS.

The sheath (*Fig.* 3*a*) is a hollow tube or catheter to which are attached :—

1. The lighting equipment, consisting of: (i) A pair of rings situated at the external or ocular end of the instrument for the reception of a detachable switch; (ii) A lamp at the vesical end; and (iii) A wire joining (i) and (ii).

2. A valve to prevent escape of bladder contents when the telescope is not in position.

The sheath is about 10 to 12 in. long, having a diameter corresponding to 21 on the Charrière scale. It has two extremities, an inner or vesical extremity, and an outer or ocular (*Fig.* 4). The former is short, bent at an angle of 45° with the shaft, and contains the female portion of a screw (A) for the reception of the lamp. Centrally placed at the bottom of a small cup-shaped depression in the end of the cystoscope will be seen an insulated electric terminal (B) for contact with the wiring of the lamp. Immediately behind the

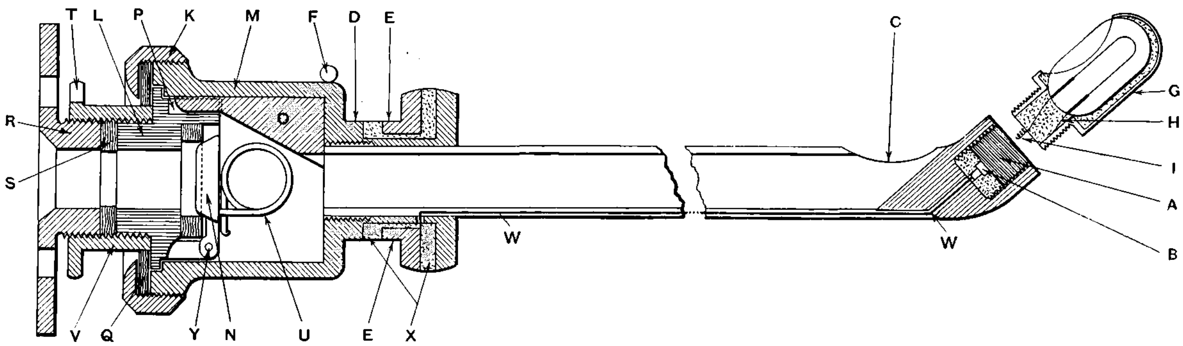

Fig. 4.—LONGITUDINAL SECTION OF EXAMINATION CYSTOSCOPE (SHEATH). A, Female portion of screw for lamp; B, Insulated electric terminal; C, Fenestra; D, Metal ring for reception of coupler, and in contact with valve chamber; E, Other ring insulated from sheath by ebonite seating (X) but connected to B by wire (W); F, Knob; G, Metal cap of lamp; H, End of lamp filament attached to hood; I, Filament for contact with B; K, Valve ring fixing valve (L); M, Wall of valve chamber; N, Hinged door (clappet); O, Key; P, Key way; Q, Rubber washer (large); R, Compression screw; S, Rubber washer (small); T, Slot for telescope pin; U, Spring of clappet; V, Valve collar; W, Electric wire; X, Ebonite or bakelite insulation for ring (E); Y, Hinge of clappet.

angle at the vesical extremity is a small window or fenestra (C) cut in the concavity of the sheath, beneath which the prism appears when the telescope is in place.

A small metal cap (G) containing the lamp forms the beak of the cystoscope. Its distal extremity is rounded, whilst its proximal extremity ends in a screw for attachment to the vesical end of the cystoscope. The lamp consists of an exhausted glass bulb which projects into a lateral orifice cut in the side of the metal cap. When in position this orifice should be situated directly in front of the fenestra in the sheath, so that the telescopic field and the field of illumination may correspond. It contains a metal filament of which one end (H) is soldered to the metal hood, the current being conducted by the walls of the cystoscope to the external end of the instrument. The other end of the filament (I) emerges centrally and makes contact with the metal terminal (B) observed at the vesical extremity of the sheath. It is produced outside the lamp for a short distance in order to ensure good contact.

At the external end of the cystoscope the sheath proper is surrounded by two rings of metal which make spring contact with the terminals of the switch. The ring (D) lying in apposition with the valve chamber (M) is in metallic continuity with that structure, and through it passes the return flow of the electric current. The other ring (E) is insulated from the sheath by a seating of ebonite or bakelite (X), but is connected to a fine insulated wire (W) running in the floor of the catheter and terminating at the vesical end of the instrument in the metal terminal (B) already observed there.

All the parts within the cystoscope concerned in the conduction of the current have now been described, and it may be advantageous to trace the complete circuit. Commencing with the metal ring (E), which is situated farthest from the ocular, we may imagine the current running along the wire (W) in the floor of the sheath until it reaches its metal terminal (B). This terminal makes contact with the central filament of the lamp (I), and the current running through the bulb reaches the metal case and travels via the wall of the sheath to the ring (D), which, as before stated, is part of the body of the cystoscope. The two rings, of course, bring the cystoscope into connection with a source of current by means of the switch, which will be described later.

Immediately behind these two rings the catheter undergoes a generous expansion (valve chamber) (M), in order to accommodate the valve and its accessories. The enlargement is about an inch in length. At its distal edge is mounted a small knob (F), so placed that it will indicate the position occupied by the fenestra when the cystoscope is in the bladder. By reference to this knob the surgeon is kept informed as to what area of bladder is under inspection.

The ocular end of the instrument is closed by a valve fixed in position by a screw-cap (K). It controls the escape of vesical fluids when the telescope is not in place. The valve (L) is shown in *Fig. 5b.* It is a thick-walled tube so shaped as to be accurately received into the valve chamber (*Fig. 5a*) of the cystoscope. Its bore corresponds to that of the sheath, and lies directly opposite the same. A hinged door (clappet), opening from without inwards and regulated by a spring, closes this orifice when not in occupation either by the telescope or the faucet. The clappet is hinged at its lowest point so that when the obliquely cut end of the telescope or faucet is correctly inserted its extremity encounters the free upper margin of the door and so easily opens it. To ensure that the valve is accurately inserted, a projection from the roof of the valve chamber fits into a groove on the upper surface of the valve. The projection is known as the 'key', and the groove as the 'key-way'. A screw cap (valve ring) with an internal thread overlaps the extremity of the cystoscope and

a *b* *c* *d* *e*

Fig. 5.—*a*, Cystoscope sheath (note the key in valve chamber and the key-way cut in valve); *b*, Valve, valve collar, and valve ring (these cannot be taken apart except by the makers); *c*, Compression ring; *d*, Faucet; and *e*, Syringe nozzle.

holds the valve in position. Between the valve and the screw is a rubber washer.

Embracing the outer part of the valve (L) is a short, wide, flanged tube (valve collar) (V) with an internal screw thread. This projects through the valve ring (K), and on the upper margin of its flange is a slot (T) for the reception of a pin attached to the telescope (*Fig. 3b*). This slot and pin maintain the telescope in position so that it does not rotate away from the window (C) in the sheath. The outer portion of the tube accommodates the compression screw (R), and between this and the end of the valve is a second and smaller rubber washer (S). The washer and the compression screw are centrally perforated for the transmission of the telescope, and their bore corresponds to its diameter. When the compression screw (R) is tightened it compresses the washer against the valve so that it bulges towards the sides of the telescope and renders the junction watertight. During the insertion of the telescope it is very important that this compression screw be released, otherwise force will have to be used to overcome the resistance of the washer. This is one of the most fertile causes of a bent telescope (*see* page 28).

The *switch* is shown in *Fig.* 6. It consists of two plates of metal separated by a layer of insulating material. At one end two concave rings make spring contact with the cystoscope. At the other end the plates are attached to two cords responsible for uniting the cystoscope to a source of electrical energy. One of the plates is divided about its centre, and the two halves are insulated. The connection between these two halves can be re-established by means of a slide. The position of the slide determines the passage or otherwise of the current.

The function of the *faucet* (*Fig.* 7) is to open the valve for evacuation or irrigation of the bladder.

Fig. 6.—The switch.

Fig. 7.—The faucet.

It is a tube about 2 in. long, cut obliquely at one end to facilitate the depression of the valve. The other end is somewhat expanded and has a conical bore, so that it will make watertight connection with the nozzle of the bladder syringe. Alternatively the two-way irrigating tap shown in *Fig.* 8 may be preferred.

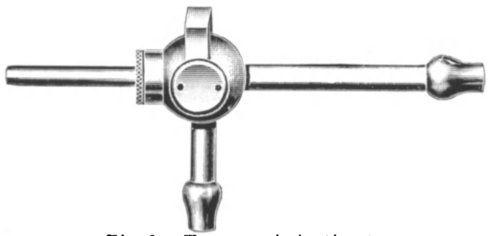

Fig. 8.—Two-way irrigating tap.

II. TELESCOPE AND OPTICAL ARRANGEMENTS.

The telescope (*Fig.* 9) contains the optical apparatus of the cystoscope, the function of which is to transport the vesical picture to the eye of the observer in such a form that it will produce on his retina an image of sufficient magnitude and brilliance to be appreciated easily. In the earlier instruments the telescope was permanently built into the cystoscope, but in the best modern examples it is separate from the sheath, and intending purchasers should avoid any instrument in which this is not a feature. It consists of a thin tube in which is contained a series of lenses, whose number varies according to the design. In the direct cystoscope the vesical picture gains admission through a terminal opening. In the indirect instrument it enters through a lateral opening, or fenestra, underneath which is situated a right-angled prism to divert rays through 90° along the telescope. With the aid of an appropriate system of lenses these rays ultimately reach the observer's retina.

The maker of these instruments is severely limited in the amount of space at his disposal, and all materials have to be used with most

Fig. 9.—The telescope.

rigid economy of dimension. It follows that the telescope tubing is very thin and therefore easily bent. It demands the greatest gentleness in use, as the least distortion will obviously throw the long lens system out of alinement, with disastrous results. These facts should be impressed on hospital sisters, or any others on whom devolves the care of these instruments, for bending is a frequent occurrence, and is quite avoidable if proper precautions are taken.

In the orginal Nitze cystoscope the lens system was a direct one, there being no reflecting device, and the inlet of the system being

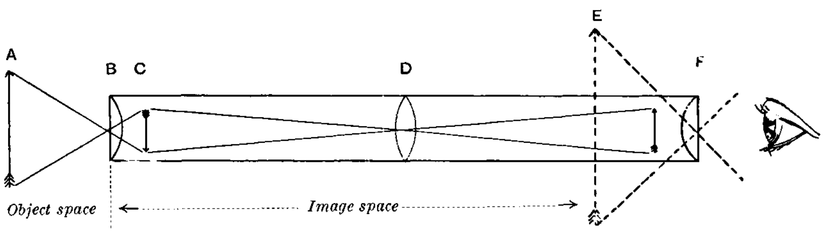

Fig. 10.—The lens system of Nitze's cystoscope. A, Object; B. Objective; C, Real inverted diminished image; D, Central, inverting, or transporting lens; E, Upright magnified virtual image; F, Ocular.

terminal. The direct view is retained in certain posterior urethroscopes to-day, of which the Joly model may be cited as an example. It is convenient to study the lens system in these simpler forms before taking into account the complications produced by the addition of a prism. In Nitze's original instrument (*see Fig.* 2) there were three lenses, the objective at the vesical end, a central or inverting lens, and an ocular (*Fig.* 10). The function of the objective was to concentrate within the small dimensions of the telescope, the rays diverging from the object. These were brought to a focus behind the objective as a real, inverted, diminished image, and the rays were then taken up by the middle or inverting lens and focused in front of the ocular as an upright image of the same small dimensions as the previous image. As this corresponded in size to the bore of the containing telescope (in modern instruments about 4 mm., in Nitze's rather more), it became necessary to magnify it in order that a clear retinal picture might be obtained. The image was therefore amplified by the ocular to such a degree as experience proved most serviceable (*see* page 15). An upright magnified virtual image resulted.

The principles of this simple system have been retained in modern cystoscopes, though they have evolved considerably. All who employ these beautiful instruments should be acquainted with a few of the more important optical considerations governing the construction of a good telescope, and an elementary description will therefore be given.

Objective.—If one looks through the ocular whilst the objective faces a bright surface, a circle of light will be seen. This circle is of the same size whether the surface is distant or close, whether it is the sky or an adjacent sheet of paper. It is known as the apparent visual field, or the apparent or virtual image, in contrast to the external or actual field of view, which in the foregoing illustration was represented by the sky or the sheet of paper. It will easily be appreciated that the former of these is of constant dimension, whilst the linear extension of the latter is proportional to its distance from the objective. Thus, if the objective is close to the object, the external field will be of practically the same size as the lens itself, whilst, when the instrument is held towards the sky, the external field is infinitely distant and is therefore of infinite size. In Nitze's instrument objects at all distances were equally in focus ;* the system had, therefore, a universal focus. This is also true, within certain wide limits, of the modern cystoscope.

Reference to *Fig.* 10 will indicate how the object space is

* When objects seen through an optical instrument at widely varying distances are all in uniformly good focus, that instrument is said to have a 'great depth of focus' or 'great penetration'. This feature depends on the small diameter of the emerging pencil of light, but it is for this reason incompatible with good transmission of light, which depends on a large emerging pencil (*see* page 18). Light transmission has been greatly improved in recent years by means that will shortly be outlined, and there has therefore been some loss of 'penetration', in that objects beyond a certain distance from the objective are not in perfect focus. This, however, is not important provided that the cystoscopist himself has a normal range of accommodation, for he can then compensate with ease any imperfection, and indeed a normal eye does not perceive the faulty focus. Moreover, penetration is perfect for objects situated within the first few inches from the objective, and this is the only part of the range employed in intravesical work.

constituted.* It corresponds to a cone whose apex is at the central point of the objective, and whose base is at infinity. The angle formed at the apex varies in size and depends on the focal length of the objective, and the internal tube diameter (usually about 3·8 mm., or $\frac{1}{8}$ in.).

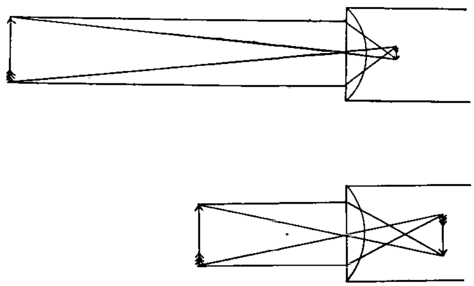

Fig. 11.—Diagrams showing effect of distance on the size of the resultant image.

If a penny is placed on a sheet of white paper and the end of the telescope is alternately approximated and withdrawn, it will be noticed that the penny appears to vary in dimensions, being large when the objective approaches it and becoming smaller when it recedes (cf. ***Fig.* 11**). At close quarters it cannot be contained in the apparent visual field, but as distance increases a circle of white surrounding the penny appears and enlarges, whilst the penny appears to diminish. Similar phenomena occur in the bladder, and are illustrated in the case of a calculus by ***Fig.* 12**.

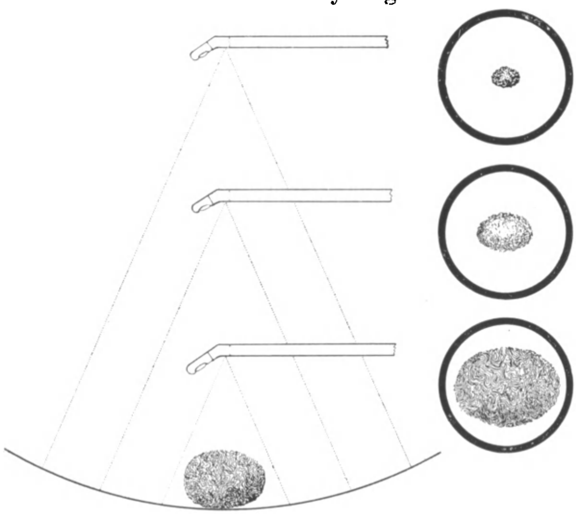

Fig. 12.—Examination of vesical calculus from three different altitudes, showing the effect of distance on magnification.

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* The term 'object space' denotes the space in front of a lens or lens system in which the objects are situated, in contradistinction to the 'image space' on the opposite side of the lens where the real image of the object is formed (*Fig.* 10).

The normal field of view for which the cystoscope is made is the bladder, and here the distances are limited by the size of that organ. It is uncommon to have to inspect the bladder wall from a distance greater than 50 mm. (say, 2 in.). Even for the upper parts of the organ, and in cases of dilatation, it is usually possible to bring the beak of the instrument within that range.

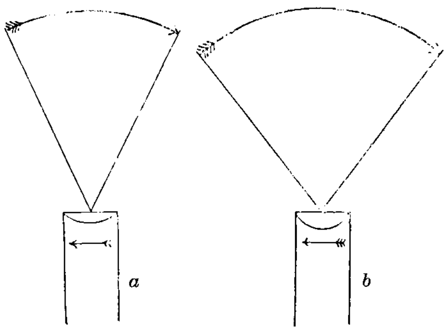

Fig. 13.—*a*, Objective with small angle; therefore small field of view, good magnification and illumination. *b*, Wider-angled objective; large external field, loss of magnification and illumination.

At a given distance (say, 25 mm. or 1 in.) and with a given diameter of lens tube, the extent of the field of vision will be determined by the focal length of the objective lens; the shorter the focal length the larger the field (*Fig.* 13). If no lenses are employed, as in a simple endoscopic tube (e.g., Kelly's), the extent of the field of view is equal to the lumen of the tube (*Fig.* 14). Whilst it is desirable to have a good field of vision, it should be appreciated that as this increases in extent, other things being equal, so magnification and definition diminish, and as these are very important features of the cystoscope, they must not be lightly renounced. They could, of course, be recovered at the other end of the instrument by increasing

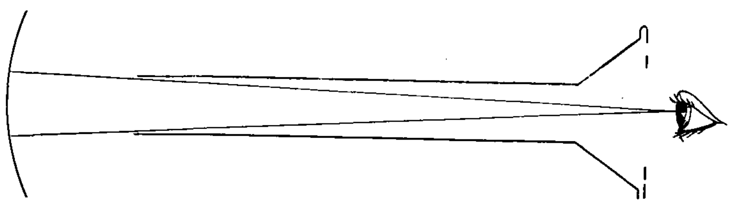

Fig. 14.—Inspection through Kelly's tube. The field of view corresponds in size to that of the lumen of the tube.

the strength of the ocular, but this again would lead to a reduction in the brightness of the image, which also must not be sacrificed (*see* page 17). The objective has to be designed to effect a compromise amongst these three competing factors—namely, a large field of view, good magnification and definition, and adequate illumination. As a rule the focal length adopted lies between 3·5 mm. ($\frac{1}{8}$ in.) and 6·5 mm. ($\frac{1}{4}$ in.).

Let us examine the properties of the instrument, adopting the simplest possible figures in order to avoid complicated calculations (*Fig.* 15). Let us therefore take the focal length of the objective as $\frac{1}{4}$ in.; it will then be found that with the object at a distance of 1 in. the external field will also have a diameter of 1 in. This must be reduced to the size of the interior of the telescope, say $\frac{1}{8}$ in., so that a real inverted image, one-eighth the size of the object, will be formed. If we now take an object 2 in. distant, the diminution will be proportionately greater, a reduction of 16 times taking place.

Inverting Lens.—The image is transferred to the ocular unchanged in size, the inverting lens system playing a passive rôle so far as any alterations in the proportions of the image are concerned.

Ocular.—The minute image thrown in front of the ocular would be invisible to the eye, and must be enlarged. This is the function of the ocular, and by it an enlarged, upright, virtual image is formed. It is customary to use a lens of such power that it increases the image to a greater extent than the objective lens has previously reduced the external image. A lens giving a magnification of between 10 and 20 times is generally employed. In continuing the foregoing illustration it will be convenient if an ocular which has double the power of the objective is adopted. This represents with fair accuracy the relative capacities of these units

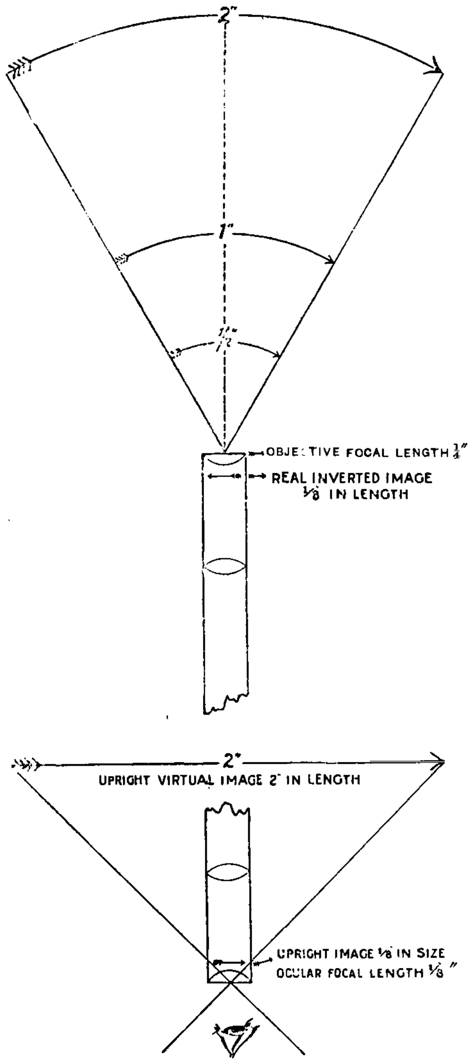

Fig. 15.—Diagram illustrating the properties of the telescope.

adopted in many cystoscopes. As the objective had a focal length of $\frac{1}{4}$ in. the ocular will now have one of $\frac{1}{8}$ in. and will magnify the image by 16 times. It will be remembered that the objective had to reduce a field situated 1 in. away by 8 times, and one situated 2 in. away by 16 times, in order to condense them within the telescope (*Fig.* 15). It will now be seen that the 1-in. field, after magnification by 16 diameters at the ocular, will be presented to the observer's eye with an ultimate amplification equal to twice its actual size, whilst a field which is 2 in. removed from the objective will be presented with its correct measurements.*

The nearer the objective approaches the object, the greater will be its magnification, and this is important in bladder examination, for there are areas of that viscus of which it is impossible to get a distant view (save perhaps by means of a retrograde cystoscope). The vesical neck is, of course, in actual contact with the prism during inspection, and those portions of the trigone which lie nearest to the meatus must always undergo high magnification (up to 8 or 10 diameters), and this must be allowed for when interpreting bladder pictures or any pathological lesion.

Beyond a distance of 2 in. (50 mm.) the bladder image would suffer diminution. In actual practice the wall of the bladder is rarely as much as, and practically never more than, 2 in. away from the prism, so that the object is almost always magnified to some extent. A convenient and easy distance at which to conduct an examination (canonical distance) is about $\frac{3}{4}$ in. to 1 in. from the bladder wall, the virtual image then having approximately twice the size of the actual object. For the more accessible portions of the viscus (trigone, ureteric orifices, lateral walls, etc.) it is easy to increase the magnification by making the beak of the instrument approach the mucosa. With experience it is possible to judge the degree of approximation by noting the definition and magnification of the detail of the mucosa, and by other things such as the way that the light reaches the eye, a translucent effect being produced with the indirect cystoscope when working at close range (*see Fig.* 63).

The cystoscope, when held directly opposite to one of the walls of the bladder, faces a concavity, each portion of which is roughly equidistant from its lens and is therefore similarly magnified. If, however, it is held obliquely opposite to one of the walls, those portions which are the nearer to the lens will be magnified to a greater extent than those which are more distant, and this will be more evident as

* The rate at which magnification increases, however, is not strictly proportional to the rate of approximation ; it exceeds the latter, so that at a distance of say $\frac{1}{2}$ in., when a magnification of 4 times would be expected, one slightly greater than this will be found (Newton's law).

the obliquity increases (cf. *Fig.* 22). It is well exemplified in the examination of the anterior wall of the bladder or when the instrument is laid on its side on the base and looks sideways towards one of the ureters. Again, when some convex intravesical object—for instance, a stone or a growth—is observed there is a considerable difference in the magnification to which its component parts are subjected, the most prominent area, which is generally centrally placed in the field, being enlarged to a much greater extent than the periphery (*Fig.* 16).

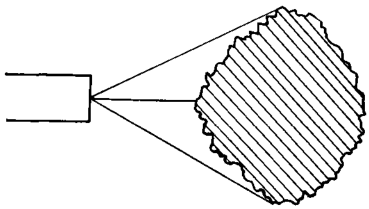

Fig. 16.—Diagram to indicate that the portions of a convex object closest to the prism are more highly magnified than those which are more remote.

Illumination.—The degree of magnification could be increased indefinitely by increasing the power of the ocular. As the magnification increases, however, it must be remembered that illumination decreases as the square of the radius of the exit pupil*. Thus, when

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* The intensity of illumination is inversely proportional to the square of the distance from the source (*Fig.* 17).

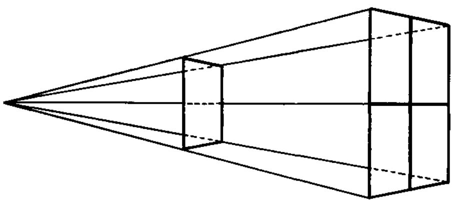
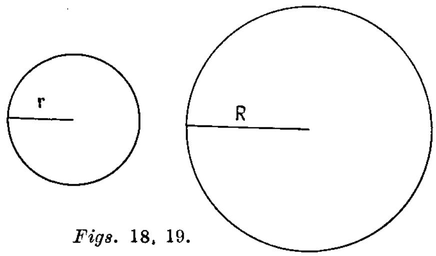


Fig. 17.—Illustrating loss of light by distance of lamp from object.



Figs. 18, 19.

If instead of a rectangle a circle (*Figs.* 18, 19) is used as a field—

If area (a) of circle of radius $r = \pi r^2$
and if area (A) of circle of radius $R = \pi R^2$
and if $R = 2r$ $(R^2 = 4r^2)$
$\therefore A = 4\pi r^2$ $= 4a$

Therefore the intensity of illumination is inversely proportional to the square of the radius of the field.

The same considerations apply to the illumination of the bladder wall by the lamp. Thus a field ½ in. away from the lamp will be 4 times more brightly illuminated than one 1 in. away, and 9 times better lit than a field 1½ in. away. It is obvious therefore that by approximating the beak of the cystoscope to the vesical wall there is a gain not only in magnification and definition, owing to the optical properties of the telescope, but also in illumination. When, however, the object and the cystoscope are too close to each other the field of view and the area of brightest illumination may not correspond.

amplified twice, the brilliancy of illumination diminishes to one quarter, and when amplified three times it is only one-ninth (we are not taking into account the brightness of the lamp, which has limitations, and may for present purposes be considered constant). Anyone accustomed to the use of optical apparatus prizes good conservation of light even more highly than magnification of the field. It is evident, therefore, that, just as with the objective a compromise had to be effected between the extent of the field of view and its magnification, so with the ocular a compromise must be made between the degree of magnification and the illumination of the image. Magnification may therefore be gained at the objective at the expense of a reduction in the extent of the field of vision, or it may be obtained at the ocular by the sacrifice of illumination. In practice we get magnification and to spare, if we are able to approximate the objective of the instrument to the bladder wall.

Good illumination, however, depends also on other factors. We have reviewed the properties of the objective and of the ocular, and the considerations which govern their focal lengths. The modern cystoscope has effected still more radical changes in the transporting lens system. We have seen that this plays a passive rôle as regards magnification, but we have now to learn that it is very important in regard to conservation of light. In the original Nitze system a centrally placed convex lens served as a transporting system. Multiple transporting lenses were first introduced by Lowenstein and Ringleb, and their work has subsequently been elaborated by numerous other investigators. Though there are many variations in design, all cystoscopes now employ a number of lenses in this system.

The amount of light passing through the central or inverting lens is measured in terms of the entrance pupil,* and the size of this

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* Every lens system has an entrance pupil and an exit pupil, and on their respective sizes depend the essential qualities of an instrument. When a cystoscope is held in such a position that the light from a distant source enters the ocular end, a very small circle of light of intense brightness can be observed at the bladder end. This circle of light is called the 'entrance pupil' of the instrument. If the position of the cystoscope is now reversed, so that the light from the distant source enters by the prism, a circle of light from 1 to 2 mm. in diameter will be noticed if the instrument is about 25 cm. from the observer's eye. This is termed the 'exit pupil' of the instrument. It is evident that the only rays of light that enter the lens system and the observer's eye are those that pass through the entrance pupil. The size and position of the entrance pupil depend on the focal power of the objective, and the position and size of the inverting lenses. By judicious selection and grouping of these inverting lenses appreciable improvements have been realized in the modern cystoscope. Whilst the amount of light which enters the telescope is regulated by the size of the entrance pupil, the illumination or brightness of the final image is dependent on the size of the exit pupil. An exit pupil equal in size to the pupil of the observer's eye is the most suitable, and as the latter is a variable factor, an average diameter of 2 mm. has been adopted in most modern cystoscopes.

entrance pupil increases as the distance between the objective and middle lenses diminishes.

This is simply demonstrated in *Fig.* 20, where C may be taken to represent the central lens as found in a Nitze cystoscope, being

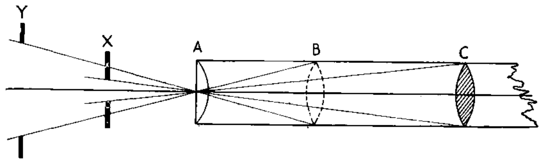


Fig. 20.—Diagram illustrating the respective size of the entrance pupil in the new and the old lens systems.

far removed from the objective A. The corresponding pupil is seen at X and is small in size and so admits little light. B is the first lens of the transporting system in a modern telescope, and Y demonstrates the large size of the corresponding entrance pupil, thus allowing much improved illumination. It will be observed that in Nitze's cystoscope all rays entering the objective and meeting the wall of the telescope between A and C are lost, whilst in a modern instrument only those between A and B are lost.*

Whilst approximation of the objective and the inverting lens has been effective in conserving light, the distance between the latter and the ocular has now become too great. The gap is bridged by a series of lenses, and the whole group thus formed takes the place of the central lens of the Nitze cystoscope and is known as the transporting system in view of its function of transporting the image from the objective to the ocular. The lenses vary in number and detail in different models. A system is depicted in *Fig.* 21 which represents

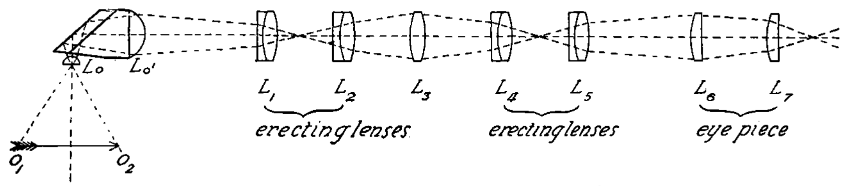


Fig. 21.—Lens system used in instrument made by the Genito-Urinary Manufacturing Co., London. O_1 O_2, The object; L_0 L_0', Two parts of objective separated by a roof prism; L_1, L_2, L_3, L_4, L_5, Transporting system; L_6, L_7, Eye-piece.

* In the diagram it may be remarked that the positions of the entrance pupil of the two systems are not the same, which fact will appear at first sight to be unfair to the Nitze instrument. They are, however, correctly represented, for their location is determined by the position where the images of the respective lenses B and C would fall if projected through the lens A into the object space (conjugate foci).

a combination employed in one of the standard models made by the Genito-Urinary Manufacturing Company of London. The multiplication of lenses has made it possible materially to reduce the size of the telescope, a fact which is of first-class importance in the operating and catheterizing models, as a small telescope makes additional room available for larger catheters and other instruments.

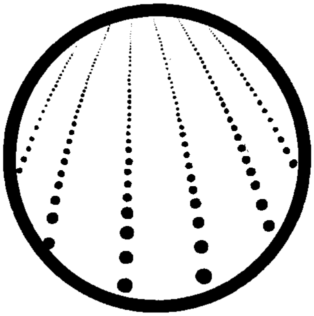
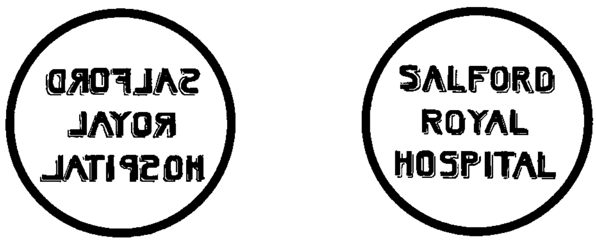


Fig. 22.—Lines of parallel dots on a printed card seen through the cystoscope, showing the effects of foreshortening and distortion.

Such are the principal qualities of the direct cystoscope and posterior urethroscope. The limitations of this instrument soon become evident in practice, for it can only inspect those portions of the bladder wall directly opposite to the observer (fundus, etc., though indeed these particular areas are more conveniently brought into view by this instrument than by its successor, the indirect cystoscope). The summit and anterior wall, and large portions of the lateral wall, are hidden from view, whilst that most important area, the trigone, is greatly foreshortened and distorted (cf. *Fig.* 22).

For the above reasons Nitze early displaced the instrument by his indirect or prismatic cystoscope, an instrument in which to the three sets of lenses already described was added, at the vesical extremity, a right-angled prism capable of deflecting field rays entering its lateral surface through 90° into the telescope. It is placed



Figs. 23, 24.—Legend seen through uncorrected and corrected cystoscope.

underneath an appropriately cut fenestra at the vesical end of the tube. This ingenious modification marked a notable advance, for it brought into direct view the bladder base and the upper and other walls of the viscus which previously were unapproachable by direct cystoscopy.

It nevertheless introduced a complication in that the picture reflected was a mirror view—that is to say, it is correct as regards its sides, but inverted as regards the upper and lower poles (*Figs.* 23, 24). This single disadvantage of the indirect system was not remedied until 1906, when Weinberg introduced his 'Ortho-Kystoscope', which was improved upon in the following year by Franck, who placed a prism in the ocular end as shown in *Fig.* 25, thus effecting a correction of the upper and lower poles.

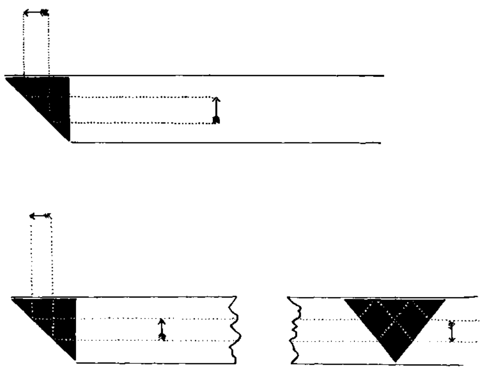


Fig. 25.—Correction of image by insertion of an extra prism.

To-day all makers of cystoscopes obtain an upright or corrected image by some device or other, the Americans using an erecting prism (central prism) near the ocular, others producing correction at the bladder end. The latter is the better method. The prism shown in *Fig.* 26 is used in instruments of British manufacture, and is known as the Amici or 'roof' prism. It was first employed in cystoscopic work by that able innovator Ringleb. It consists of a right-angled prism in which the hypotenuse is divided into two portions, the planes of which cut each other at an angle of 90° like the roof of a house, so that it really forms a double mirror and gives an image which is inverted not only in the direction of the upper and lower poles, but also of the lateral poles, so that by the provision of an odd number of inversions in the lens system a corrected image is obtained.

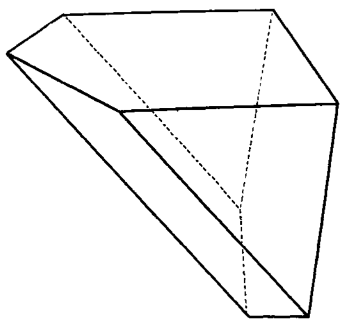


Fig. 26.—Amici's 'roof' prism.

The objective lens is made in two portions in order to avoid spherical and chromatic aberration; sometimes one of these is placed on the vesical aspect of the prism, at others they are both placed in the telescope. In models made by the firm of Wappler, the prism, together with the two lenses, form a single unit, cut as a hemispherical lens, the plane surface of which, being placed at an angle of 45° with the axis of the telescope, reflects rays into that tube. If tilted back through one or two degrees, this lens can be made to give a retrograde view (*Fig.* 27).

Each lens of the transporting system is also made of two portions, the one consisting of flint, and the other of crown glass. When employed in correct proportions this combination obviates spherical and chromatic abèrration.

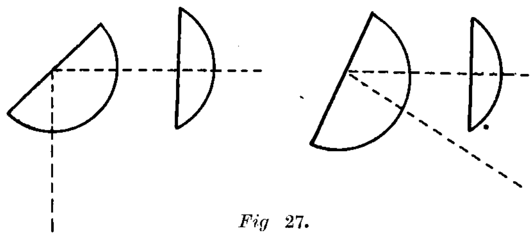


Fig 27.

THE CARE AND STERILIZATION OF THE CYSTOSCOPE.

The cystoscope is a delicate and valuable instrument, and its owner will be well advised to give personal time and attention to its cleansing and sterilization, or else to train with care the nurse who is to be responsible for it. Lack of proper attention will not only lead to the deterioration of the instrument, but will render it unsafe owing to inadequate sterilization.

When the instrument has been used it must be taken to pieces for cleansing. The compression screw (*see Fig. 5c*) which tightens the washer is first of all loosened, and the optical portion can then be removed. The two screws which fix the leather washer and the valve respectively are next removed. The instrument now consists of four separate portions, and each of these must be thoroughly cleansed by rinsing under running water and rubbing with a piece of lint, particular attention being paid to flushing the interior of the barrel. The two screws, together with the valve and the faucet, may now be sterilized by boiling or by dropping them into spirit.* The remaining portions are incapable of standing treatment by heat, as the cements which fix the lenses and prisms would be injured and the insulation of the wiring would be destroyed.† Start, then, by removing all water with a clean towel, and next treat the exterior of each portion with a swab soaked in methylated spirit. Now take the wool-holder provided for the purpose (*Fig.* 28) and on to its roughened end wind closely a pledget of cotton-wool, soak it in methylated spirit, and with it cleanse the barrel

* Boiling reduces the life of the washers attached to these screws, but they are inexpensive and easily replaced ; they are, moreover, the only absorbent portion of the instrument and therefore most prone to retain sepsis.

† See, however, below (p. 24).

of the catheter. Then take the sheath of the instrument, and, placing a finger over the eye, fill it brimful of methylated spirit and allow it to remain thus for some seconds. Those portions of the instrument which

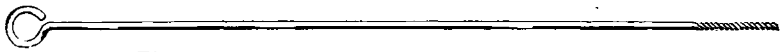


Fig. 28.—Wool-holder for cleaning barrel of cystoscope.

have been under sterilization by boiling may now be recovered, and the cystoscope re-assembled. Before fixing the valve see that it is working efficiently and is not being held open by any portion of débris or grit. If the instrument is required for another case, it may now be put to stand in antiseptic lotion, the beaker in which it is contained being sufficiently deep to submerge the whole of the shaft. Suitable lotions for this purpose are carbolic lotion 1–60, boric acid (sat. sol.), oxycyanide of mercury 1–1000, or methylated spirit. The instrument should be allowed to stand in the selected lotion for fifteen minutes before being used again. If it is not required for use immediately, each part must be thoroughly dried, special attention again being paid to the interior of the barrel and valve, and it should then be returned to its case.

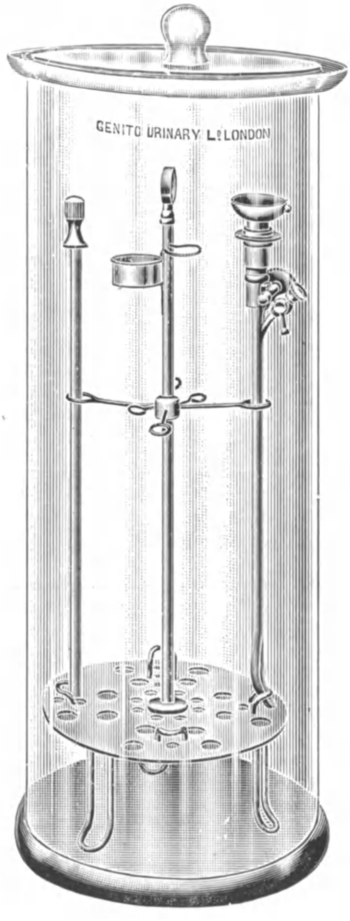


Fig. 29.—Jar for sterilization of cystoscopes

If the surgeon is doing a series of cystoscopies, he should attempt to arrange them in such order that the aseptic cases are dealt with first and the most septic last, much in the same way as the cases are preferred on an operating list.

Sterilization by Formalin.—Another method is sterilization by the vapour of formalin, and this may be used either warm or cold. If warm, sterilization is obtained after half an hour; but if the cold vapour is employed, two days should be given to the process. The method requires the possession of a number of cystoscopes if several examinations are to be conducted consecutively; it also involves apparatus to sterilize them in. For sterilization in the cold vapour an upright glass bottle or flask, as shown in *Fig.* 29, is used, and the instrument is suspended therein. There is a holder for the tablets of paraform which is generally situated at the upper part of the flask so that the heavy vapour will fall around the instruments. Sterilization by warm vapour requires a special stove. The vapour is freely liberated as soon as a temperature of 40° C. is reached, and if it is kept between this and 55° C., no undue injury will be done to the instrument. If, however, the temperature rises above this point, the instrument is liable to be damaged. The stove is so constructed that a greater temperature cannot be attained. A certain amount of deterioration eventually occurs in a cystoscope which is frequently exposed to warm formalin vapour, and it is preferable, when circumstances allow, to obtain sterilization in the cold state.

Before introducing any cystoscope into formalin vapour, care should be taken to see that it is perfectly dry, special attention being paid to such internal parts as the barrel, valve, etc. The telescope and catheter should be suspended separately, and the instrument should be allowed to remain exposed to dry air for a time before being placed in the receiver. A quantity of fresh calcium chloride should be sprinkled in the bottom of the jar to absorb atmospheric moisture. During formalin sterilization the cords and switch of the instrument may be hung in the vapour and thus rendered aseptic.

This method of sterilization is more efficient and penetrating than washing with antiseptics, asepsis being obtained in the numerous chinks and crannies which abound in the instrument, many of which must escape adequate attention with the swab. Its disadvantages are the length of time required and the consequent impossibility of using the same instrument on two cases consecutively. In the irrigating cystoscope the bladder contents pass out through the barrel of the catheter, which is subsequently used on a second case, so that the possibilities of infection are obvious.

Sterilization by Boiling.—In recent years the difficult problem of producing a boilable cystoscope has been solved. The first instrument to be thus equipped was the Swift Joly. Now all cystoscopes made by the Genito-urinary Manufacturing Co. have catheters which are boilable. The standard telescope must not be boiled, but boilable ones will be supplied if specially ordered. Neither the sheath nor telescope will stand prolonged immersion such as is employed for ordinary surgical instruments. The separated components should be put into tepid water and brought slowly to the boil. After half a minute on the boil the tray in which they rest is removed from the sterilizer and they are allowed to cool. They will suffer injury if seized with ordinary instrument forceps. Cystoscopes must not be placed in the sterilizer together with other instruments unless enclosed in a special compartment. Sterilizing boxes with perforated walls are provided for this purpose. Hard water must be avoided, as it deposits a chalky precipitate on the moving parts and they become clogged. If the town's supply is hard, distilled water should be employed. The advantages of sterilization by heat are self-evident, particularly in an instrument which has so many chinks in which to secrete sepsis.

THE EXAMINATION OF THE CYSTOSCOPE BEFORE USE: TRACING FAULTS.

Some time before it is required an examination of the cystoscope should be made to ascertain that all its various parts are functioning perfectly. Faults may occur at many points, and will be considered under three headings: (1) *The lighting*; (2) *The valve*; (3) *The telescope.* A knowledge of the causation and methods of location of faults will often obviate a return of the instrument to the makers.

1. The Lighting.—All breakdowns of the lighting system result in the failure of the lamplight, and when this occurs it may be due to a fault in any part of the circuit, and the site of the breakdown must be located by a process of exclusion. The possibilities may be conveniently considered under the following headings: (*a*) Lamp; (*b*) Internal wiring of the cystoscope; (*c*) Battery and cords; (*d*) Switch.

When working with a combination set an alternate sheath is supplied so that the one which has failed can be replaced by its neighbour (it is presumed unlikely that both cystoscopes are simultaneously at fault). If this second instrument lights, it will exclude any fault in the battery or the cords and switch, and will point to the apparatus distal to these as the site of the trouble—namely, the sheath or the lamp. Conversely, if it fails, suspicion will be thrown on the battery cells, cords, and switch.

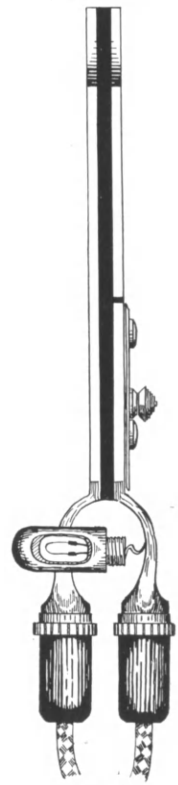


Fig. 30. Method of testing the lamp.

a. Lamp.—Taking the former case first; one will naturally examine the two parts (sheath and lamp) separately. Unscrew the lamp and examine the central protruding filament. Elevate it with a pin, and test the lamp across the switch as shown in *Fig.* 30. A lamp which is fused generally gives rise to suspicion by discoloration of the bulb. A break in the wiring may sometimes be seen on close inspection. Should the lamp prove faulty, it is put on one side for refilling and is replaced by a fresh one from stock. The lamp is the element which most commonly breaks down, but it is also the one which is most easily remedied. Before replacing the lamp make a habit of removing any foreign substance, grease, or dirt from the copper terminal at the bottom of the lamp socket in the end of the cystoscope, by scraping it with a pin. Make sure that the filament is projecting well before returning the bulb to its seating. Exceptionally a terminal which is actually too long has given trouble by coming into contact with the sheath and so forming a short-circuit.

b. Internal Wiring of the Cystoscope.—Should the lamp, battery, and external wiring have been proved efficient, the fault is traced to the internal wiring of the cystoscope. Glance at the connecting rings which unite the cystoscope to the switch and reassure yourself that these are clean. A short-circuit in the instrument itself can be confirmed in the following way :—

Remove the lamp from its fitting. Place the body of the cystoscope in circuit with one pole of a voltmeter, the other pole of which is in contact with a battery terminal. The other battery terminal is brought into relationship with that electric connection ring of the cystoscope which is fused to the wire lying in the floor of the sheath. This ring may be identified by the fact that it rests between two insulating rings. In the absence of the lamp no circuit should be formed when the current is turned on, and the voltmeter finger should remain at rest. In the presence, however, of a defect in the insulation a current will be registered on the voltmeter.

c. Battery and Cords.—If the defect proves to be in the proximal (battery and cords) section of the circuit, these must be alternately replaced in order to find out which is wrong. The wires of the instrument not infrequently form faulty contact with the switch or other terminals, and it is little wonder, for they are repeatedly subjected to improper handling, with the result that the copper breaks within its coverings, the site of election being the point where it joins the switch or ebonite plugs. At these sections the coverings are reinforced, but they nevertheless remain vulnerable points. Two rules may be laid down : (i) When coupling up to the battery box grasp the body of the ebonite plug, particularly avoiding pressure at the end where the wire emerges, as this kinks and breaks the metal wire ; (ii) Similarly in disconnecting at either end pull on the terminals themselves and not on the wires.

Faults in these external wires are characterized by intermittency of the light. By pushing the wire towards its seating, or by withdrawing it, the current may be made or broken. The location of the fault in the wires can be surmised where the covering is seen to be frail.

d. Switch.—The switch is a fairly frequent offender; it may give rise to trouble in two ways: (i) The slide is by far the more common transgressor. Adequate contact with the distal portion of the split plate is regulated by the correct tightness of the two screws which fix it. When too tightly or too loosely screwed home the slide fails to connect the two portions of the divided plate. Pressure by the thumb immediately re-establishes continuity, and this can quickly be made permanent by resetting the screws with a screw-driver. (ii) It was customary at one time to unite the two opposing plates of the switch by means of insulated metal screws. It occasionally happened that [redacted] became disturbed or perished, [redacted] was produced. In modern [redacted] have replaced the metal screw [redacted] fore disappeared, at least so [redacted] concerned.

2. The Valve.—Examine [redacted] valve chamber, for it is often [redacted] trifling portion of grit or oth[redacted] clappet. The hinges may bec[redacted] of closing the valve, whilst th[redacted] not uncommonly gives way.

When the valve is faulty, [redacted] telescope is inserted. A fing[redacted] counteract this. Some surge[redacted] which the valve goes out of or[redacted] discontinued to employ one, [redacted] finger, however, is very liable to be contaminated by touching objects the sterility of which cannot be guaranteed, and its close contact with the vesical contents is therefore undesirable.

3. The Telescope.—In examining this part of the instrument, take it in one hand and hold it so that the prism faces a lighted window or an electric light, and, placing the eye to the ocular, note: (*a*) The clarity; (*b*) The outline and extent of the field.

a. Clarity.—If not clear, the cause will probably be found in a badly cleaned ocular or objective. Start by cleaning the ocular, using lint or gauze. Greasy substances on the lenses are conveniently removed by methylated spirit. Having cleaned the ocular, pay attention to the window of the prism. In doing this be careful to support the vesical end of the telescope whilst rubbing, in order to avoid torsion or bending of the long and malleable shaft. Spots or other opacities remaining after cleaning of these external parts are located in the interior of the telescope, and must be remedied by the makers.

b. Outline and Extent of the Field.—It has already been indicated that the manufacturers of cystoscopes are severely restricted in the calibre of the instruments and that the thickness of the tubing of all parts is reduced to a minimum. Such attenuation involves greater delicacy and malleability. Bending of the telescope is therefore a frequent accident. Very slight distortion will be quite sufficient to cut off a large portion of the field in so long and narrow an optical system. The appearance seen in *Fig.* 31 results from a slightly deflected telescope. The dimly illuminated crescent owes its existence to rays of light reflected from the lateral wall of the tube.

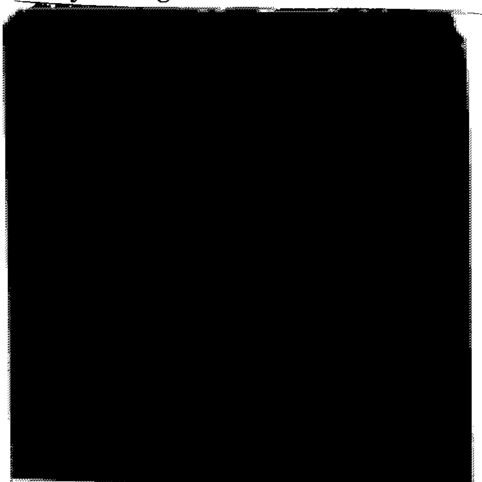


Fig. 31.—Ellipse of field of view cut off owing to bend in the telescope.

A slightly damaged telescope can be used temporarily, as a portion of the field still remains. Moreover, when it is introduced into the sheath the rigid walls of the latter partially restore its shape. It is possible to straighten the telescope with a little gentle pressure, but it is wiser to return the damaged part to the instrument maker. A telescope is often bent through forgetting to unscrew the compression screw of the cystoscope before inserting it into the sheath. The former is usually grasped close to its ocular extremity, and if force is used in overcoming the resistance of the unreleased rubber washer, the shaft of the telescope will give way.

The catheter also is made of soft and malleable metal, and frequently gets bent in cleaning, etc. When the telescope is inserted into a bent sheath it accommodates itself to the shape of the latter and a section of the optical field is cut off. On withdrawal of the telescope, however, it will be found that it recovers its straightness, and the fault is thus traced to the bent catheter.

ADJUSTING THE CURRENT.

The proper setting of the shunt which controls the brightness of the lamp should be determined before the cystoscope is introduced into the bladder. Beginners are liable to increase the current too rapidly and so overshoot the filament's capacity, with the result that they soon run through their store of lamps. The correct method is to couple the cystoscope to its source of electric energy, previously noting that the full resistance of the shunt is in, and then gradually increase the current until the lamp commences to glow. Once the lamp has lit the progress of the slide should be slow.

What is the degree of brightness which a lamp will tolerate ? In estimating the brilliancy of the lamp, the amount of illumination in the room must be taken into account. A cystoscopic theatre should not be brightly lit, as if the eye is adjusted for a strong light, it will not readily adapt itself to the degrees of illumination which are possible in the bladder. Assuming therefore that the room is moderately illuminated, one increases the current until the filament appears to be burning fairly brightly but the shape of the wire can still be seen. When a little more current is passed the form of the filament will be lost to view, obscured by its own brightness which causes an extension of its apparent beyond its actual boundaries (irradiation). This is roughly the correct amount of current to use. It will give sufficient illumination when conditions are favourable, but when visibility is poor, owing to hæmorrhage, cystitis, etc., one need not hesitate to burn the lamp more prodigally. It will stand being overworked for short periods without burning out, especially if the current is switched off when opportunity serves. Having settled the degree of brightness which it is expedient to use, the shunt is left at this position in readiness for the cystoscopic examination, and the cystoscope is uncoupled and returned to its antiseptic bath.

STORE OF LAMPS.

Two lamps are supplied by the makers with the cystoscope, but the purchaser is strongly recommended to supplement them ; it is best to do this at the time of the original purchase, in order that the lamps may be fitted to the individual instrument. If fresh lamps are acquired subsequently, the sheath of the cystoscope should be returned to be fitted; otherwise much annoyance may be caused by the lamp's screwing home to a point which is not opposite to the fenestra and so illuminating the bladder inaccurately. I personally keep four lamps for each of my hospital cystoscopes and have a chart showing the number of good and used lamps on hand, and the number which are being filled. In this way I never find that the supply of lamps has unexpectedly run out. Old cases must be carefully preserved for refilling, as, in addition to being economical, this ensures that the lamp will fit the sheath properly.

SOURCES OF CURRENT.

There are three sources from which a supply of electrical energy may be obtained. These are: (1) *A dry cell;* (2) *The town's current;* (3) *An accumulator.*

Fig. 32.—Dry-cell battery.

1. Dry Cells.—These are by far the most satisfactory and convenient source of current; they are cheap, light, and easily transportable. The outfit which I invariably use is shown in *Fig.* 32, and is supplied by the Genito-urinary Manufacturing Co. Two cells of generous dimensions are housed in a box. In the lid is a mechanism whereby spring contact is made with the terminals of the cells. The shunt is also placed inside the box lid, and is controlled from the exterior. The cystoscope terminals are received in two small holes and are immediately secured in position by spring contact. These cells do not require frequent replacement, and generally a pair will last in constant use for many months.

Small cheap cells may be purchased in any electrician's shop; their voltage is generally two to four, and therefore two cells must be joined together and used with a small rheostat (*Fig.* 33). They are frequently found to be of inferior voltage to that indicated by the maker, and tend to run down rapidly when standing. They must not be relied upon unless recently tested.

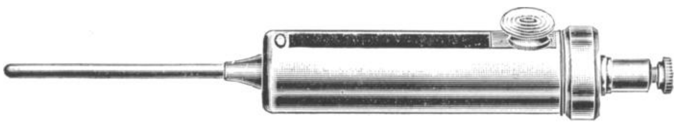


Fig. 33.—Sliding rheostat for direct connection to the terminals of dry cell.

2. The Town's Current.—The town supply may be used for cystoscopy, but should never be employed in such a way as to connect the instrument *direct* to the mains. Shunt resistances or other means sometimes employed to reduce the original voltage of 100–250 down to the 6 volts required have possibilities of danger and should be rejected.

If the mains are *alternating*, a small earth-free static transformer can be used. With this the low voltage current is generated in the secondary winding entirely by induction and has no electric connection with the town's mains. Such an arrangement is quite satisfactory.

If the supply mains are *continuous*, the problem is not so simple, and the best plan is to convert in the first place to alternating and then employ a suitable static transformer. To do this some form of motor or rotary converter must be employed, and the so-called 'Universal Machines' embody a suitable motor and also usually an earth-free transformer. The exact arrangement may vary with different machines, but the main point—namely, that there must be no direct connection to the supply mains—should be regarded as fundamental.

3. An Accumulator.—Use may be made of an accumulator, but it is not very suitable. Its large size and weight are inconvenient, especially for travelling. It is expensive in the primary outlay and also in upkeep. It will give a light continuously for many hours, but should be recharged periodically, even when not in use, as it tends to discharge spontaneously. It deteriorates when not fully charged.

CHAPTER III.

EXAMINATION OF A UROLOGICAL PATIENT.

ORDER OF INVESTIGATION.

During the last quarter of a century or so the invention of new instruments and the discovery of fresh means of diagnosis have greatly increased both the complexity of our investigations and the length of time which must be devoted to them. A generation ago our predecessors were able to complete the examination of a case by methods which were clinical in the narrow sense of the word, and in a short period of time could send the patient away fully diagnosed according to their lights. Under modern conditions a complete overhauling is often spread out over a number of days, and is a research in which several men may collaborate.

In no department is this more true than in urology. A patient who presents himself to-day at a urinary clinic must give up several days to being investigated. The surgeon who undertakes the work should have in his mind a clear conception of the order and progress of the inquiries to be pursued. If they are made in a haphazard way, time will be lost, efficiency sacrificed, and the patient may become dissatisfied by the extent of his examination. The schema on page 33 sets out the principal investigations required in an average urinary case, together with their order and spacing. It shows the routine adopted in my own hospital clinic, and can be recommended as a basis from which other schemes may be evolved to fit the special requirements of other hospitals. A glance at it will show that the investigation is so arranged as to occupy three visits to the Out-patients' Department, and the object of each visit is indicated.

First Visit to the Out-patients' Department.—Once a week an out-patients' session is taken to which fresh cases are referred and at which old cases and late operation cases can also be seen. The new cases are those which interest us at present, and at this, their first visit to the hospital, a record of the history and symptoms is obtained, and a couch examination for physical signs is made. The urine is tested by the usual clinical methods, and an intelligently collected specimen is sent for laboratory investigation. The specimen tested at this first visit is not a catheter specimen; this will be obtained later, on the third occasion that the patient comes to the hospital (page 49). It

SCHEMA FOR THE EXAMINATION OF A UROLOGICAL PATIENT.

<table>
<tr><td>First Visit to Out-patients' Department.</td><td>Clinical—
1. History
2. Symptoms: Pain and other sensory disturbances; Alterations in the act of micturition, especially frequency, strangury, and obstruction; Alterations in the urine observed by the patient, especially hæmaturia
3. Signs and physical examination :—
Inspection
Palpation: Renal, Vesical, Genital — and general abdominal; Rectal or vaginal
Percussion
General conditions (uræmic, cardiac, respiratory, central nervous system, etc.)
Urine—
Clinical tests :—Naked-eye appearance, reaction, specific gravity albumin, blood, pus, sugar, etc.
Laboratory tests: Chemical; Histological; Bacteriological</td></tr>
<tr><td>Second Visit to O.P.</td><td>X-ray Examination</td></tr>
<tr><td>Third Visit to O.P.</td><td>Cystoscope—
Exploratory
Chromocystoscopy
Bacteriology of catheter specimen of urine</td></tr>
<tr><td>Wards *</td><td>Cystoscope—
Catheterizing :—Histological examination, Functional examination — Separated urines
Pyelogram
Treatment

Function—
Total renal function
Separate ,, ,, —ureteric catheter and separation of urines</td></tr>
</table>

* This work is now carried out in the clinic at the third visit to the Out-patients' Department, an arrangement which has been rendered necessary by the large amount of clinical material to be dealt with. The installation of a small X-ray set in the Genito-urinary Department renders pyelography possible and is quite indispensable. Only when patients are feeble, or would have a long train journey, are they now admitted to the wards for these examinations.

is collected, however, with a view to the exclusion of urethral pus. For this purpose the patient is instructed to urinate into two separate receivers. The first urine sweeps before it all the urethral contents, and the second may be regarded as representative of the urine as it occurs in the bladder. Any difference between the two specimens is noted, and must be regarded as indicative of the condition of the urethra; the diagnosis will be affected thereby, as also will the advisability of cystoscopy.

This two-glass method of testing is very frequently used in the male, where urination into two specimen glasses will aid the inspection of the fluid for opacities, etc. It is most important in the exclusion of urethral disease. In the female it is less often used, but is nevertheless possible and desirable. The first glass in this sex, even in health, invariably contains a considerable quantity of opacity, chiefly mucus and epithelium, derived both from the urinary and genital passages, whilst the second glass in health is clear. The naked-eye inspection of the urine in the female is just as important as it is in the male, and with a little care the specimen can be acquired. It is desirable to know, even at this early stage of the investigation, the contents of the bladder urine, free from urethral contamination. It is, however, objectionable to employ a catheter at the present juncture, especially in view of the fact that the bladder probably holds some unknown morbid change, itself rendering catheterization inexpedient. The second specimen, gathered as above, may be regarded as representative of the bladder urine, but its condition will be corroborated subsequently at the third visit to the hospital, when an actual catheter specimen will be obtained.

Second Visit to the Out-patients'.—The next step is an X-ray examination, and as two days must elapse before the alimentary canal can be rendered fit for this, the patient is provided with a card on which are printed directions how to prepare for a radiological examination. The card gives instructions concerning a purgative (preferably castor oil) to be taken on each of two nights previous to the examination; this purgative must contain no metallic drugs. Also, in the event of the patient's being inclined to constipation or being stout, it advises the administration of an enema on the morning of the visit. Only a light diet is to be taken on the actual day. It is a good thing also to avoid cellulose in the diet for a couple of days prior to the examination, and charcoal biscuits may be recommended if the patient is inclined to flatulence.

Third Visit to the Out-patients'.—The surgeon sets aside a portion of another day for the cystoscopic examination of his patients, and this may conveniently fall two or three days after the X-ray examinations have been completed, so that films and radiologists' reports may be available for personal inspection. A limited number of cystoscopies should be arranged. The number will be determined by the amount of time which is set apart, and also by the amount of assistance which is available for bladder preparation, etc. Care should be taken that adequate time can be given to each case, as nothing is more productive of bad results than hurry.

When the surgeon arrives he should find collected on his desk notes of the histories, symptoms, and signs which were obtained a few days previously, together with the reports on the urines from the laboratory and the X-ray plates and their reports. These are read through carefully and considered, after which the surgeon is in a position either to proceed to the cystoscopy in the out-patients' department or to arrange for the admission of the patient for this purpose, as he may judge best.

INDICATIONS FOR AND CONTRA-INDICATIONS TO CYSTOSCOPY.

In the absence of contra-indications most urological patients will be submitted to cystoscopy. In many it will prove to be the most valuable diagnostic agency employed; in few will it be superfluous. Even where the diagnosis is apparently straightforward—for instance, a renal stone which is shown in the radiogram—much accessory information may be acquired by the cystoscope. This will chiefly concern the presence and function of the second kidney, but often unsuspected complications are found which throw light on the case and alter the attitude of the surgeon to treatment.

It is undesirable to attempt cystoscopy in any acute infection of the lower urinary tract. Acute anterior or posterior urethritis would be injuriously affected by instrumentation, as would also acute prostatitis. The examination would be painful and it would involve the risk of infecting the bladder. Acute cystitis is not an absolute contra-indication, but it is generally better to avoid cystoscopy until a less acute stage is reached, unless there is some pressing reason for its performance.

ANÆSTHESIA.

There are four methods of inducing anæsthesia for cystoscopy, and each of them has its own special sphere of usefulness. They are: (I) *Local*; (II) *Sacral*; (III) *General*; (IV) *Spinal.* The best of all anæsthetics, however, is a gentle and educated touch, and no other kind will make up for a lack of this. Local and sacral anæsthesia are specially applicable to routine out-patient work, though they are also useful in the operating theatre. Admission to the wards is desirable for spinal and general anæsthesia, though occasionally I administer a general anæsthetic in the out-patients' department when faced with unexpected difficulties, or in children, the patient being subsequently allowed to return home.

I. LOCAL ANÆSTHESIA.

A clear idea of the possibilities and limitations of local anæsthesia is requisite. The problems that need to be considered are: (1) *The urethra* (*a*) *in the female*, (*b*) *in the male*; (2) *The bladder.*

1. The Urethra.—

a. In the Female.—The urethra is short, straight, and mobile, has only one sphincter, and no specially sensitive areas. The amount of urethral pain produced by the introduction of the cystoscope is negligible, and it is momentary, for as soon as the instrument is in place it ceases. As a rule I use no local anæsthetic; but if for any reason one is considered desirable, the application of a crystal of cocaine to the external meatus, the most sensitive spot, can be recommended. A convenient method is to place one or more lamellæ of cocaine just within the external meatus and leave them there for a few minutes to dissolve, when the investigation may be proceeded with.

b. In the Male.—The urethra is a long curved channel, divided into two sections, an anterior and a posterior; it has two sphincters, is fixed by membranous ligaments at its proximal end, and contains

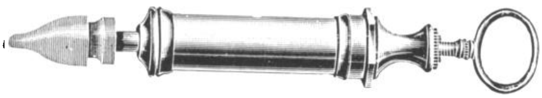


Fig. 34.—Everidge's urethral syringe.

two hypersensitive areas—the position of the compressor urethræ and the verumontanum. From the point of view of local anæsthesia it presents three problems: (i) To anæsthetize the anterior urethra; (ii) To anæsthetize the posterior urethra; (iii) To allay the pain caused by straightening out the more or less fixed curves of the proximal urethra.

The anterior urethra is treated by the introduction of a solution of one of the derivatives of cocaine. Novocain (5 per cent), percain (0·1 to 0·15 per cent), and stovain (4 per cent) can be recommended. Novocain is known to be a poor anæsthetic for mucous surfaces but has nevertheless considerable popularity. Percain is somewhat toxic, but as it is ten times more powerful than cocaine and novocain this toxicity is nullified. The addition of adrenalin (20 minims of a 1–10,000 solution to every 100 c.c. of anæsthetic solution) to any of these drugs diminishes absorption and concentrates their action.

Any form of urethral syringe (*Fig.* 34) may be employed. The urethra should be fully distended, and then a clip (*Fig.* 35) should be placed on the tip of the penis in order to retain the fluid for a few minutes. At the end of this time the surgeon takes hold of the end of the penis with the left hand, and with the right hand in the perineum massages the fluid back past the anæsthetized compressor urethræ into the posterior urethra. Here it is allowed to remain for another similar period, when the whole length of the urethral mucosa will have been exposed to the action of the drug.

Other methods of anæsthetizing the posterior urethra involve the introduction of an Ultzmann syringe or an applicator for dropping pellets; either of these procedures is nearly as painful as the introduction of the cystoscope itself, and therefore not to be recommended.

Though the discomfort which is caused by straightening out the curves of the posterior urethra cannot be relieved by local anæsthesia, one precaution may be taken to reduce it. When the thighs are flexed slightly on the trunk the suspensory ligament of the penis is relaxed, whilst if they are extended, it is on tension. Whatever position is chosen for the cystoscopy the operator should see that the

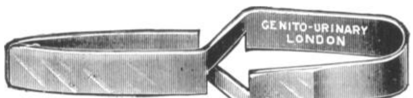


Fig. 35.—Thomson-Walker's penile clamp.

thighs are slightly flexed so as to avoid unnecessary strain on this portion of the passage when the penis is depressed by the instrument (*see Fig.* 41).

If a series of patients is to be examined, it is convenient that an assistant should be deputed to induce local anæsthesia in an anteroom; by this means considerable time is saved to the surgeon.

2. The Bladder.—The tactile and pain sense of the healthy bladder *mucous membrane* are of a very low order. A ureteric catheter may touch it without being perceived by the patient, and even a stilette may be placed against it without eliciting pain. A patient who has passed a stone from his ureter into his bladder—the latter being healthy—is barely conscious of its presence until either he commences to pass it out per urethram, or the bladder becomes inflamed and therefore sensitive. If the tactile sense were not thus low, the presence of even a small quantity of urine in the viscus would undesirably obtrude itself upon the consciousness. Langley and Anderson have shown that in the hypogastric nerves afferent fibres are present in proportion to efferent fibres only as 1 : 10, and Langley has suggested that the paucity of afferent nerve-fibres is the reason for the high threshold to sensory stimuli.

With the inflamed bladder, however, it is different. The organ becomes sensitive as soon as it is inflamed. Guyon demonstrated that a stone is not felt in a healthy viscus, but that when it has given rise to an area of inflammatory reaction at the position where it rests, pain is experienced. Whenever the bladder is inflamed, even superficially, some lowering of the threshold for sensory stimuli will be found. This lowering advances in proportion to the depth to which the inflammatory process has penetrated rather than to its superficial extent. When the deeper coats of the bladder are involved, vesical tenesmus makes its appearance. A single area of ulceration gives origin to more irritation than a widely diffused but superficial cystitis, as may be realized by comparing the tuberculous bladder with that of simple cystitis. This variation in the tolerance of different organs led the old school of urologists to classify cystitis according as it was painful or painless. The point from which these more painful stimuli arise appears to lie deep, probably in the *muscular* coat.

Local anæsthesia, though capable of controlling pain arising in the mucosa of the bladder, is useless for that originating in the muscle, or indeed for the pain caused by the distortion of the deep urethra in the male. These being the two most prominent causes of discomfort in cystoscopy, the writer has abandoned local in favour of sacral anæsthesia for men, and has used it almost continuously in the Out-patients' Department for several years. As it has proved itself very valuable, and as its technique is not so well known as that of the other varieties of anæsthesia, a short description is thought desirable.

II. SACRAL ANÆSTHESIA.

The bladder has a dual innervation through the sacral plexus and through the sympathetic, the former being the more important. Each of these carries afferent and efferent fibres, and is in part responsible for the sensory and motor supply of the bladder. The sacral nerves in addition innervate the prostate and urethra. The sympathetic fibres gain access to the central nervous system via the lower thoracic and upper lumbar roots. Head has shown that they carry stimuli caused by over-distension or prolonged distension of the viscus. Caudal injection is capable of blocking all impulses travelling via the sacral nerves and therefore anæsthetizes the urethra, prostate, and in part also the bladder. An area of skin and the rectum and anus are included. It leaves unaffected the sympathetic distribution to the bladder, but as this is a relatively unimportant channel it is found in practice that excellent anæsthesia is obtained. Only from the most exquisitely sensitive bladders do sufficient stimuli travel by this alternative route to inconvenience cystoscopy. In such circumstances even general anæsthesia may be inadequate, but spinal anæsthesia provides a method for its control. It is, however, very seldom necessary.

Technique.—The patient's buttocks are exposed and he lies face downwards on a couch. The skin overlying the sacrum is sterilized with iodine. A needle $2\frac{1}{2}$ in. long attached to a large Record syringe filled with solution is employed. The position of the sacral hiatus is identified by palpation, two tubercles which guard its entry forming useful landmarks (*Fig.* 36). Its aperture is closed by an obliquely placed fibrous membrane whose resistance is recognizable as the needle perforates it. The point is made to pass through this membrane perpendicularly, but immediately afterwards the needle is depressed so as to bring it into line with the sacral canal (*Fig.* 37). It is gently guided along this channel for a distance of about $1\frac{1}{2}$ to $2\frac{1}{2}$ in. Occasionally it is impeded by irregularities in the bony boundaries, from which, however, it is easily freed by a little manipulation,

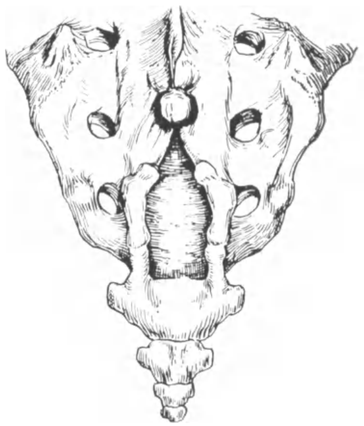


Fig. 36.—Lower part of sacrum showing bony landmarks around the hiatus.

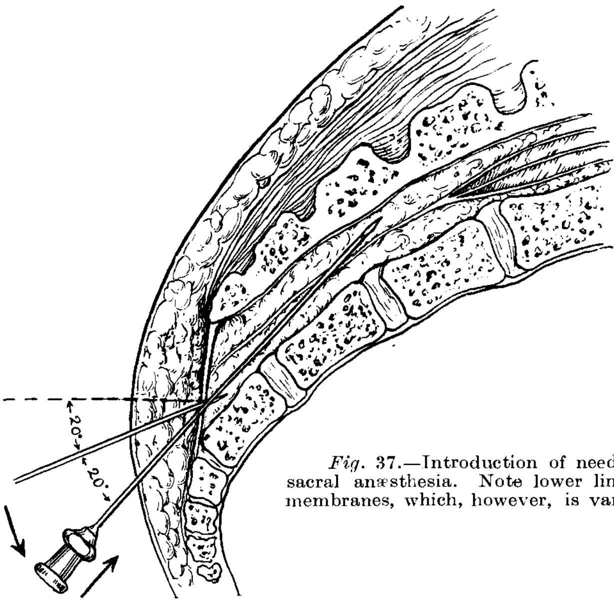


Fig. 37.—Introduction of needle for sacral anæsthesia. Note lower limit of membranes, which, however, is variable.

and eventually it is arrested by the natural curve of the canal. Abnormalities, however, are not infrequently so marked as to render the injection impossible. When the needle is in position the surgeon pauses momentarily to assure himself that neither blood nor cerebro-spinal fluid escapes. This is a rare accident, but should it happen the needle must be withdrawn a suitable distance. The dura mater extends to the level of the second or third piece of the sacrum and the injection must be extra- or epidural. It should not encounter resistance, for that would indicate that the point of the needle is buried in periosteum. If necessary it can be liberated by withdrawing it slightly. The anæsthetic should be introduced slowly, and its injection should be painless.

Solutions Employed.—I employ a solution of novocain made to the following formula :—

℞	Novocain	0·60 grm.
	Sod. bicarb.	0·15 ,,
	Sod. chlorid.	0·10 ,,

Dissolve in 30 c.c. of distilled and sterile water. The whole 30 c.c. to be injected.*

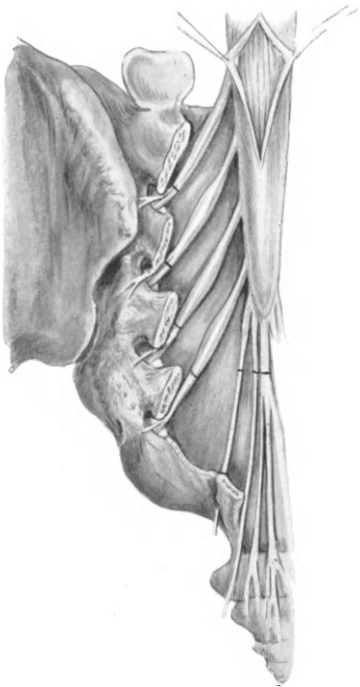


Fig. 38.—Dissection to show arrangement of nerve elements in sacral canal. Transverse lines on nerves show approximate limit of investing membranes.

* Different workers use different quantities of fluid for injection into the sacral canal, but many emphasize the necessity for a sufficiency. To determine the most suitable amount Grodinsky and Best injected cadavers with 30, 40, 60, and 100 c.c. of methylene blue and found that the injections sometimes reached extraordinarily high levels. Thus 60 c.c. (or more) might extend up to the foramen magnum, though at other times they would reach only the 2nd lumbar vertebra (average 5th dorsal vertebra). Thirty c.c. in some instances also appeared at the foramen magnum, but in others did not go beyond the 4th lumbar vertebra (average 7th dorsal vertebra). The stain was found to pass in variable degrees through the anterior foramina along the emerging nerves. It percolated particularly freely through the upper but less freely through the lower sacral foramina, a fact which would suggest that the upper sacral nerves would be more completely anæsthetized than the lower. This is contrary to clinical experience, but an explanation for the apparent discrepancy is forthcoming. The nerves are invested with membranes to a point just distal to their ganglia (*Fig.* 38), and the membranes are impervious to anæsthetic solutions. The lumbar and upper sacral ganglia occupy the intervertebral foramina. The lower sacral and the coccygeal nerves, on the other hand, have a longer post-ganglionic course within the sacral canal, and it is apparently here that they are most easily affected by injected solutions. This accounts for the mode of onset and the ultimate development of anæsthesia. It is found clinically that

The novocain is kept in powders ready for use, and is added to boiling water just before it is required. It is boiled for two or three seconds only. Boiling for more than this converts the sodium bicarbonate into an alkaline carbonate, which is a powerful irritant. Schlimpert showed that if boiled for three minutes the solution will, when injected subcutaneously in laboratory animals produce local gangrene of the skin. Laewen was responsible for the introduction of sodium bicarbonate into the formula, as he found that the anæsthesia is better and more prolonged than when novocain acts unaided. Following this short period of boiling the fluid is cooled, and to it may then be added, if thought desirable, four to six drops of adrenalin (1–1000) in order to delay its absorption after injection.

Results.—The onset of anæsthesia occurs in four or five minutes, and reaches its fullest development in fifteen to twenty minutes. The patient remains face downwards during the first ten minutes in order that such fluid as escapes from the sacral canal may pass forward along the course of the emerging nerve-roots and be absorbed by them. At the end of this time he may move to the cystoscopic chair for bladder preparation.

Desensitization first shows itself over the skin of the anus, perineum, and scrotum, and spreads to the penis and buttocks. In a few instances it involves the hypogastrium and thighs. Some unsteadiness of gait when the patient is walking from the couch to the cystoscopic chair is therefore not uncommon, and someone should be present lest he should fall.

Sacral anæsthesia has been much used in my department. Its results are excellent in the best cases, but are not quite uniform. Some patients experience pain and a sensation of bruising at the site of injection which may last for a day or two. The pain arising from distortion of the prostatic area, which is unrelieved by local medication, causes but little discomfort to the patient under sacral anæsthesia, and there is little or no straining or reflex micturition. The

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the 5th sacral segment (anus) is always the first and most completely anæsthetized and that the 4th (region anterior and lateral to the anus) follows. The 2nd and 3rd sacral segments (scrotum and penis in the male, vulva and clitoris in the female) are affected later and less deeply. The extent varies with the quantity of fluid used. " By a 20 c.c. injection one cannot hope to anæsthetize more than the 5th sacral nerve completely and the 4th (occasionally the 3rd) less completely . . . the 30 c.c. injections can be counted upon for anæsthesia of the 3rd, 4th and 5th segments only. The distribution of anæsthesia of the 40 c c. injection is about the same but more complete " (Grodinsky and Best). Appreciation of pain invariably disappears before tactile sense, and the latter may remain unaffected throughout the examination even when pain is absent. The condition is then an analgesia rather than an anæsthesia. We often find this to be the state of the 2nd and 3rd sacral segments.

skin anæsthesia varies both in extent and in degree, extending to the thighs when well marked. The desensitization of the urethra is probably more constant than that of the skin. The following complications have been witnessed: nausea and vomiting, headache, temporary paralysis of the anal sphincter, collapse.

Mr. E. D. McCrea, who assists me at my cystoscopic clinic, has kindly looked up for me the records of 100 consecutive cases of sacral anæsthesia, and reports that in 85 the anæsthesia was good, in 6 it was sufficient, and in 9 poor. In 6 of these last 9 cases there was difficulty in the introduction of the needle into the sacral canal. In 13 cases there was temporary paresis of the legs, and paralysis of the anal sphincter in 2. In every instance these paralyses quickly passed off. In 4 patients nausea occurred, in 3 it went on to vomiting, and in 2 there was collapse. The duration of anæsthesia is more than sufficient to allow any ordinary cystoscopic examination. The patient in all instances was able to return home within half an hour of the finish of the operation.

III. GENERAL ANÆSTHESIA.

General anæsthesia is frequently employed for in-patients being examined in the operating theatre. It is useful for children and very nervous subjects, and for prolonged cystoscopic operations. I prefer to use general or spinal anæsthesia for the treatment of vesical tumours (*see* Chapter X, page 182). It temporarily depresses kidney function owing to its toxic effect on the renal epithelium and to its lowering the blood-pressure. It must therefore be employed with discretion when function tests are being made. Its effect in this direction has, however, been exaggerated.

IV. SPINAL ANÆSTHESIA.

The sphere of usefulness of spinal anæsthesia has been indicated previously. It is occasionally valuable to block impulses referred from hypersensitive organs via the sympathetic. Its use is exceptional, and when employed particular care should be exercised to avoid injury of the bladder by over-distension.

PREPARATION OF THE BLADDER.

Preliminary Treatment.—For a day or two before and after cystoscopy it is a good plan to administer antiseptics by the mouth, and the following prescriptions may be recommended:—

1. When the urine is strongly acid: Hexamine, 10 gr. three times a day before meals.
2. When the urine is alkaline: The hexamine may be given as

above recommended, and a mixture containing acid sodium phosphate, 10 to 20 gr., and tincture of hyoscyamus, 15 to 30 min., administered after meals.

The hexamine is given before meals in order to avoid, as far as possible, excess of free hydrochloric acid in the stomach.

Certain conditions must be fulfilled before cystoscopy can be performed. The urethra must be capable of admitting a cystoscope. The bladder must be of sufficient size, and the contained medium clear enough to allow a view of the wall to be obtained. The very large majority of cases present no insuperable difficulties in these respects, and therefore it is wise to make the first exploration of the urethra and bladder when preparing for the cystoscopy. Should difficulties then be encountered, little or nothing will have been lost. Some operators, however, especially on the Continent, make a habit of testing the urethra and bladder instrumentally a few days before the cystoscopy is undertaken. For this purpose they pass a catheter of about 23 French gauge to prove the urethral permeability, and then, having withdrawn the urine from the bladder, they inject fluid to estimate the vesical capacity. Such a procedure is unnecessary and meddlesome. It is open to grave objection in that the bacterial content of the urethra is unknown, whilst the bladder may be pathologically susceptible to infection. If sepsis is introduced, for instance, into a tuberculous bladder or one containing a neoplasm, not only may the cystoscopic picture be changed, but also the whole course of the disease may be altered for the worse. If, however, the history of the case definitely suggests a stricture, it may be considered desirable to investigate its size by bougies prior to the cystoscopy. It should be remembered, however, that the point of an ordinary curved metal bougie is liable to bruise the roof of the bladder, as I have demonstrated on many occasions, especially if the bladder is not fully distended at the time when it is passed. The small submucous hæmatoma which results is liable to confuse the diagnosis, and is not a desirable addition to a bladder the pathology of which is as yet unknown.

The capacity of the bladder should never under any circumstances be estimated by distending it. Reduction in size or irritability can usually be surmised from a history of frequent or urgent micturition, whilst lack of clearness of the medium may be anticipated as a cause of difficulty when the second of two urines passed into separate glasses is seen to be turbid. If large quantities of pus are present in this second glass, it may prove impossible to get the bladder sufficiently clear for examination. It should, nevertheless, be left to the time of the cystoscopy to see whether or not this is so, for it is only exceptionally that cystoscopy fails from this cause in experienced hands.

In the interval preceding the operation oral administration of urinary antiseptics may be tried, but has probably already been employed. Vesical lavage should be avoided. In some cases it would doubtless be valuable; in others it would certainly be harmful, and it is not easy to forecast the reaction beforehand. Its value or harmfulness depends on the presence or absence of an underlying cause for the cystitis. To diagnose the underlying cause is one of the objects of the examination, and an opinion regarding its presence prior to the cystoscopy must be mere surmise. If the cystoscopy fails, it is then time enough to resort to vesical lavage.

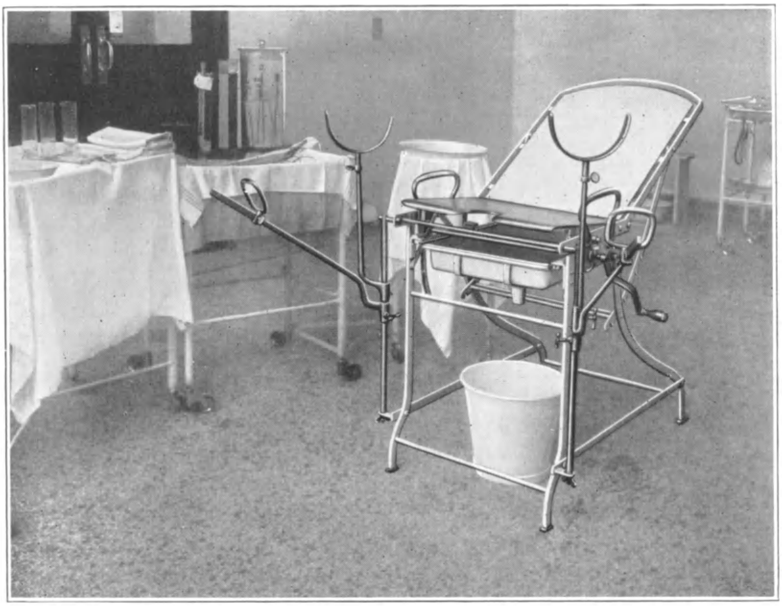


Fig. 39.—Cystoscopic chair.

Position of the Patient.—If the best results are to be obtained it is expedient that cystoscopy should be conducted by the surgeon in comfort, and for this purpose the axis of the instrument must correspond approximately to the horizontal when the bladder base is being inspected. When the patient is correctly placed the base of the bladder, as it is traced posteriorly, recedes gently from the horizontally held cystoscope (*see Fig.* 51) and is easily inspected. The position of the vesical floor is regulated by that of the bony pelvis, as the bladder is fixed thereto. It will be found that when the sacrum is resting flat on a cystoscopic chair (*Fig.* 41), conditions are favourable for an easy examination. The patient is put on the chair (*Fig.* 39) with the buttocks reaching to the edge of the seat, and the back of the chair is slightly

Fig. 40.—Patient in position for operation.

raised. The knees are supported on the rests, and the feet occupy the stirrups* (*Fig.* 40). The thighs should make an angle of about 45°

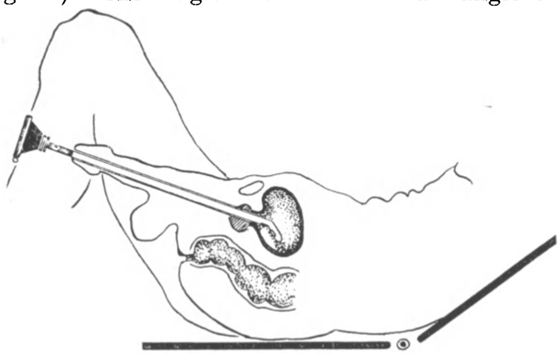


Fig. 41.—Correct position of patient on the cystoscopic chair.

with the trunk (*Fig.* 41), for in this position they avoid tilting the pelvis and thus altering the lie of the vesical base. Variations from

* Frequently, however, I do not employ the stirrups, as the extended legs are liable to hamper one's movements.

the normal result from flexion or extension of the lumbar spine causing a corresponding rotation of the pelvis and bladder.

Extension not uncommonly occurs when an apprehensive patient involuntarily arches his lumbar spine (*Fig.* 42). The pelvis is thrown

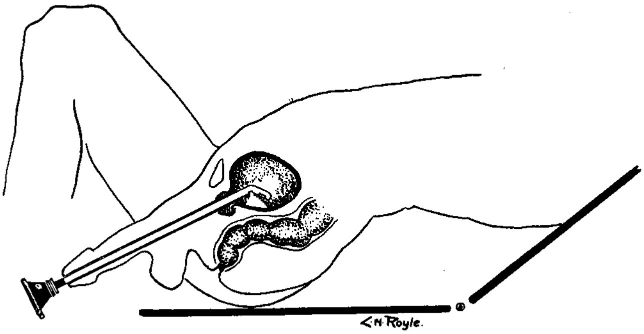


Fig. 42.—Shows arching of the lumbar spine and the depression of the ocular necessitated thereby.

forwards, and, in order to maintain the correct relationship of the cystoscope to the bladder, the surgeon is compelled to depress the ocular end inconveniently. Even when advised of the desirability of

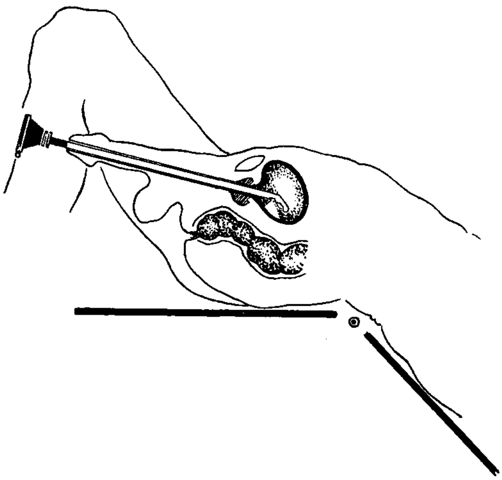


Fig. 43.—The back of the chair lowered to correct extension shown in *Fig.* 42.

maintaining the correct attitude, nervous subjects may do so with difficulty, but by lowering the head of the chair to a point below the horizontal the trouble may be circumvented (*Fig.* 43).

Flexion of the pelvis on the trunk results in the opposite disadvantage. The extravesical end of the instrument must now be elevated until, when the bladder base is under inspection, the shaft approximates to the upright, and the surgeon, unable now to be seated, must bend forward to bring his eye into line with the instrument. This position is most commonly seen when cystoscopy is undertaken on an operating table and the patient is thoughtlessly placed in the full lithotomy position, the feet occupying the stirrups and the thighs being strongly flexed towards the abdomen (*Fig.* 44). A readjustment of the lower extremities will rectify the trouble. The knees should be supported close to and outside the uprights in straps, the legs being allowed to hang free, whilst the thighs take up a position similar to that used on the cystoscopic chair. The inexperienced operator may fail to appreciate the disadvantages additional to the discomforts which this erroneous position entails, and frequently attempts to orientate the bladder with the shaft of the cystoscope in the accustomed horizontal plane (*see* p. 57 and *Fig.* 51). As the trigone under these circumstances is placed perpendicularly, he may locate it with difficulty or even fail to do so, whilst catheterization of the ureters and other intravesical operations are rendered unnecessarily difficult. This trivial error is a fertile source of needless embarrassment to the occasional cystoscopist.

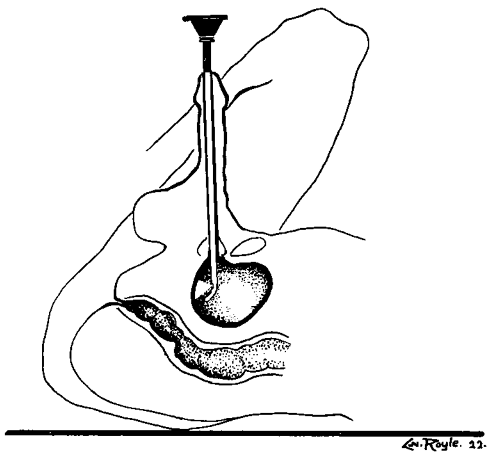


Fig. 44.—Incorrect position, with thighs flexed strongly on the abdomen.

Irrigation and Filling of the Bladder.—

Choice of Instruments.—The filling of the bladder may be accomplished either through a rubber catheter or through an irrigating cystoscope. The advantage of the former is that it is a soft and flexible structure, causing little discomfort when in position. It would at first sight, therefore, appear to be peculiarly suitable for washing out a viscus when considerable time will probably be taken up in that operation—for instance, one containing much mucopus—but actually this is not the case. The thick walls of the rubber catheter reduce the size of its bore to such an extent that much time is lost, and the advantage of the thin-walled metal instrument, with its large lumen and fenestra, is most evident in practice. Especially is this so when there are masses of ropy pus lying in the bladder. These are incapable of escaping through a rubber catheter, but on the introduction of the irrigating cystoscope flow out in quantity, and the bladder is often rapidly cleansed with a few washes. It is almost indispensable in bladders which fill rapidly with blood or pus, from whatever source, and especially where urethral bleeding fouls the fenestra during introduction. An additional advantage with the irrigating cystoscope is that it involves the passage of a single instrument only.

In the male the cystoscope, once introduced, will be held in position by the fixed parts surrounding the proximal urethra, and the surgeon may abandon his hold on it whilst occupying his hands with the syringe, etc. When working short-handed this is very con-

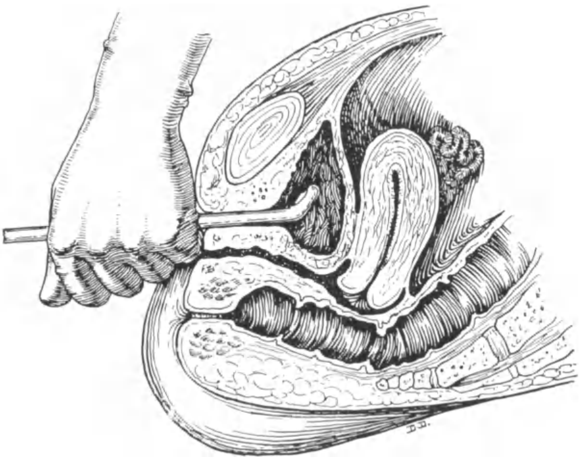


Fig. 45.—An assistant holds the cystoscope during lavage of the female bladder, and the ulnar border of the hand makes a fixed point of the perineum in order to obviate movements of propulsion and retropulsion. Note the degree of advancement of the cystoscope into the bladder which prevents vesical injury. (Towels omitted.)

venient. In the female, on the other hand, the cystoscope must be maintained in position by the operator, as the urethra will not support it. These facts, taken in conjunction with the relative painlessness of urethral instrumentation in women (allowing of the passage of more than one instrument), lead me to use a rubber catheter in that sex where I should employ an irrigating cystoscope in the male. I never use the customary glass catheter, as bruising of the vesical fundus frequently results. The adoption of a rubber catheter in the female has an additional advantage, in that the preparation of selected bladders can be relegated to the nursing staff, and much of the surgeon's own time is thereby saved. If assistance is available, however, the cystoscope is held as shown in *Fig.* 45. If the cystoscope is employed to irrigate and fill the bladder, it should be introduced with the telescope in position, acting as an obturator, so that the edges of the fenestra shall not injure the urethral mucosa. When the tip is in the bladder the telescope is removed and the faucet substituted.

Obtaining a Catheter Specimen.—The patient is instructed to pass his urine three hours before he is expecting a cystoscopy, and then to avoid further micturition until after the operation. In the case of patients who suffer from frequency of micturition this rule, of course, requires modification. Thus, for example, if the period for which the urine can be held is only three-quarters of an hour, he is expected to pass it at that interval before the examination.

The patient, having been routinely cleansed and anæsthetized, is placed on the chair or table. The selected instrument is introduced into the bladder, and the urine present is withdrawn. This specimen of urine—a catheter specimen—is free from urethral contamination, and is sent to the pathologist for histological and bacteriological investigation. It is withdrawn into a sterile glass receiver, and before it is sent away the surgeon, holding it up to the light, carefully scrutinizes it for the presence of pus, blood, or other opacity. From the condition of the urine he will acquire indications as to the presence of cystitis, and as to the length of time that the bladder will require to be irrigated before it is ready for cystoscopy. A small portion of the urine may also be retained for clinical tests if thought desirable, but it will be remembered that these tests have already been carried out at the patient's first visit to the clinic, so far as a normally voided specimen is concerned. Fresh clinical tests would only be required in the event of suspicion that pus or other extraneous material, observed at an earlier examination, was of urethral origin. The bladder is completely emptied, the degree of ejaculatory force of the detrusor being noted. When this is weak it may be necessary to assist it with manual pressure applied to the hypogastrium.

The absence of opacity in the specimen sent to the laboratory would suggest that there was no inflammatory reduction in the bladder capacity, and that the first wash would be returned clear. Only a few ounces of fluid are injected, therefore, and on their return are caught in a fresh glass receiver and again examined against the light. If the fluid is transparent, the bladder is forthwith distended with 8 oz. of solution and is ready for cystoscopy.

Syringe.—The bladder may be irrigated and distended by means of a syringe or by a funnel and tube. The superiority of the former method is very marked.

The syringe which the writer invariably uses (*Fig.* 46) is made either with a glass or with a metal barrel. The advantage of the metal barrel is that it is not subject to breakage by knocks or by heat during sterilization. It is, however, made of soft metal and any trifling bruise will jam the piston. The advantage of the glass barrel is that the presence of air in its interior can be readily detected and remedied. The capacity of the syringe is 8 oz., and the piston shaft of the metal syringe is marked with notches, the distance between each pair representing 2 oz. of fluid in the barrel of the syringe, so that the quantity in use can be readily observed. The measurements are marked on the barrel itself in the case of the glass syringe. The nozzle is conical and is designed to fit accurately into the cone-shaped interior of the cystoscope faucet, whereby a water-tight connection is instantly produced during bladder preparation.

The use of a syringe is convenient and accurate. One always knows exactly how much fluid has been introduced into the bladder. When using the syringe the surgeon should insist that it is handed to him quite full. During the filling a certain amount of air is sucked in around the piston and screws ; this air must be evacuated by

Fig. 46.—Glass bladder syringe with tapered nozzle to fit faucet. It is graduated on the piston shaft.

turning the point upwards and then raising the piston until the lotion makes its appearance at the nozzle. It should then be turned downwards whilst the piston is *still supported*, and the remaining portion of the syringe filled. If the piston is not continuously supported, gravity will displace it and air will again be introduced. This is a small but important point, for often when injecting the last ounce into the bladder a gurgling of air is heard, and on cystoscopy a large bubble is found to obscure the apex of the viscus. The smaller the bladder the greater the importance of keeping the air-bubble small.

Funnel and Tube.—I imagine that few experienced cystoscopists now employ this method ; it is clumsy and laborious and should become obsolete. It is very difficult to be sure exactly how much fluid has been injected into the bladder—a most important point—and also there is always a large amount of air displaced from the long airway into the bladder, with the result that the air-bubble is undesirably large.

When the bladder is being prepared with a funnel and tube one generally sees the emptying of the viscus performed by inverting the whole of this long water channel over a bucket. A column of fluid with a definite momentum is thus produced. As soon as the bladder is evacuated, the continued movement of this column acts as a water-hammer. A portion of the vesical mucosa is liable thereby to get sucked into the catheter eye and to be damaged. I have frequently noted the kick of the fluid in the tube, comparable to the concussion which one observes in a water-pipe when a tap is suddenly closed. The remedy is obvious, and consists in removing the tube at its junction with the in-lying catheter, and allowing the bladder contents to flow out gently under the action of the detrusor.

Bladder Capacity.—

Normal Capacity.—The usual capacity of the healthy bladder is from 8 to 12 oz., being rather greater in the female than in the male. It is desirable to distend the organ to a point at which all the folds of mucosa are straightened out, so that every part of the viscus may come under observation. Further than this it is not good to go, as over-distension will lead to restlessness and a desire on the part of the patient to urinate. In the female, therefore, 10 oz. may be used, and 8 oz. in the male. In both sexes, however, I prefer to use 8 oz., as it is good practice to get accustomed to a certain bladder capacity and keep to it. One's ideas of distance, size, and orientation are thereby assisted. Further, in practice it is convenient to use the amount of fluid contained in the 8-oz. bladder syringe.

Large Bladders.—In filling the bladder allowance should be made for any alterations in its capacity which may be indicated by the history. Thus, a bladder which has had much residual urine for some long period will take perhaps as much as a pint or more of fluid with comfort ; it is then necessary to use a larger quantity of fluid in order to distend the folds in the mucosa. At the same time it should be kept in mind that too great a distension will be inconvenient, for it necessitates wide excursions of the vesical end of the cystoscope in an attempt to see all portions of the mucosa.

Small and Irritable Bladders.—Small quantities of fluid will be used in bladders which are hypersensitive and pathologically reduced in capacity. Cystoscopy becomes difficult when the bladder is of very small content, and diminishes in value as the size diminishes. Finally, it becomes impossible with a capacity less than about 2 oz.

When pus is present in the first vesical washings it is advisable to proceed with caution in the distension of the organ. As a number of washings are certain to be required, there is no advantage in commencing with large ones. After an evacuation of the bladder, therefore, a single ounce of lotion is inserted and allowed to return. The next wash consists of 2 oz., the third of 3 oz., and so on. Ultimately the cystoscopist diagnoses the capacity of the viscus. When injecting the lotion he watches carefully the effects produced on the patient's respirations. If distension is reaching its limit, they are increased in frequency and depth, and the patient may also complain of pain or of a desire to micturate. Even under general anæsthesia the respiratory reflex is very sensitive, and will give valuable suggestions regarding the capacity of the viscus. The surgeon now continues his irrigation until the lotion returns clear, or as clear as he deems the circumstances will allow. During those lavages subsequent to the diagnosis of the vesical capacity he will avoid over-distension. In practice it is wise to fall short of the maximum capacity by one or two ounces, in order that the organ may not be fatigued or irritated. When the bladder is finally filled for inspection the distension should be less than the maximum, as otherwise it is liable to empty itself before the examination is complete. It should be borne in mind that additional fluid is constantly being contributed by the kidney. If the examination is commenced with full distension, there will not be room to accommodate this extra fluid.

Where irritability is extreme it is advisable to avoid emptying the last ounce or so of fluid, as it is found that these bladders tolerate interference better if a small quantity is left in at the end of each wash. The reason for this is probably twofold. First, the swollen and hyperæmic mucosa does not easily adapt itself to the completely emptied state, and, secondly, this membrane is brought less intimately into contact with the end of the catheter or cystoscope if an ounce of lotion remains to accommodate it. Many bladders containing pus show a normal or more than normal capacity. Such a one, for instance, is the bladder obstructed by prostatic hypertrophy or urethral stricture. Nevertheless the technique described has no disadvantages, and will frequently be serviceable even in these patients.

The source of origin of pus may sometimes be diagnosed by the way the bladder reacts to lavage. If it comes from the kidney, the vesical medium usually clears rapidly under lavage ; but when there is a copious supply of pus, as, for instance, from a pyonephrosis or a tuberculous kidney, it rapidly fouls the bladder again. On the other hand, if the pus is of vesical origin, it is often mixed with quantities of sticky mucus and is therefore very adherent. Further, cystitis has frequently some associated complication, such as false or true diverticula, etc., from which fresh amounts of pus continually recontaminate the organ. Bladder washing may, under these circumstances, be prolonged and require much patience ; but once the organ is clear it tends to remain so for at least the duration of the cystoscopy. Pus from the kidney may, of course, infect the bladder, when the above rules would be correspondingly modified.

Hæmorrhage.—Hæmorrhage may show itself during bladder preparation, and its source may be urethral, vesical, ureteral, or renal. The first of these is generally easily overcome by the use of the catheterizing cystoscope.

Vesical Bleeding.—This is frequent, and is usually amenable to gentle manipulations and continuous lavage, over-distension being particularly avoided. Sometimes, when coming from an extremely inflamed bladder, or one containing a neoplasm, it may be very obstinate, and in such cases the more one irrigates, the more profuse the hæmorrhage becomes. If the bleeding is fresh, the wash is a bright pink in colour, whereas old blood is darker and more 'laked'.

Lavage with silver nitrate 1–1000 may control the hæmorrhage, but adrenalin, ½ drachm of the 1–1000 solution to one pint of water, will be found the most certain remedy. When the patient is being cystoscoped under general anæsthesia, and the surgeon is contemplating the addition of adrenalin to the bladder wash, he should advise the anæsthetist of his intention. If the patient is receiving pure chloroform, it is now well known that the injection of this drug is fraught with grave danger of adrenalin shock. The change to ether or a mixture of chloroform and ether will remove the danger.

Renal Bleeding.—Blood from the kidney which is lodged in the bladder is usually rapidly washed away; it is uncommon to encounter renal hæmorrhage so profuse that the bladder cannot be prepared for cystoscopy, though such has been my experience occasionally.

Sometimes when hæmorrhage, whether renal or vesical, has been profuse prior to cystoscopy, clots are found to have formed in the bladder sump and render the examination impossible. They cannot be washed away; they completely hide the underlying base, together with the ureters and any lesion which may exist there; and they persistently exude blood-pigments into the vesical medium and make it opaque. It is then best to abandon the attempt and to put the patient to bed until the urine is free from blood and has remained so for three or four days. It is wise not to be too precipitate in cystoscoping immediately the urine has cleared, for when the hæmorrhage has been so severe decolorized clots may remain for some time and be troublesome in obscuring the base. It is occasionally necessary to wait for many days before the conditions are ripe for a successful cystoscopy.

To deal with hæmorrhage which is otherwise difficult or impossible to control, Wardill recommends a technique in which paraffin is used as a medium. The blood, as it is shed, does not mix with the paraffin, so that the medium remains clear and the source can be identified and perhaps dealt with by the cautery. The selection of a proper grade of oil is important, since the ordinary medicinal paraffin is too viscous. Wardill advises one with a specific gravity of about 0·860, which is much easier to handle and which can be obtained from any good chemist. If difficulty is encountered in removing opaque material from the bladder sump, he recommends the use of a sucker.

THE INTRODUCTION OF THE CYSTOSCOPE.

Females.—In women the introduction of the cystoscope is easy, as the canal is short, wide, and mobile. The beak of the instrument is introduced in the line of the channel, and as it slips in the shaft is lowered so as to come into line with the urethra.

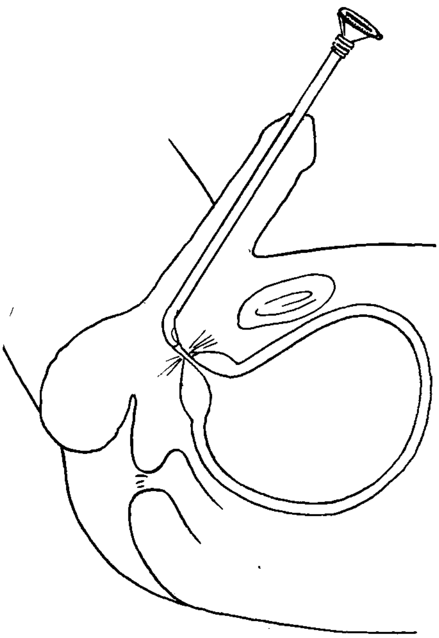


Fig. 47.—Introduction of the cystoscope : beak ready to pass into the membranous urethra.

Males.—In men the introduction is generally easy if properly executed, but in certain cases it may be extremely difficult ; the problem which presents itself is the insinuation of a straight rod with an elbowed extremity through the long, narrow, curved urethra. Advantage is taken of the fact that the pendulous portion of the penis is mobile in order to bring it into line with the first portions of the fixed urethra which are encountered. This is done by elevating it fully on to the surface of the abdomen. The beak of the cystoscope is introduced into the meatus and the shaft gradually passed down the tube. Movements should be slow, gentle, and steady, the instrument being held lightly in the fingers. Rapid or jerky movements cause considerable pain, whilst slow ones are scarcely noticed by the patient. The motion should be a combined one in which both hands participate, the penis being drawn well up over the shaft like a glove finger, whilst the instrument is allowed to slide by its own weight down the urethra. When the beak approaches the curve of the membranous urethra (*Fig.* 47) the passage should be held on the stretch, all folds in which the nose of the instrument might catch being thus obliterated. The penis is kept well up over the abdomen until the beak is felt to move forwards towards the prostate; when this occurs the cystoscopist knows that it is in position for the next manœuvre, the nose lying against the triangular ligament and waiting to enter the membranous urethra. If he is in any doubt as to its having reached this portion, the left hand may be allowed to relinquish its hold on the penis and may be placed in the perineum, where it will easily determine the correctness or otherwise of the position. If the instrument is not sufficiently close to the compressor urethræ, there will be a danger that in the next movement the beak may hitch on the symphysis pubis and bruising of the upper wall of the urethra may result when the ocular is depressed.

During the next stage (*Fig.* 48) the ocular is brought down by a

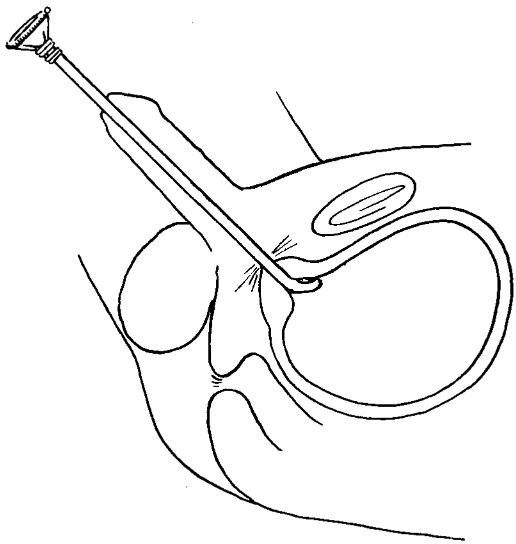
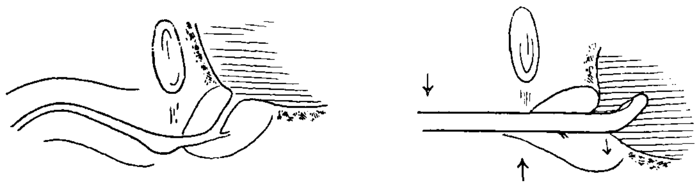


Fig. 48.—Introduction of the cystoscope: ocular end depressed between the thighs of the patient; the beak entering bladder.

circular sweeping motion until it comes to lie between the thighs of the patient. As it does so the beak slips through the pursed-up aperture in the compressor urethræ and passes along the prostatic urethra into the bladder. As the beak enters the prostatic urethra it lies approximately in the line of this portion of the passage, but when the shaft follows a tilting back or retroversion of the gland occurs through the channel being straightened out (*Fig.* 49 *a* and *b*). The gland constantly tends to return to its normal position, so that it will easily be understood that there will be two points of pressure in this section of the urethra, situated respectively on the postero-superior and antero-inferior region of the prostatic urethra. These two points, together with the orifice in the triangular ligament and the suspensory ligament of the penis, are the sites of tension in the male urethra during cystoscopy. In enlargement of the prostate gland there is usually an alteration in the line of this section, such that the angle made with the rest of the canal is increased. When therefore the

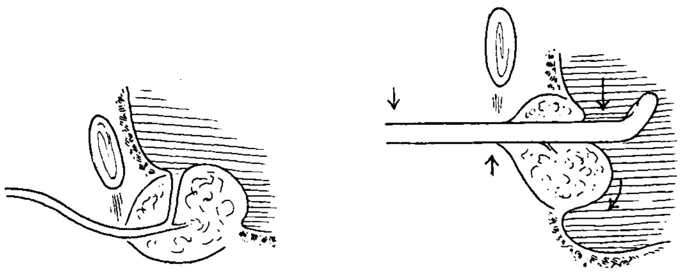


a b

Fig. 49.—*a*, Normal male urethra prior to introduction of cystoscope. *b*, The same after introduction of cystoscope. Note the straightening out of the canal. To permit this the prostate is retroverted—anterior end slightly elevated, posterior portion considerably thrown back.

cystoscope is introduced in prostatic hypertrophy there will be a very considerable amount of retroversion of the prostatic gland (*Fig.* 50 *a* and *b*).

Failure to pass the instrument may result from its becoming caught on the symphysis pubis, when a return to the first position will be necessary so that the beak may be passed further down into the



a b

Fig. 50.—*a*, Male urethra in prostatic hypertrophy. Note increase in the curve of the prostatic urethra as compared with the normal (*Fig.* 49*a*). *b*, The same after introduction of cystoscope. Marked retroversion of prostate causing exaggeration of the retroprostatic pouch.

bulbous urethra. Again, it may have caught in the dilated cul-de-sac of the bulb, when one or two lateral movements will generally release it. Obstruction may also be due to the ocular extremity not having been sufficiently depressed between the thighs of the patient, in which case, if the cause is recognized, the remedy is easy.

Pathological conditions giving rise to trouble are stricture of the urethra and prostatic hypertrophy. The former will be recognized when skilfully applied movements remain unsuccessful. Many surgeons explore the urethra a day or two prior to the cystoscopy in order to exclude this possibility, but, as has previously been stated, the present writer considers this to be undesirable. The presence of a stricture should, however, be confirmed by the use of bougies. The aero-urethroscope should never be employed immediately following a failure at cystoscopy, as bruising of the mucosa may be present and fatal air-embolism result from air-distension.

Difficulty arising from prostatic hypertrophy can usually be overcome by further depressing the ocular, and by elevating the vesical end with a finger on the perineum or in the rectum, so that the beak hugs the upper urethral wall closely. Experience shows that the postero-inferior wall is very susceptible to trauma in this condition and that hæmorrhage may be excited by insignificant injury, whilst the converse is true of the upper wall. In introducing the instrument, therefore, the beak should be made to hug the antero-superior wall by the means above described.

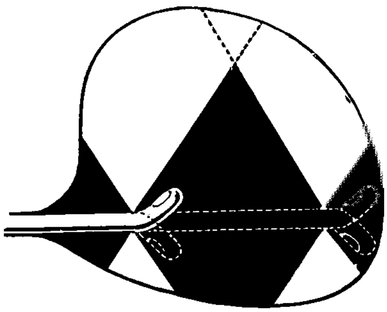


Fig. 51.—Cystoscope in the primary position. Note the distances from base and vault respectively. The movements of introduction and withdrawal are also shown.

As soon as the instrument has entered the bladder it slips along more easily, so that the cystoscopist is aware of its having reached its destination. It can now be rotated freely round its own axis owing to the elbowed end having escaped from the confines of the urethra into the more generous spaces of the bladder. As it slides into this viscus the cystoscope occupies a similar position relative to the bladder cavity in both the male and female. In the female it lies in a direct line with the undistorted urethra. In the male it takes up a position which is the resultant of the pressures exerted upon it by the straightened-out curves of the urethra. The fixed points of the urethra virilis correspond, as previously stated, to the suspensory ligament of the penis, the orifice in the triangular ligament, and the retroverted prostate. These points tend to hold the instrument in a fixed position, which in the future will be referred to as the *primary* position of the cystoscope. It is represented in ***Fig.* 51** and should be noted with care, for it is from this starting-point that the operator initiates his investigations. Note that the instrument, where it rests in the meatus, lies close to the floor of the bladder, and that there is a gradual declination of the bladder base as it is traced posteriorly. At no point, however, does it lie more than $\frac{1}{2}$ in. to 1 in. away from the line occupied by the cystoscope when in this primary position. Note by contrast the relationship of the other walls of the viscus. In front it will be observed that the anterior wall rises steeply from the meatus, and that its more distant portion, together with the rest of the vesical dome, is much removed from the fenestra of the instrument when held in this line. The importance of these facts will become evident when the method of examination of the bladder is described.

THE EXAMINATION OF THE BLADDER.

The cystoscope is now in place and the fenestra and lamp are facing upwards as indicated to the operator by the position of the knob on the ocular end of the instrument. The operator seats himself opposite the end of the cystoscope, and the chair is placed close to the patient so that the examination can be conducted in comfort. The electric coupler is attached and the light switched on.

The student should accustom himself to holding the cystoscope correctly; it is steadied by means of the electric coupler held in the left hand in a dependent position. All the rotary movements of the cystoscope are performed by the right hand, the instrument revolving around its attachment to the coupler. A finger of this hand constantly strays towards the knob or indicator at the ocular end, and by its means the operator is kept informed as to the direction in which the fenestra is looking.

There are three chief movements which can be imparted to the cystoscope, and it is by combinations of these that all the various segments of the viscus can be successively scrutinized; they are: (1) *Movements of introduction and withdrawal, propulsion and retropulsion*; (2) *Rotation*; (3) *Pendulum or see-saw movements.*

1. Introduction and Withdrawal (*Fig.* 51).—The cystoscope moves in the line of its own long axis. In extreme withdrawal or retropulsion the fenestra lies just on the margin of the internal meatus. In extreme propulsion the beak is in contact with the posterior wall of the bladder. By these movements any single strip of the bladder mucosa lying in the sagittal plane may be surveyed—the strip lying on the inferior, superior, or lateral wall, according to the position of the fenestra.

2. Rotation (*Fig.* 52).—In the movement of rotation the cystoscope revolves around its long axis. When it occupies the primary position, circular bands of the mucosa can thus be inspected. It should be noted, however, that in this primary cystoscopic position the bands vary in character in different parts of the organ, for in the inferior part, to which the instrument lies fairly adjacent, the band will be narrow, brightly illuminated, and the image clear and highly magnified; whereas on the upper parts, from which it is far away, the band will be broad, badly illuminated, and the image indistinct and little or not at all magnified, or in exceptional circumstances even diminished. It will therefore be impossible adequately to examine these latter areas with the cystoscope in the primary position, and secondary movements must be undertaken to bring them into view. These are known as :—

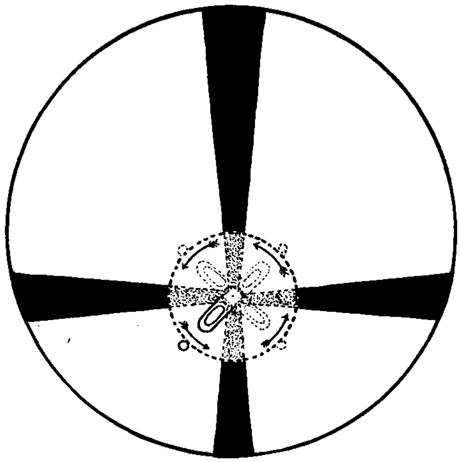


Fig. 52.—Movements of rotation of the cystoscope on its long axis. The shaft of the instrument occupies the primary position and is therefore excentrally placed as regards the bladder.

3. Pendulum or See-saw Movements (*Fig.* 53).—By these the instrument rocks around the neighbourhood of the neck of the bladder as a fixed point or pivot, so that when the ocular is carried in one direction the beak approaches the opposite bladder wall. Thus if the ocular is depressed, the beak is elevated; if carried towards the left thigh, the beak approaches the right side of the bladder. In all these pendulum movements the degree of motion which it is necessary to impart to the ocular in order to get a given range of movement by the objective will depend on the point at which the shaft of the cystoscope rests in the bladder neck—that is, the relative amounts of the intra-vesical to the extra-vesical portions of the instrument. The distance from the ocular to the objective is usually about 12 in.; if therefore the shaft could

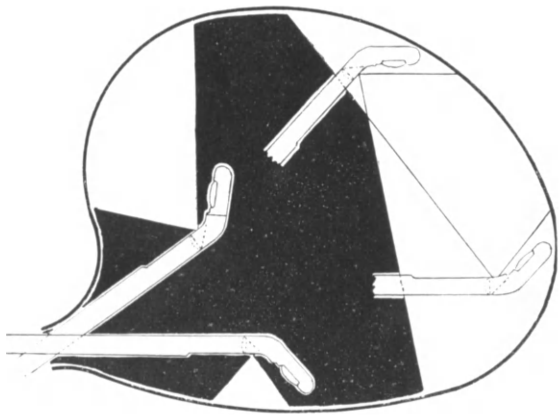


Fig. 53.—Showing rocking movements of the cystoscope, and also methods of examining the fundus of the bladder.

be gripped at a point midway between the two lenses, a given movement of the ocular would determine an exactly similar range of movement for the objective, but in the opposite direction. If it is held at a point 1 in. from the objective, an 11 in. range of movement will have to be imparted to the ocular to gain a 1 in. movement of the fenestra. This must be borne in mind when examining the various parts of the organ; if the fundus is being inspected, upwards of 4 in. of shaft lie in the bladder cavity. If, on the other hand, the neck is being examined, less than $\frac{1}{2}$ in. may lie within the viscus. It is obvious that if a given excursion—say, $\frac{1}{2}$ in. —is required in the former case, a much smaller sweep will have to be performed by the ocular than if a similar degree of excursion were desired in the latter.

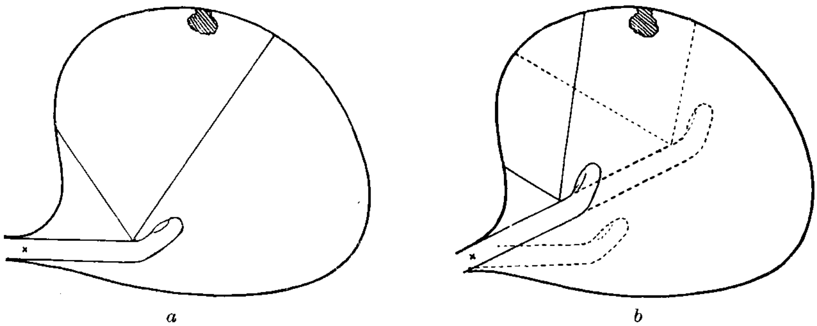


Fig. 54.—*a*, An object seen in the distance through the cystoscope; *b*, Rocking movements of the cystoscope throw it out of the field of view. To recover it the instrument must be pushed farther into the bladder.

The advantages which accrue from rocking movements are the result of the greater approximation of: (*a*) The light, whereby the intensity of illumination is enhanced; and (*b*) The fenestra, whereby magnification is increased. As a general rule these movements have to be associated with that of propulsion. ***Fig.*** 54 illustrates the reason for this. It will be seen that an object which has been observed from a distance and which it is desired to inspect more closely is thrown out of the field by a simple pendulum movement, and that the instrument must in addition be pushed farther into the bladder in order to bring it into the field again (propulsion).

Reasons for Seeing Nothing in the Bladder.—It happens sometimes that when the eye is applied to the ocular no field of view is discernible. This may be due to some defect in the lighting which has taken place in the short time which has elapsed since the cystoscope was examined. A quick inspection of the various connections should be made to ascertain that the contacts are good, but the instrument should not be hastily withdrawn from the bladder to make sure that the lamp is still burning.

Fig. 55 illustrates several circumstances capable of accounting for a darkened field. The fact that the prism is still in the urethra may be the cause (*Fig.* 55*a*). Conversely the beak of the cystoscope may be sunk in the posterior wall of the bladder and its light will be shaded thereby (*Fig.* 55*b*). In the same way it may be embedded in a neoplasm (*Fig.* 55*c*) or be in too close contact with a stone (*Fig.* 55*d*). Sometimes the vesical cavity is misshapen, usually as the

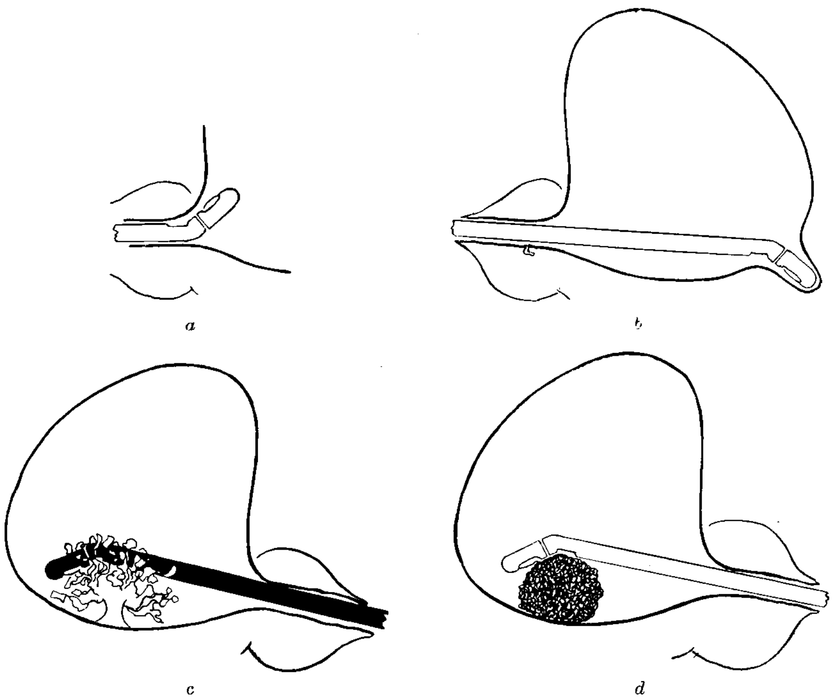


Fig. 55.—Four reasons for seeing nothing in the bladder: *a*, Window still in the urethra; *b*, Beak of cystoscope sunk in posterior wall of bladder; *c*, Beak of cystoscope embedded in neoplasm; *d*, Prism and lamp in close contact with a stone. Fields of illumination and of view do not correspond.

result of extrinsic causes. Prominent amongst these may be mentioned the mechanical results of change in the shape or position of the uterus (Chapter XVIII). Thus the posterior wall may be bulged in by the gravid or fibromatous organ, and the cavity may at some points be obliterated by its anterior and posterior walls coming into contact, whilst the bladder's position and shape may be greatly altered by uterine prolapse. Tumours arising in organs other than the uterus—

for instance, an ovarian cyst or a large vesical diverticulum—may similarly distort the bladder and impose obstacles to orientation.

When this type of difficulty arises the surgeon, unaware of the exact cause of his trouble, should attempt to discover some point in the viscus which is illuminated, however indistinctly. From this partially lit base he should move warily. If the darkness returns, he will retrace his steps and make a fresh start in a new direction. Movements of rotation, withdrawal, etc., will be alternately tried. Eventually a satisfactory field will probably be discovered, and from this he will get his bearings and be able to trace some considerable extent of the bladder. He will ultimately return to investigate the object of his original trouble. If, after a fair trial, no illumination can be made out in the bladder, the cystoscope will be withdrawn to make certain that the fault does not lie with it.

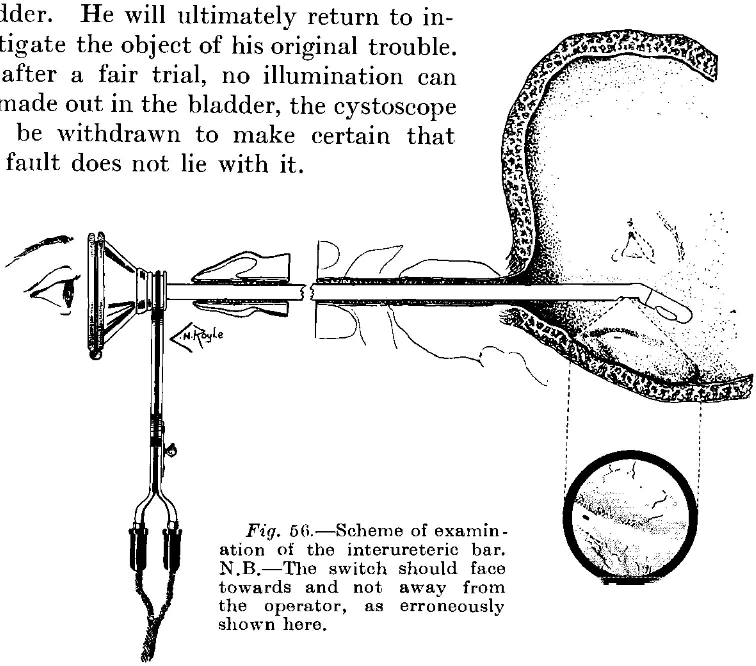


Fig. 56.—Scheme of examination of the interureteric bar. N.B.—The switch should face towards and not away from the operator, as erroneously shown here.

Orientation of the Bladder.—Most urologists commence the examination of the bladder at its uppermost point. It has already been shown that the objective lies a considerable distance away from this point when the cystoscope is held in the *primary* position, the result being that illumination is poor and magnification defective. This is, in fact, one of the more difficult areas to examine, and in order to see it efficiently wide excursions of the instrument must be resorted to. It is recommended, therefore, that the cystoscope be turned over and that the inferior wall, from which it is distant only about ½ to 1 in., be examined in the first place (*Fig.* 56). The illumination and magnification will there be found good without any pendulum movements of the instrument, so that the examination can be easily and rapidly commenced. The cystoscopist obtains his bearings immediately and finds a point from which he can trace the remaining walls of the viscus.

By adopting this order the most interesting and important parts of the organ are inspected in the first instance. A large majority of bladder lesions are situated here, and it is often advantageous to examine it first, as thereby one obtains an early indication of any pathological condition which is present. Particularly is it important in the case of a restless patient, or one with an irritable bladder, when speed may be essential, for if time is unnecessarily lost in examining the less important regions, the viscus may empty itself involuntarily before the diagnosis is complete. Similarly, in dealing with those conditions in which the medium quickly becomes clouded with blood or pus it is advisable to commence in this vital area. The only danger of the method is that the remainder of the bladder may be neglected, the finding of a lesion in the lower part so occupying the mind of the investigator that the possibility of another lesion situated in the upper segment is forgotten.

The indicator of the cystoscope is therefore rotated until it lies midway between the vertical and horizontal, and an area of the bladder wall comes into view which is, as a rule, in the neighbourhood of, or just posterior to, one of the ureteric orifices. This point is examined and the instrument is made to rotate slowly on its long axis, the indicator moving in a pendulum fashion to a corresponding point on the opposite side, each area of the mucous membrane meanwhile being carefully scrutinized as the fenestra moves across. The strip thus examined is the retrotrigonal portion of the bladder, or 'bas fond'. The cystoscope is now slightly withdrawn in the direction of the operator, and a second strip lying just anterior to the previous one is examined. As it passes across the base of the viscus this time the interureteric bar and the two ureters, together with the portions of the wall lying immediately external to these structures, will be seen. When they have been examined successive bands lying closer to the meatus are similarly examined, the cystoscope being withdrawn a distance of about $\frac{3}{4}$ in. for each strip. Finally, an area of the bladder lying just within the meatus and corresponding to the most anterior portion of the trigone is inspected.

Examination of the Internal Meatus.—If the instrument is now withdrawn another short distance, the fenestra will come to lie actually within the meatus, and the field will become darkened as the result of its being covered by the mucosa of the urethra. A small amount of manœuvring will bring it into such a position that the anterior half lies within the urethra and the posterior half lies in the bladder cavity (*Fig.* 57). When this is done a translucent line will be seen to pass across the field of vision (*Plate I* C, page 68). Behind it the field is illuminated, whilst in front of it, it is dark. This translucent line represents the internal meatus, and the shape of the whole orifice is readily appreciated if the cystoscope is rotated so that the margin is successively examined in its whole circumference. In the normal state it shows itself as a concave shadow (*Fig.* 58), perfectly regular in the upper four-fifths of the circumference, but slightly flattened, or even convex, in the lowest fifth, where it is in relation to the trigone. Any alteration in the shape of this line would indicate an abnormality, except that, in the case of

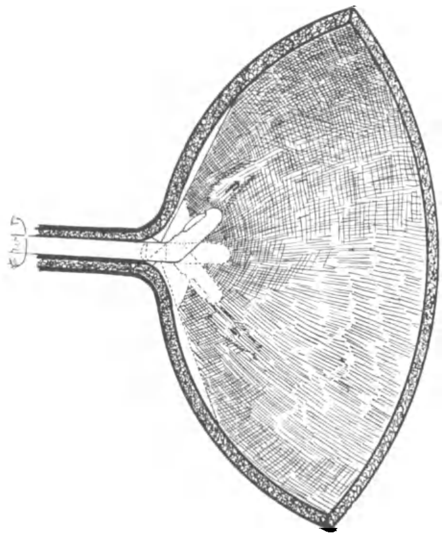


Fig. 57.—Method of inspecting the bladder neck. Note that the vesical orifice and portions of the bladder mucosa in the region of the neck are contained in the same cystoscopic field, and that they vary considerably in the distance to which they are removed from the fenestra and therefore in the quality of their illumination and magnification.

the female, folds or rugæ may quite commonly be seen apart from any pathological condition (*Plate I* D). The commonest morbid variation seen is in hypertrophy of the prostate, when one or more lobes of that organ obtrude themselves upon the bladder cavity, and show a convex in place of a concave margin (*Plate XII* A and B, page 244). Occasionally also some inflammatory process involves the sphincter of the bladder and causes irregularity there. Alterations of the shape of the sphincter are appreciated by the cystoscope only when they affect it in the sagittal plane of the body (*Fig.* 59). Those which lie in the transverse body plane—that is, which bulge towards the urethra—cannot be perceived by this instrument, as their only effect is one of magnification. They require a posterior urethroscope for their demonstration (***Fig.*** **60**).

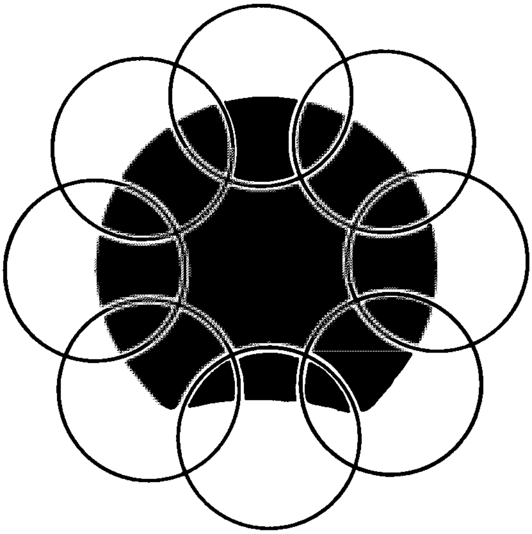


Fig. 58.—Series of cystoscopic fields collectively showing the contour of the internal meatus as the instrument is rotated on its long axis. The orifice is circular save at the lowest point, where it is flattened or slightly convex.

Examination of the Bladder Walls.—Having now examined the sphincter, we pass to the anterior, upper, lateral, and posterior walls. The best way is to start with the anterior portion and to examine

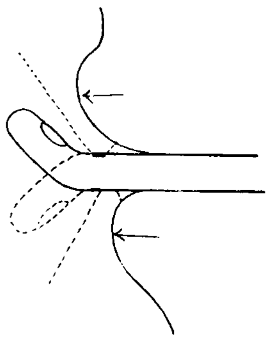


Fig. 59.—Cystoscope examining prostatic hypertrophy appreciates increase of the gland occurring in the sagittal body plane.

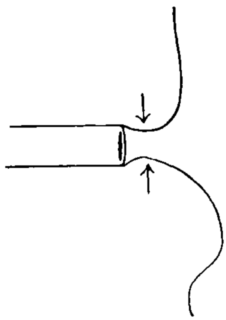


Fig. 60. —Urethroscope examining prostatic hypertrophy appreciates increase of the gland occuring in the transverse body plane (cf. *Fig.* 157, page 248.)

consecutive transverse bands from before backwards, pretty much in the same way as strips of the base of the bladder were examined in the first instance. Each successive rotation of the cystoscope, which must now be combined with rocking movements, will be made to take in an area of the bladder wall extending down the lateral walls so as to overlap those portions of the base which were first examined. To examine the anterior wall closely, it will be necessary to depress the ocular deeply between the thighs of the patient so that the fenestra may be brought into comparatively close apposition with this wall of the bladder, which ascends steeply into the retropubic region (*see Fig.* 53). This is perhaps the most difficult area to bring into view, and indeed it is occasionally impossible to do so successfully. When examining the upper wall the cystoscope must again be deeply depressed, though not to such an extent as in the case of the anterior wall, whilst for purposes of examining the lateral walls the ocular must be carried over towards the opposite thigh of the patient. These manœuvres will bring into view successively every portion of the viscus, with the exception perhaps of a small area high up on the fundus, which can be inspected in the two alternative methods depicted in *Fig.* 53.

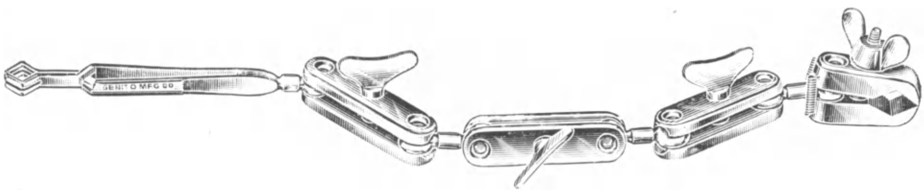


Fig. 61.—Cystoscope holder. Useful for steadying the instrument when intravesical conditions are being demonstrated or are under prolonged inspection, as when being drawn.

The whole of the bladder has now been brought under observation, and if any lesion has been found, the cystoscopist may repair to that lesion and review it in detail. A cystoscope holder (*Fig.* 61) may be used for steadying the instrument during the prolonged inspection of some special part of the bladder. If no lesion has been found in the bladder, it is probable the surgeon will desire to examine the ureteric orifices more closely in order to obtain any evidence they may offer as to the condition of the kidney (*see* Chapter XXI).

Variations in the Shape of the Bladder due to Different Degrees of Distension.—The shape of the bladder is governed by its distension (*Fig.* 62). When filled it is an irregularly rounded viscus, but as evacuation proceeds the roof sinks down to meet the base, leaving long anterior and posterior limbs in which the mucous membrane of the vault has come into contact with that of the section lying opposite to it. The roof as seen from outside becomes flattened or even concave. The changes produced in the interior of the organ will be easily realized from examination of *Fig.* 62. The bladder occasionally discharges itself during cystoscopy. As it does so, one of the alterations first remarked by the operator is the diminution of space between the roof and the base. This is most evident in the neighbourhood of the fundus and at the junction of the anterior and superior walls of the viscus. Eventually transverse sulci form in these situations. The

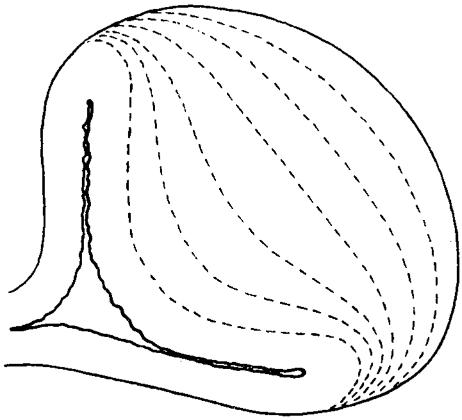


Fig. 62.—Shape of the bladder as altered by various degrees of distension. (*Modified from Poirier and Charpy.*)

portion of the cavity overlying the trigone and ureteric orifices is the last to be obliterated. As the organ becomes emptier its mucosa becomes more wrinkled in order that it may be accommodated in the diminished space. If *Fig.* 62 is compared with *Fig.* 65, page 88, the important differences between the physiological and pathological methods of producing reduction in the size of the bladder cavity will become evident.

CHAPTER IV.

THE NORMAL BLADDER.

THE MUCOSA.

THE normal vesical mucosa is a bright, even, and clean-looking membrane (*Plate I* A). Its surface in health is devoid of obvious secretion, is smooth in texture, and reflects light well. A dull, granular, or non-reflecting surface, or the presence of secretion is evidence of pathological change.

Colour.—The colour of the membrane is sandy-yellow, but when the illumination is poor it may look brownish. Here and there, where

PLATE I.

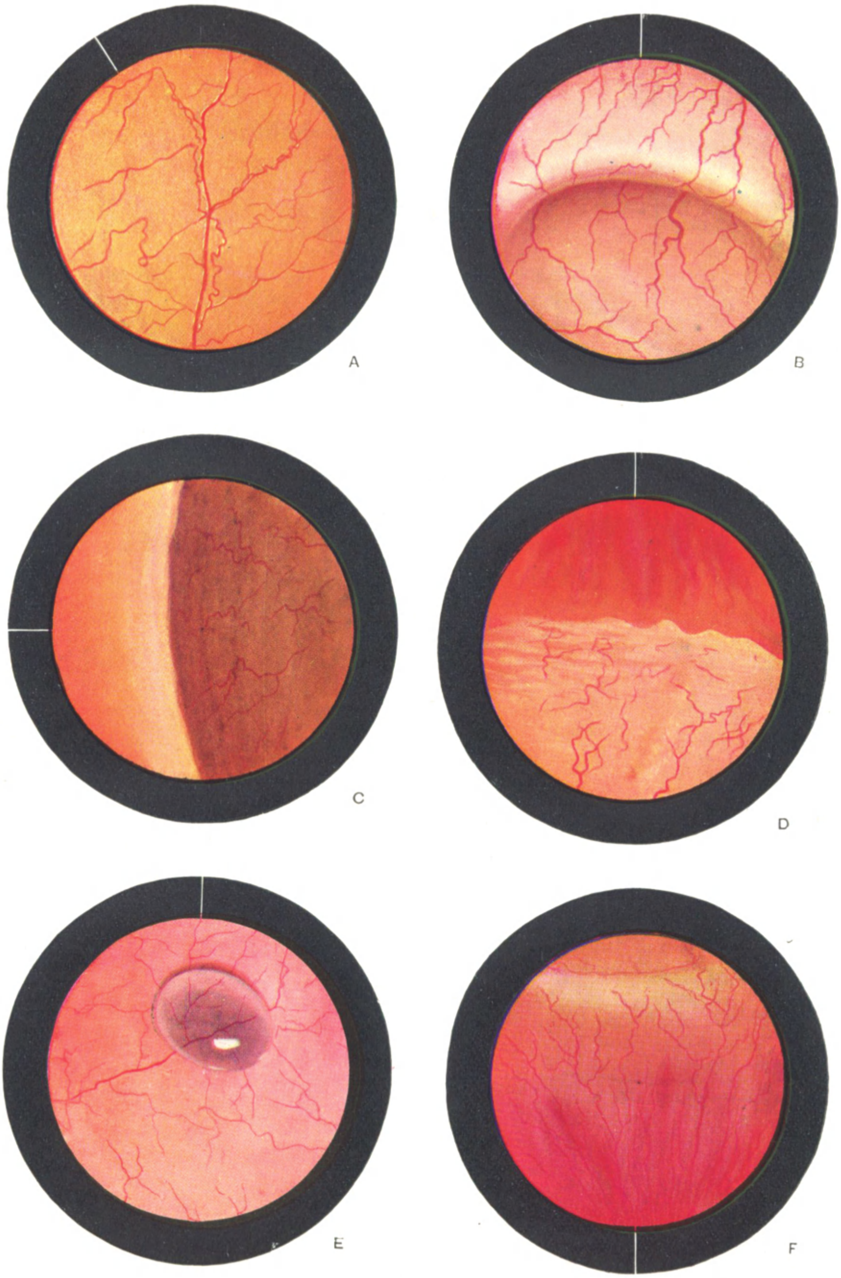
A, Normal bladder. Note main arterial stem accompanied by corkscrew-like satellite vessel, also the reflection of light from the prominent margin of the vessels. B. Deep recess at the site of the urachus. C, Neck of normal bladder in the male (right side under examination, margin regular and even). D, Neck of normal bladder in the female (antero-superior area being examined). In C the bladder neck is illuminated and the interior of the viscus is in shade. In D this is reversed. The appearance is due to the relationship of the lamp and not to any difference between the sexes. E, The air bubble. F, The trigone. Note the deep coloration and the high vascularity. The interureteric bar is seen crossing the upper third of the picture.

it is specially vascular, it is flecked with pink, and in the shaded areas may develop a purplish tinge. The coloration varies slightly in different individuals and in different parts of the same viscus, pigment being specially developed near the outlet. The brightness with which the cystoscope lamp is burning affects the vesical colour tone—a statement which can easily be confirmed by varying the position of the control on the rheostat. The coloration provided by the modern filament lamp is paler and brighter than that of its predecessor, the carbon filament. The medium selected by the operator also influences the colour, thus with oxycyanide of mercury it appears yellower than when plain water or boracic is employed; but—more important than this—a small amount of blood in the vesical fluid will give a red tinge to the viscus which may be misinterpreted by the uninitiated as an inflammatory manifestation.

Blood-vessels.—At varying intervals blood-vessels, particularly arteries, appear irregularly and radiate close beneath the mucosa, where they may be clearly seen. In most fields one or more of these

PLATE I.

THE NORMAL BLADDER



parent stems are to be observed running for longer or shorter distances. Frequently a vessel will pass through several cystoscopic fields before breaking up into a number of delicate arterioles. The main stems may run a fairly straight or a wavy course. Careful inspection will show that some of them are closely accompanied by a vessel of lesser calibre, which twines about them with an irregular corkscrew-like course, and is first seen on one side and then on the other (*Plate I* A). The main vessels or their terminals may pass over or under neighbouring arterioles, and anastomoses between the terminals of the various systems occur.

The vascularity of different sections of the bladder varies considerably, the trigone being the most, and the lateral walls and apex the least, vascular. In the neighbourhood of the ureters one or two important stems may generally be observed which appear actually to emerge from the orifice. Veins are also to be seen, but are less numerous, more deeply placed, and larger than the arteries. Through the mucosa they look to be of a greyish-blue colour, and they may run a slightly tortuous course.

THE BLADDER MUSCULATURE.

Beneath the membrane appear strands of the inner muscular coat of the bladder. In ordinary circumstances they are few in number, but they elevate the mucous membrane in little ridges, with edges which are clean-cut, fairly sharp, and often sickle-shaped. They cast a shadow on the neighbouring mucosa. They are better developed in old age than in youth and are least obvious in childhood. If the bladder is over-distended, and especially if the patient is straining to urinate, they become more numerous and more evident. They may also be seen when a bladder is under-distended, particularly in the female. A distinction must be made between this normal trabeculation and that of vesical hypertrophy as seen in cases of stricture, prostatic hypertrophy, and in certain nervous lesions. These conditions will be described in Chapter IX.

THE TRIGONE.

The lowest and most anterior portion of the bladder presents an area differing widely in structure and appearance from what we have described above. It is known as the 'trigone' (*Plate I* F). The three orifices of the bladder constitute its angles, and it forms an equilateral triangle of which the internal meatus may be conveniently considered as the apex, whilst the two ureteric orifices lie at each end of the base. Each side of this triangle is about 1½ in. long, and is formed by a muscular band. The band constituting the base is known as the 'interureteric bar', 'torus uretericus', or sometimes as the 'bar of Mercier'. The bars which pass from the ureter to the internal meatus are known as the ureteric bars. They were first described by Sir Charles Bell and are known by his name. The bars of Bell are better marked than is that of Mercier. Under cystoscopic examination they appear to run in the line of the ureter and towards the cystoscopist, being in fact a continuation of the fibres of the ureter which are receiving insertion into the bladder and urethra. Though they vary considerably in development, they are, as a rule, easily recognized during cystoscopy. In this they contrast with the interureteric bar, which is feebly developed in about 30 per cent of cases and frequently cannot be recognized as an elevation.

The shape of the trigone is not constant. In some cases its sides are straight, in others they are concave inwards, the trigone then presenting a Y-shaped appearance. Generally the various sides are equal in length, and the ureters are placed at equal distances from the internal meatus, and are also equidistant from the mid-line of the bladder. Occasionally, however, this is not so, one side of the trigone being more developed than the other, so that the ureter is displaced.

The mucosa which covers this region is smooth in texture and never exhibits the trabeculation which is seen in other portions of the bladder. It is highly vascular, the vessels lying immediately underneath the mucous membrane and radiating in a fan-shaped manner from the internal meatus towards the ureters and the interureteric bar. As they approach these structures they diminish rapidly in number and finally vanish into the normal structure of the bladder mucosa. Both arteries and veins are present and can to some extent be distinguished. Occasionally the veins are tortuous and prominent.

The cystoscopic appearance of the trigone is a stumbling-block to the inexperienced, who at first mistake its high vascularity for inflammatory hyperæmia; but considerable care must *always* be exercised in interpreting appearances in this region. A reference to *Fig.* 63 will show that the beak of the cystoscope in examining the extreme anterior part of the trigone lies very close to the mucous membrane; this produces high magnification of the structures (*see* page 16), so that even the smallest irregularity will become greatly exaggerated and simulate a pathological lesion. By depressing the ocular steeply between the thighs of the patient, the fenestra may be carried away from the mucous membrane to some extent, and will then give a truer picture of the condition. When the cystoscope is held close to the mucosa not only will the magnification be high but the rays of light which reach it from the lamp will approach the surface obliquely

(*Fig.* 63), with the result that a sheeny or translucent appearance is imparted to the membrane.

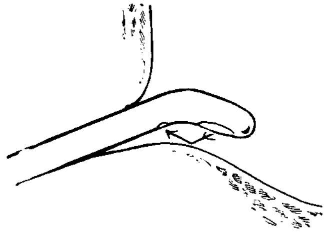


Fig. 63.—Examination of the most anterior area of the trigone. Note approximation of fenestra to object, which produces a high degree of magnification ; also the oblique way in which the light is reflected from the membrane to the prism, often resulting in a sheeny appearance. Cystoscope tilted to obtain distance between the mucosa and fenestra.

NOMENCLATURE OF OTHER PORTIONS OF THE BLADDER.

The nomenclature adopted for the bladder by cystoscopists is slightly different from that employed by anatomists. An interior view of the organ is shown in *Fig.* 64.

Retrotrigonal Recess or Bas Fond.—Immediately behind the trigone is a recess or hollow of somewhat variable development. It is bounded in front by the interureteric bar—posterior limit of the trigone—and

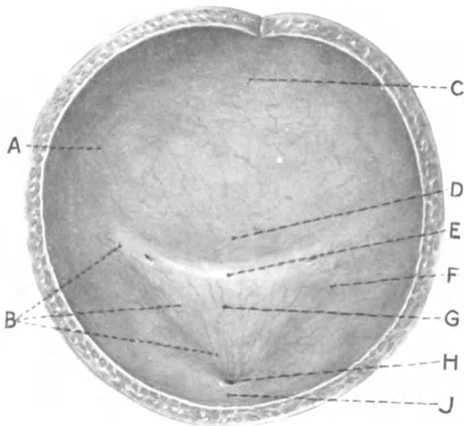


Fig. 64.—Interior of bladder. A, Lateral wall ; B, Ureteric bar ; C, Fundus ; D, Retrotrigonal recess or bas fond ; E, Interureteric bar ; F, Lateral recess ; G, Trigone ; H, Internal meatus ; J, Anterior wall.

externally by the most posterior portion of the ureteric bar. In a backward direction this area merges insensibly into the posterior wall of the viscus, which is known as the *fundus* of the bladder.

External to the ureteric bars are recesses lying between those structures and the side wall of the bladder, which will be referred to in this book as the *lateral recesses* of the bladder. They are better developed in the female than in the male, probably owing to the different support afforded by the underlying structures in the two sexes. In the female the rounded anterior surface of the uterus elevates the central portion of the bladder but leaves the lateral area unsupported, whilst in the male the vesical floor is in relation to the prostate and seminal vesicles and is more evenly sustained by them.

The depth of both the 'bas fond' and the lateral recesses depends partly on the elevation of the trigone and the development of the ureteric and interureteric bars, which varies considerably. They are also better marked when the bladder is well filled.

URETERIC ORIFICES.

The ureteric orifices lie at the angles of the trigone and are mounted on the elevation where the ureteric and interureteric bars meet. Ability to recognize them is indispensable ; they are, in fact, the most important points of repair in bladder examination. Their appearance gives information about the condition of the corresponding kidney or ureter, pathological changes showing themselves in many ways, such as excessive activity, hyperæmia, œdema, ulceration, malformation, emission of blood or pus, and the like.

PLATE II.

A, Both ureters, left side very small. B, Efflux seen from in front. C, Efflux seen from side. Orifice erect. D, Small orifice obscured by numerous blood-vessels. E, Unusual but normal orifice at rest. F, Same orifice in efflux. Retraction marked.

The Appearance of the Normal Ureter.—This varies considerably, and several types could be portrayed. A representative one will be described, and then the variations from this outlined.

The ureter passes through the vesical muscle and mucous membrane obliquely, and the most usual cystoscopic appearance is that of a sloping, tunnel-shaped orifice leading upwards and outwards through the mucosa (*Plate II* A and C), the anterior wall being deficient for a greater distance than the lateral ones, which rapidly shelve down to become confluent with the surrounding bladder base. Frequently a number of blood-vessels ramify in its vicinity, some stout twigs actually emerging from the ureteric orifice, whilst others correspond to the ordinary vascular ramifications of the bladder wall. In general the coloration of the meatal lips is sandy and similar to that of the rest of the bladder wall, but frequently, without any departure from the normal, there is a delicate purplish coloration due to more generous capillary development. This often goes hand in hand with a semi-transparent, pellucid appearance of the lips.

Any one of the characteristics of the normal orifice may fail, or be over-developed without pathological significance—thus :—

PLATE II.

THE NORMAL URETER

Size.—The size is quite variable, punctiform orifices often being seen, as are also orifices of abundant dimensions.

Position.—The orifice is generally on the front surface of the muscular eminence, but it may frequently be seen on the outer lateral aspect. As before mentioned, it may open on the ureteric bar at a point nearer to the internal meatus than is customary. More extreme variations, such as its opening in the centre of the trigone or in the urethra, are to be regarded as congenital malformations.

The Eminence.—This is frequently under-developed, when the ureter opens on a flat surface. The converse also occurs, when it emerges on the summit of an exaggerated elevation.

Shape.—Variation in the shape of the meatus depends on the degree of development of the lateral folds or lips. When these are attenuated, a wide-mouthed, patulous, horseshoe-shaped opening results; when, on the other hand, they are of generous proportions, and especially if confluent below, the orifice is slit-like, or shuttle-shaped, the lips being so well evolved that the opening is encroached upon.

Vascularity.—The depths of the orifice reflect a warm purplish glow, due to its vascularity, and in some instances, where the lips are ill-marked, this may be the sole evidence of the presence of the ureteric orifice. To the experienced eye it is evident because it lies in the correct position and direction. It may be mistaken for a blood-vessel, but its length, purplish hue, absence of branches, together with the fact that it is somewhat shuttle-shaped, and that its edges are not clearly defined, but fade gradually into the surrounding mucosa, serve to distinguish it. When lying in a vascular area, however, it may be difficult to detect (*Plate II* D).

Each of these variations is quite common and they can be seen in all possible combinations. Further particularization is unnecessary; the important thing is that they shall be recognized as types of the normal and not accounted as pathological.

The *efflux of urine* from the orifice confirms the belief that a structure which has been under observation is, in fact, the ureter. When it is about to eject a quantity of urine into the bladder, it gathers itself together with a slow vermicular movement, its lips become rigid and erect, and the orifice closes slightly for a time. It then somewhat rapidly relaxes, a jet of fluid is shot into the bladder cavity, and the ureteric region reverts to its previous resting condition. The novice often experiences difficulty in discerning the swirl of the efflux. It has been likened to the appearance seen in water when a drop of glycerin is placed in it. A representation of the act is shown in *Plate II* B, C, and F.

The *distance between the two ureters* is $1\frac{1}{2}$ in. in actual measurement. This diminishes slightly as the bladder is emptied, though the trigone takes a minor share in contraction. When the bladder is distended and the surgeon is examining this area the cystoscopic magnification will give him the impression that the distance between the ureters is greater than it actually is; they will, in fact, probably appear to be separated by about $2\frac{1}{2}$ to 3 in. If, therefore, one ureter has been found, the second ureter can usually be discovered by rotating the cystoscope over an interval of bladder wall which appears to be about $2\frac{1}{2}$ or 3 in. in extent. In some cases both ureters are inserted nearer to the meatus than normal, in which event they should lie at a point nearer to each other, and thus maintain the equilaterality of the triangle.

Finding the Ureter.—It is necessary to be able to hunt intelligently for the ureter and to recognize it when seen. This latter is not always easy, but becomes easier as experience is gained. It should always be possible to find the ureter in a healthy bladder, but diseased organs will present themselves in which it seems quite impossible to discover the orifice. It may be lost in excessive vascularity or ulceration, or hidden by neighbouring recesses or diverticula. It may be covered by blood or pus, stone or growth. If one ureter can be found, it is generally possible to discover the other by the method above described—that is, by rotating the cystoscope on its long axis through a number of degrees corresponding to a distance of about $2\frac{1}{2}$ in., whilst avoiding any movement of propulsion or retropulsion.

The order of procedure which was recommended above for investigation and orientation of the bladder should discover the ureters early in the operation. If they are not quickly seen, the cystoscope may be withdrawn almost to the internal meatus and then pushed back into the bladder along the line of one ureteric bar, examining closely all the way for pits and depressions which may prove to be the object of the search. The orifice should be situated where the ureteric and interureteric bars meet. If therefore the latter can be identified, it should, when followed to its extremities, lead to the position of the meatus. If after a search the ureter still remains unrecognized, recourse may be had to indigo-carmine injected intravenously. A portion of this is excreted by the kidney (*see* page 375), and on reaching the bladder can be recognized as a blue jet (*see Plate XIV* D, page 328). Its site of emergence will indicate the position of the ureteric opening. Indigo-carmine should not be used until the bladder examination is otherwise complete, as the dye, if copiously excreted, will quickly render the vesical contents opaque.

Internal Meatus.—A description of the cystoscopic appearances of this structure is given on page 64.

MOVEMENTS OF THE BLADDER WALL.

Movements of the bladder wall are frequently observed during cystoscopy and result from varied intrinsic and extrinsic causes.

Intrinsic Causes.—The most commonly observed intravesical movement of all is that seen at the ureteric orifices during the efflux of urine as above described. Contractions of the bladder musculature have already been noted, and are chiefly seen when the patient is conscious of an impulse to urinate.

Extrinsic Causes.—Intestinal peristalsis has occasionally been detected through the vesical wall, precisely as it may be through thin abdominal parietes. Pulsation from the great vessels may be observed in thin and nervous females, and in cases of arteriosclerosis and aneurysm. It may also be seen in tumours of the bladder, uterus, or other pelvic organ. Under ether anæsthesia vascular throbbing is occasionally noticeable, as may also be the transmitted effects of the wide diaphragmatic excursions to which this anæsthetic gives rise.

THE AIR BUBBLE.

At the highest point of the bladder there is always a greater or less collection of air (*Plate I* E, page 68) which has been driven into the bladder from the catheter during preparation. It forms a beautiful object, reflecting the rays of the lamp and trembling delicately with every motion of the contained fluid. It may be round or oval, is generally single but occasionally multiple ; multiple bubbles may be seen lying in apposition or may be separated from each other by a short intervening distance. A crescentic shadow is thrown on to the bladder wall by the bubble, and through the bubble can be dimly seen the vessels of the mucosa. The air-bubble is a point of repair in the orientation of the bladder to which some cystoscopists attach considerable importance. Too large a bubble is objectionable, for its convex surface acts as a lens, and by this means, and also by reflecting light, it obscures the apex of the viscus. The size of the bubble should not represent more air than that contained in the catheter. Air introduced from the syringe indicates carelessness in preparation. The surgeon should take a pride in keeping the air-bubble small.

CHAPTER V.

CYSTITIS. SIMPLE ULCERATION.

CYSTITIS.

This condition may be dealt with as follows: (I) *Simple cystitis: general features;* (II) *Cystitis due to the Bacillus coli communis;* (III) *Gonorrhœal cystitis.*

I. SIMPLE CYSTITIS: GENERAL FEATURES.

The term 'simple' is used to exclude the tuberculous and syphilitic varieties of cystitis, each of which will be described separately later. Simple cystitis is of everyday occurrence in a urological practice, so that an intimate knowledge of its cystoscopic features is of great importance. By its frequency, however, it presents repeated opportunities for study.

Indications for and Contra-indications to Cystoscopy.—In acute cystitis it is usually unnecessary to employ the cystoscope, as the diagnosis can be made from the symptomatology. A sudden onset of frequent and urgent micturition, with pyuria, and perhaps terminal hæmaturia and pyrexia in severe cases, is usually sufficiently characteristic. As there is a definite danger of adversely influencing the course of the complaint by trauma to the inflamed mucosa, or by the introduction of fresh flora into the bladder, it is generally wise to abstain from cystoscopy. On the other hand, chronic cystitis and many cases of subacute cystitis require cystoscopy in order to determine the reason for their failure to respond to treatment, and to ascertain whether there are any unsuspected complications in the bladder or kidney which are responsible for the protracted course of the disease.

Acute urethritis is an absolute contra-indication to cystoscopy, and in subacute urethritis it should only be undertaken after careful consideration. Bladder symptoms arising in the course of acute posterior urethritis are very common, especially frequency of micturition and terminal hæmaturia. It should be assumed that they are caused by the posterior urethritis, and in fact they almost invariably disappear as this subsides. The lesion responsible for such symptoms is an œdema of the vesical outlet (*see* page 92). Patients suffering from advanced renal deficiency in suppurative nephritis associated with cystitis should be investigated, as far as is possible, by other means before urethral instrumentation is undertaken, because of the danger of expediting suppression of urine.

Preparation of the Bladder.—The preparation of the inflamed bladder has already been dealt with on page 51. Inflamed bladders, being hypersensitive, resent the interference that is necessary in preparation, which is unfortunate, for they require a greater amount of lavage than does the normal organ owing to the difficulty experienced in getting them clear of pus, etc. They must be handled skilfully, for otherwise the cystoscopy will fail. However, they vary considerably in their tolerance of bladder washing, and their behaviour can be only approximately surmised in advance. Generally speaking, if an inflamed viscus has had a free exit it will have emptied itself at short intervals and will be found to be contracted and difficult, whilst one which has been obstructed, and especially one in which residual urine has been present, will be of good size and often actually dilated. Such bladders are usually quite tolerant, even though inflamed, and can be handled without restraint. Occasionally, however, they contract down immediately they are emptied, and refuse thenceforth to take more than a few ounces of fluid.

If a small bladder is over-distended before its limitations are realized, irretrievable mischief, as evidenced by hæmorrhage and increased intolerance, may be done, and a satisfactory cystoscopy may be prevented. Whenever, therefore, pyuria and a history of frequent micturition or tenesmus are met with the surgeon should be on his guard. He should assume that the bladder will be difficult to prepare until it is proved to be otherwise, and the precautions recommended below should invariably be instituted *from the beginning.* They are a résumé of the method already more fully discussed elsewhere (page 51).

1. Good anæsthesia is essential (*see* page 35).
2. Note condition of catheter specimen as regards pus, also quantity of urine present in the bladder.
3. Inject 1 oz. and no more.
4. Successively increase by 1-oz. stages, until signs of restlessness or increased depth of the respirations become apparent. These latter will show themselves, even when the patient is under general anæsthesia, but probably not under spinal anæsthesia. Regard this as the maximum capacity of the bladder. Do not utilize the whole available space again.
5. Never completely evacuate the bladder. Leave in 1 oz. or so to accommodate the tip of the catheter.
6. When filling the bladder for examination do not distend to the maximum, as further fluid will be contributed by the kidney and must be accommodated.

7. Be careful not to bruise the bladder wall by rough handling of the cystoscope, for this will cause hæmorrhage and bruising of the vesical mucosa, and will also be painful.
8. Waste no time in commencing and carrying through the investigation once the bladder is ready, for your opportunity may disappear.

Data Required.—The cystoscopist will require information with regard to the following :—

1. *The type* of the cystitis ; acute, subacute, or chronic ; hæmorrhagic or gangrenous ; whether decomposition of urea is occurring or not. In many cases the organism may be surmised from the lesions present.

2. *The anatomical distribution*—for instance, whether basal, cervical, general, surrounding one ureter, etc.

3. *Site of orgin*—ascending or descending, etc.

4. *Other complicating lesions.*

5. *Size and irritability of the bladder.* Already observed during preparation.

6. *Progress.* Signs of extension or resolution, active ulceration, etc., less or more severe than at a previous cystoscopy. The number of ounces of fluid which the bladder will tolerate is a valuable indicator.

7. *Prognosis* as judged by a review of all the factors.

8. *Indications for treatment.*

Etiology.—The surgeon will attempt to locate the origin of the cystitis, though this quest is not always an easy one. All the most important varieties are bacterial in origin, but frequently *mechanical, chemical, and thermal irritation* will produce hyperæmia, œdema, etc., of the mucosa. Thus an injected membrane may be found as the result of contact with a urine of high concentration or otherwise abnormal in constitution, or as a sequel to the use of a thermal or chemical irritant in the bladder lotion. Similarly the region occupied by an aseptic stone may be hyperæmic, œdematous, or even ulcerated, whilst a median basal œdema may follow ungentle instrumentation of the bladder.

When the disease is of *bacterial* origin the primary focus of infection must, if possible, be determined. It should first be ascertained whether any previous instrumentation may have infected the viscus. Failing that, the primary focus must be either in the kidney (a descending infection, *see* page 324) or in the prostate and urethra (an ascending infection, *see* page 252). Direct invasion of the bladder from the blood-stream is held to be rare. Infection from an adjacent viscus, e.g., the bowel or a seminal vesicle, is occasionally observed and is usually preceded by some morbid process in that organ itself —for instance, appendicitis or diverticulitis, or malignant disease which goes on to perforation.

Cystitis may occur as an infection of a previously healthy bladder, or as a *complication* in a viscus which already contains some other pathological process. In the latter case it can, of course, occur as an unconnected incident; but it must be remembered that the majority of bladder diseases predispose to the onset of inflammatory mischief, and that in many the organisms would never have obtained a foothold had not the resistance of the bladder been reduced by some preceding disease. In conjunction each lesion is adversely affected, so that the cystitis itself is likely to be more severe and intractable. In all cases, but especially where the cystitis is of long-standing, or persists in spite of treatment, the cystoscopist must be on the look-out for complications. Cystitis may, of course, be added to any bladder lesion whatsoever, so that a complete list of these would include every possible bladder disease. The following, however, are the important ones, and they are frequently encountered: malformations, especially diverticula (true and false); other inflammations, especially tuberculous; fistulæ; parasites, especially bilharziasis; bladder stone and foreign bodies; and neoplasms, simple and malignant. The conditions which cause urinary retention constitute another group not primarily intravesical yet predisposing to cystitis, and they are recognizable during the cystoscopy or its preliminaries. They are stricture, prostatic hypertrophy, and diseases of the central nervous system in the male, and in the female certain enlargements of the uterus, especially fibroids and carcinoma, and, again, disease of the central nervous system. Each of these will be considered in its appropriate place.

Cystoscopic Appearances of Cystitis.

Cystitis offers an excellent opportunity to study the naked-eye changes which a typical mucous membrane undergoes in inflammation. Nowhere can these be more advantageously observed. The appearances are, however, slightly modified by two factors—namely, the necessity of examining through a fluid medium, and, under certain circumstances, the presence on the membrane of the products of urinary decomposition. We shall study the subject under the following headings: (1) *Vascular changes*; (2) *Changes in the mucosa*—desquamation, œdema, ulceration, proliferation; (3) *Inflammatory products observed on the bladder wall*—mucus, epithelium, pus, blood, membranes, products of urinary decomposition; (4) *Changes in the musculature*—alterations in size, trabeculation and false diverticula.

1. **Vascular Changes.**—Dilatation and increase in apparent size and number of the vascular systems is the earliest change observed. All types of vessel undergo an increase in size. Minute arterioles which normally are unrecognizable become apparent; vessels which

were previously small twigs take on more important dimensions, whilst the parent trunks increase notably in breadth and may become several times their previous girth. The various systems therefore become larger, richer, and more complex, and in addition inosculation between them becomes freer and more evident. The general tone of the bladder wall becomes redder and duller. These changes are illustrated in *Plate III* A, which is taken from a case of mild cystitis. When the dilatation is further advanced the vessels in some instances show a liability to rupture. This mainly implicates the parent stem, the hæmorrhage not uncommonly being seen where the trunk first emerges under the mucosa. It usually remains submucous—a hæmatoma with its maximum concentration situated over the vessel and the effusion diminishing in intensity towards its periphery, which exhibits the washed appearance seen in *Plate III* B. The hæmorrhage may, however, occur on the surface of the membrane (hæmorrhagic cystitis). This is particularly well seen in gonorrhœal cystitis.

PLATE III.

A, *Cystitis of medium severity.* Note the hyperæmia, the laked appearance of vessels' edges, and the washy mucosa. Mucosa appears puffy—purulent deposit. B, *Severe cystitis.* Redness of one portion very marked. It rapidly fades into an area of much less severe inflammation. Submucous hæmorrhages seen round stems of main vessels. C, *Bullous œdema*, surrounding and hiding the ureteric orifice in a case of prostatic hypertrophy. The red structure in the lower portion of the picture is the median lobe. Note that it can be seen in the same cystoscopic field as the site of the ureter (cp. page 249.) Compare these bullæ with those seen in *Plate IV* E. D, *Cystitis cystica.* Minute cysts, resembling dewdrops. E, *Cystitis membranosum.* Small portion of an extensive vesical membrane. Evidences of cystitis in this plate much less marked than usual. F, *Œdema trigoni pseudo-membranosum.* Right half of trigone with ureter. Trigone covered with thin pellicle of proliferated epithelium, the margin of which is irregular, fairly sharply defined, and slightly elevated.

Severer stages in the inflammation show increasing vascular engorgement, until eventually the sandy colour of the vesical wall is completely replaced by vascularization. The coloration at this stage resembles the rich venous hue seen in fine healthy granulation tissue, and the general appearance is in many respects comparable thereto.

When the cystitis is receding or becoming more chronic a brighter tinge is noticeable, suggesting that venous stasis and engorgement are now playing a smaller rôle, and that the blood is more generously oxygenated. However, regeneration of epithelium affording improved light reflection is partly responsible for this brighter appearance. As the cystitis subsides the blood-vessels diminish in number and size until, if resolution is complete, the normal coloration is restored.

Various parts of the same bladder frequently exhibit all the degrees of vascular engorgement, so that by moving from one area

PLATE III.

SIMPLE CYSTITIS

to another the student may pass them in review successively. *Plate III* B depicts an area in which the transition from mild to intense hyperæmia is rapidly effected.

The changes above described are less apparent over the trigone, for the normal vascularity of this section is already great, and in many instances scarcely admits of increased redness. Inflammatory change in this region is evidenced by œdema and epithelial proliferation. The colour of the mucosa can be altered by the presence of blood in the vesical medium and by other extraneous influences (*see* page 68).

2. Changes in the Mucosa.—

Desquamation.—Desquamation is one of the earliest phenomena of bladder inflammation, the shed squames being evident in large numbers when the urine is examined under the microscope. Epithelium does not exist at any period in sufficient quantity to be separately recognizable through the cystoscope, but it is most abundant in the earliest stages of acute cystitis, when in combination with a few leucocytes and a little mucus it constitutes the filmy pellicle then observable. It also occurs in large quantities in the urine in leucoplakia. In acute cystitis loss of the superficial layers is chiefly responsible for the dull and granular appearance of the mucosa.

At a certain stage in the recovery from acute cystitis, as also in some types of chronic cystitis, the bladder wall takes on abnormal brightness ; sometimes it almost appears to be flecked with silver as a result of the excessive regeneration of epithelium. This stage of epithelialization corresponds to the phase in which the vascular engorgement has partially subsided and the coloration of the mucosa has faded to a palish pink. Cystoscopy is now very easy, for light reflection is excellent, and the object is always close to the prism owing to the small size of the cavity.

Epithelial proliferation is frequently observed over the trigone in cases where there has been long-standing irritation. It has received the name 'œdema trigoni pseudo-membranosum' (Pilcher). It occurs much more often in the female bladder than in that of the male. Its appearance is that of a colourless, semi-transparent, fluffy pellicle adherent to the trigone (*Plate III* F). Its surface and its borders are irregular, and the latter may be well defined or fade away into the normal mucosa. Sometimes the whole trigone is overlaid by the membrane, but usually it is more limited in extent. This condition may be found in bladders which otherwise show little or no sign of cystitis, and where the urine is sterile. Frequently the patient complains of some degree of 'ardor urinæ'. The trouble is often traceable to some pathological condition of the neighbouring organs of generation, such as a cervicitis or a uterine displacement, etc.

6

Œdema of the Vesical Mucosa.—Some degree of transudation into the bladder mucosa invariably occurs in cystitis. It is not, however, very obvious through the cystoscope until it is well marked. In severe cystitis the swelling becomes very pronounced and the mucosa comes to look stiff and inflexible. This condition is best appreciated by observing the appearance of the muscular bundles. The edge of the mucosa covering these structures, instead of being sharply cut, becomes swollen and rounded, and as the light catches its margin it displays the coarse and granular texture of the membrane. The lesser muscular strands disappear altogether, only the larger bundles being able to show up through the thickened membrane.

Œdematous thickening is very frequently observed around the *vesical neck* in females. A minor degree of plication may almost be regarded as normal in this sex (*Plate I* D, page 68), but an œdematous exaggeration occurs during the vascular engorgement of pregnancy, at the catamenia, and in other uterine and vesical affections. The bladder neck appears to be elevated in longitudinal folds or pleats converging on the urethra, and when seen cystoscopically these are exaggerated by their close relation to the prism. They may be a cause of frequency or discomfort. Examination of the bladder in a female complaining of urinary irritation should always include a search for them.

Two varieties of œdema which may be, but are not necessarily, inflammatory phenomena are conveniently considered in the present chapter. They are bullous œdema and cystitis cystica.

Bullous Œdema.—This is one of the commonest conditions seen in the bladder (*Plates III* C; *IV* E, page 106; *VI* D, page 130; *XII* F, page 244, etc.). Whilst it is, as a rule, associated with some form of infection, simple or specific, it may also be found apart therefrom—for instance, where a stone rests on the bladder base, or surrounding a calculus impacted in the lowest segment of the ureter (*Plate XIII* C, page 302). It is seen around the base of a neoplasm, especially a malignant one (*Plate VIII* E, page 160), or near the site previously occupied by a simple papilloma following treatment with the high-frequency current (*Plate X* D, page 178), and in many other situations where asepsis obtains; it is, in fact, a simple œdema occurring in a position where special anatomical conditions are present, and producing distinctive features.

The mucosa of the vesical wall is said to be bound down to its subjacent strata by a hexagonal reticulum. Therefore when swelling occurs under the mucosa it elevates the membrane in the intervals between this honeycomb-like mesh, and the resulting appearance is that of closely-lying dome-shaped bullæ which appear to rest on the mucosa. They are usually small and have delicate translucent walls which imprison a watery, straw-coloured exudate. When more tensely filled they lose the appearance of lying side by side and project as agglomerate masses of diaphanous rounded vesicles, like a bunch of grapes, or a hydatid mole (Marion and Heitz-Boyer). This excessive development is, however, uncommon. Their superficial extent is, as a rule, limited. Their position is regulated by that of the pathological lesion which has brought them into being, so that they occur more frequently on the base, though they may be found in any part of the viscus which has been subject to irritation. Sometimes, however, they are seen in small clusters, spread widely, like a rash, over the entire surface of the bladder, each group consisting of a limited number of vesicles resting on a dull hyperæmic base whilst the remainder of the mucosa is then also somewhat red. This picture is most commonly seen in subacute or chronic *B. coli* infections.

CYSTITIS CYSTICA (*Plate III* D).—Compared with bullous œdema this is rare. In it minute cysts or vesicles occur scattered about on the bladder surface. They may be single, but are more often multiple. They are not, however, bunched together as in bullous œdema, but remain isolated and often widely separated on the mucosa. Sometimes they are seen as low-lying dome-like structures. When more tensely filled they assume a hemispherical shape, whilst quite often, perhaps characteristically, they stand up from the bladder wall like minute balloons, attached only by a delicate narrow pedicle. There is no areola of hyperæmia. Their contents are clear, and colloid in consistency, and they are paler than the bullæ of bullous œdema. Their appearance has been well likened to that of dewdrops lying on the bladder mucosa. The affection is found in bladders which have been the subject of chronic cystitis over long periods, though it is said also to occur in the healthy organ. It principally involves the trigone and surrounding parts, but a similar condition has been observed in the ureter and the renal pelvis. The exact pathology is in doubt. Rokitansky and Klebs have regarded it as a herpes, some look on it as a proliferative epithelial change, others as a true œdema. Störck and Zuckerkandl have described it as a retention in the mucous glands of the bladder, and also in certain pseudo-glands which are formed during the course of chronic inflammation.

Ulceration.—The subject of simple ulceration will be discussed at the end of this chapter (page 93).

Proliferative Changes.—When the bladder has been subject to severe inflammatory processes, especially if they have been of long duration, hypertrophic alterations in its mucosa are frequently observed. They vary widely in extent, distribution, and appearance. Generally they affect restricted areas only, and appear as small, fleshy elevations on the mucosa, not unlike exuberant granulation tissue

(*Plate IV* F, page 106). Sometimes they are more extensive, and assume various shapes, which may be aptly referred to as vermicular, cerebriform, or polypoid. Perhaps the last title best describes the most common of these major hypertrophic lesions. They consist of inflammatory buttons, rarely larger than a pea and rounded or club-shaped. They are fairly frequently found around fistulæ (*Plate VI* D, page 130); in severe tuberculous cystitis, especially when secondarily contaminated; and around malignant neoplasms, especially when infected. In the latter it may be difficult to form an opinion as to how much is true neoplasm and how much inflammatory polyp. They are also seen in chronic gonorrhœal and in syphilitic cystitis, each of which is rare. As a rule little difficulty will be experienced in distinguishing them from true neoplasms, but if their nature is in doubt, they can be snipped off with the cystoscopic rongeur for microscopical examination. Occasionally, however, it may be very difficult to establish the nature of a tumour when of a size greater than that just described, especially when, as often occurs, it is buried under phosphatic débris and incrustations or occupies a hæmorrhagic bladder. A course of vesical irrigation with silver nitrate of increasing strength continued over a number of days will probably succeed in cleansing the surface sufficiently to allow of a satisfactory inspection. If of inflammatory origin, they may disappear under this treatment.

Leucoplakia.—Thickening and proliferation of the epithelium assume their most pronounced phase in leucoplakia, to which a separate section is devoted in Chapter XV.

3. **Inflammatory Products observed on the Bladder Wall.**—No secretion of any kind is observable on a healthy vesical mucosa. Any visible deposit must therefore be of pathological origin. Such a deposit may consist of: (*a*) Excess of mucus; (*b*) Epithelium; (*c*) Pus; (*d*) Blood; (*e*) Membranes; (*f*) Products of urinary decomposition.

a. Excessive Secretion of Mucus.—This is an invariable result of hyperæmia or irritation in any mucous membrane. In urinary disease its presence is demonstrable in the flocculent deposit which settles at the bottom of a specimen glass. Unless it is rendered opaque by admixture with pus it is usually invisible in the bladder. Sometimes, however, a thick glistening streak adherent to the walls may be observed, bearing a resemblance to a snail track. The existence of mucus is evident, however, when it is mixed with pus, for it entangles the latter and twists it into bands or whorls which cling to the vesical floor and parietes.

b. Epithelium.—*See* page 81.

c. Pus.—When pus is seen in the bladder it has the same characters as that fluid when observed elsewhere. being a creamy or yellowish, opaque, and somewhat viscid liquid. When mixed with mucus, blood, phosphates, epithelium, etc., however, it assumes a variety of modified appearances. Pure pus is usually completely and easily removed from the bladder, and therefore when the preparation has been efficient none should be seen on cystoscopy. It may be seen, however, even after efficient bladder preparation if it has its origin in the kidney, for it then fouls the bladder again almost as soon as the latter has been cleansed. Fluid pus of renal origin generally remains for a time in suspension in the vesical medium, rendering it murky, but if more solid it quickly sinks on to the base, whilst if very thick and inspissated and coming from a destroyed kidney, it emerges slowly from the ureteric orifice in a worm-like stream (*Plate XIV* B, page 328) and never leaves the floor of the viscus. Pus seen on the vesical floor shortly after satisfactory lavage has been obtained, or a medium which becomes cloudy almost as soon as it has been changed, should suggest a renal origin for the pus, and a careful watch at the ureteric orifices should be instituted. Gentle massage of the loin may be employed to assist the descent of pus whilst the meatus is under observation.

When pus of vesical origin is seen in the bladder its presence is probably accounted for by its being entangled in smaller or larger membranes, which will be discussed immediately. One vesical picture should, however, receive comment, as it frequently leads to erroneous diagnosis. In mildly inflamed organs a few small purulent masses are often left behind, even after careful irrigation. About the size of a pinhead and seated on a ring of hyperæmia, they are very liable to be mistaken for tubercles by the inexperienced, and I suspect that this is a common error. It is a serious one, for it entirely alters the prognosis and treatment. Close inspection will usually show that these flakes are granular, irregular, have a non-glistening surface, and are inconstant in size. By contrast, the tubercle is a smooth, oval-topped, and flatter structure, of moderately constant size. The essential difference is that one is covered with epithelium and the other is not. Careful manipulation will project a shadow in the case of the pus flake, but the tubercle is too low-lying to allow of this. If a stream of fluid is played on to the pus through a catheterizing cystoscope, it will generally, though not always, dislodge it.

In certain exceptional instances subepithelial, non-tuberculous abscesses occur, which in due course rupture into the bladder, leaving a little ulcer. Knorr has described a similar condition under the title 'cystitis follicularis et glandularis' in which small subepithelial collections of lymphocytes and lymph occur surrounded by a red areola.

d. Blood.—The inflamed bladder bleeds easily and it is common to see on its surface a greater or less amount of recent or changed blood, or to notice hæmorrhage actively occurring into the vesical medium.

e. Membrane Formation.—A certain degree of membrane formation is almost constant in cystitis, but it is of very variable extent, from a thin diaphanous sheet of mucus and epithelium in mild cases to widespread coarse and adherent coverings in severe ones. Variety of appearance is infinite, and only a few examples will be portrayed:—

i. A thin filmy membrane, closely adherent to the mucosa, obscuring its structure, and often extending over large areas, is commonly seen in mild or early cystitis. It is composed chiefly of mucus in which are entangled quantities of recently desquamated epithelium, and perhaps a small mixture of leucocytes. Somewhere a portion of this membrane may have become partially detached and may be seen floating free at one border. A red, raw, inflamed area of bladder wall may thus be exposed.

ii. When the process is older the tendency is for purulent membranes and deposits to become thicker (*Plate III* E) and to contain more pus and less epithelium. These membranes are coarser and more opaque in texture, and when containing quantities of fibrinous material they form tough, curdled masses, which may be firmly adherent, and which it may be impossible to dislodge by irrigation. The best developed membranes are found in old-standing and severe examples of cystitis where an admixture of organisms is to be found. They are most firmly adherent when they overlie patches of ulceration or when occurring in a trabeculated bladder.

iii. The most marked adherent and fibrinous varieties are sometimes referred to as 'diphtheroid'. Streptococci are usually responsible.

iv. For œdema trigoni pseudo-membranosum, *see* page 81.

f. Products of Urinary Decomposition.—When the urine is ammoniacal and stinking, quantities of phosphatic débris are very commonly seen entangled in the meshes of masses of muco-pus that occupy the base of an infected bladder, as also in membranes such as have just been described.

Pathology of phosphatic deposits.—It may not be amiss to recall a few facts concerning the deposition of triple phosphates from the urine. There are three organisms which commonly infect the bladder, but which do not possess the power to split urea. They are the tubercle bacillus, the gonococcus, and the *B. coli*, and each of these lives by preference in an acid urine. Most other organisms possess in greater or less degree the ability to split urea, and this sets a train of consequences in motion the importance of which cannot be exaggerated and which completely changes the cystoscopic appearances, as indeed it alters the whole clinical aspect of the case.

The chemical formula of urea is $CO\langle^{NH_2}_{NH_2}$ and when bacteriologically decomposed it acquires water and is split into NH_4OH and

H_2CO_3. In this way the reaction of the urine becomes alkaline, and the offensive ammoniacal odour is produced which is characteristic of decomposing urine. This reaction is very favourable to the growth of the majority of organisms, so that if unchecked the cystitis becomes increasingly severe, but, what is more important from our point of view, it causes precipitation of phosphates. These are triple phosphates and are well known as the creamy or yellowish granular precipitate deposited from septic urine on standing. Seen in the bladder they have the same appearance, but are generally intimately mixed with pus or muco-pus, or are entangled in the recently described membranes, adding materially to their bulk and the coarseness of their texture. When these masses are large and adherent they may easily be mistaken for phosphatic calculi, especially as the conditions render cystoscopy difficult. They may adhere closely to the bladder wall itself, giving it a white encrusted coat, but they cling particularly to the surface of simple or malignant ulcers, and to a less extent to other pathological lesions. The underlying lesion in such circumstances is hidden, and a course of bladder lavage may be necessary before the diagnosis can be completed. Finally, these phosphates may cohere and form a secondary (phosphatic) calculus. Such a result is more probable in the presence of residual urine.

From what has been said above it will be realized that phosphatic deposits and secondary calculi are not found in cases of uncomplicated infection by any of the three organisms mentioned previously—namely, the *B. coli*, the gonococcus, or the tubercle bacillus. It is further a practical observation that with these three organisms membrane formation is never well marked, though of course in the tuberculous bladder a certain amount is associated with the ulceration present. Each of them has distinctive characteristics which will later be separately described. In each the nature of the disease can usually be surmised from the cystoscopic examination, or at any rate they can be differentiated as a group from the urea-splitting varieties by the reaction of the urine and the bladder appearances. When, however, secondary organisms are introduced the cystitis takes on the attributes of the latter, and the original invader is eclipsed both cystoscopically and bacteriologically. Further, the inflammation enters a severer phase. This is least marked with the *B. coli communis* and most pronounced with the tubercle bacillus, where the addition of secondary infection marks an increase in the strangury and more continuous distress. As secondary organisms are only too easily carried on the end of an instrument from the urethra into the bladder, the surgeon will realize that in all such cases instrumentation—cystoscopic or otherwise—must be definitely indicated and punctiliously executed.

4. Changes in the Musculature.—

Alterations in Size.—The size of the bladder is usually diminished. In mild cases even in the acute stage, however, it will occasionally hold 8 oz., but when the disease is severe it will be reduced and may not tolerate more than an ounce or two. Cystoscopy can be carried out in 2 oz. or thereabouts if the bladder is skilfully and gently handled, but this is a minimum below which the examination becomes valueless. The diminution is produced far more by the depth of the inflammatory process than by its superficial extent. This is well illustrated in the tuberculous bladder, where a single inflammatory area surrounding a ureter and containing one deep ulcer will cause much more contraction than does a superficial inflammation of the whole of the organ, say by the *B. coli.* In this shrinkage the trigone participates to a less degree than the rest of the organ, and on inspection its reduction may not be at all evident. When cystitis supervenes in a case of retention the bladder is prevented from contracting, and, indeed, may be of much larger dimensions than the normal viscus. In such circumstances it may be compared with a tuberculous joint which from the first has been kept in good position and in which muscular contraction has never been allowed to occur or to cause deformity.

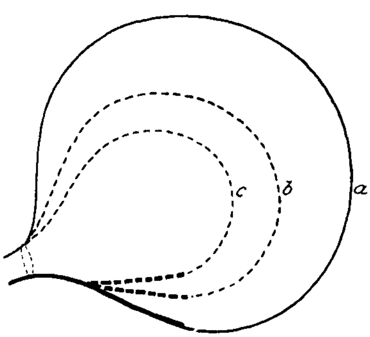


Fig. 65.—*a*, Normal size of the bladder; *b* and *c*, successive stages of reduction in size of bladder cavity. The trigone is little or not at all altered in extent, but its posterior portion is elevated or appears so through the cystoscope. The roof is more accessible to inspection. The anterior wall no longer rises sharply from the internal meatus, but passes upwards and backwards to enter into the formation of the dome.

The mucosa generally appears to shrink *pari passu* with the musculature, so that its surface does not become pleated to allow of its accommodation in the reduced organ. Pleating is, however, sometimes observed, and a good example occurring in a tuberculous bladder is depicted in *Plate IV* c, page 106, where the infected mucosa is seen furrowed like a puckered brow. This appearance has been styled 'cerebriform'.

Thickening of the mucosa as a rule hides from view the musculature of the bladder, but when hypertrophy and trabeculation are marked, as in obstruction, it may be very conspicuous. Again, where only a small area of the mucosa is inflamed the muscle bands underlying the healthy part may be observed to be in spasm, and their appearance suggests trabeculation.

Effect of Contraction of the Bladder on Cystoscopy.—*Fig.* 65 indicates the alteration in shape which occurs in the bladder as its radii diminish. The trigone is affected to a less extent than the remainder of the viscus. At cystoscopy therefore the ureters and interureteric bar seem to lie farther back than usual. They also appear to be higher up towards the fundus owing to the elevation of the posterior portion of the trigone. The anterior wall approaches the horizontal, and, together with the lateral walls, comes closer to the beak of the cystoscope. Other things being equal, this should result in greater magnification and concentration of light. Generally, however, these advantages are more than neutralized by the altered conditions of the mucosa and the vesical medium, the resultant being that visibility is impaired; but in favourable circumstances, especially where the upper segment is healthy, an improved view is obtained. Whenever the bladder cavity is reduced the importance of keeping the air bubble as small as possible is greatly enhanced; a large bubble in a small bladder may obscure and distort the whole vault.

Trabeculation and Diverticula.—*See* Chapter IX.

Acute, Subacute, and Chronic Cystitis.

It is not proposed to describe separately the cystoscopic changes observed in acute, subacute, and chronic cystitis. These can, to a sufficient extent, be surmised from the foregoing description, and in any given instance the patient's history and progress will assist in correct classification. The cystoscopic features, indeed, though generally reliable, are not an infallible guide to the category in which any given example should be included. Thus, many protracted and resistant cases, which from this aspect of their behaviour should be ranked as chronic, exhibit extreme degrees of hyperæmia, œdema, and other inflammatory changes simulating acute cystitis. These subjects not infrequently show less evidence of discomfort than the intravesical appearances would portend. On the other hand, cases in which the history is recent, the onset sudden, and the vesical distress severe, may show vesical lesions which are insignificant in comparison with the symptoms, and might, if judged by the cystoscopic appearances alone, be ranked as subacute. As similar pictures, therefore, may be found in dissimilar types of the disease, it is better to avoid particularization of the individual traits of acute, subacute, and chronic cystitis, and in placing a case in its correct class to rely on a general survey of its combined clinical and cystoscopic features rather than depend on the latter alone.

II. CYSTITIS DUE TO THE BACILLUS COLI COMMUNIS.

This is a distinctive urinary disease running a characteristic course and recognizable in most instances without cystoscopy. The following brief outline of its main features in the acute phase is inserted to assist in the recognition of the disease apart from cystoscopy, as that examination is best avoided (*see* page 76).

The onset is commonly acute and there may be fever. Occasionally this is preceded by some derangement of the alimentary canal, which is often slight and probably unassociated in the patient's mind with his urinary trouble until it is inquired about by the surgeon. Following the febrile onset, frequent and urgent micturition make their appearance, and according to the severity of the attack there may or may not be terminal hæmaturia, loin pain and tenderness, and continuation of the fever. The patient presents the usual febrile syndrome, furred tongue, anorexia, constipation, etc. Examination of the *urine* will show the presence of pus. Coming at first from the kidney it sinks to the bottom of the specimen glass as a yellowish creamy deposit. It is slightly viscid in consistency and moves but sluggishly when the glass is tilted. When the bladder becomes involved in the inflammatory process, mucus is found in the urine, so that the deposit becomes billowy and flocculent. The urine has a peculiar smell which has been likened to that of stale fish. In the absence of alkalinization by drugs, it is acid. Coliform bacilli are found with the microscope, and on culture a pure growth of the bacillus is obtained.

When the case presents such or similar features a hæmatogenous infection of the urinary tract with the *B. coli communis* may be confidently diagnosed. Does cystoscopy advance the diagnosis or do more than corroborate what is already known? My practice is to avoid it in such circumstances, as little or no assistance in diagnosis and no indications for treatment are to be obtained thereby, whilst no complications calling for modification of the prognosis or line of action are likely to be found, at any rate in the early stages with which we are at present concerned. Occasionally, however, it is necessary to investigate such a bladder, and the appearance presented is that of acute generalized cystitis. The cystoscopic changes vary with the acuteness of the infection, but are usually slighter than the bladder symptoms would lead one to expect. Apparently the accompanying pyelonephritis and ureteritis augment the vesical irritability. The most severe grades of hyperæmia are rarely seen, and the various arterial twig systems do not lose their identity, or become lost in a diffusely reddened bladder wall.

The pus, being finely particulate and easily washed away, is generally completely removed in the bladder preparation, and as that from the kidney is insufficient to soil the organ again quickly, there is little or no pus observed in the bladder. In any case no large adherent mucopurulent sloughs are seen, nor, as the *B. coli* *communis* is devoid of urea-splitting properties, is any phosphatic deposit found. Ureteric meatoscopy is undertaken to confirm the renal origin of the disease and to decide which kidney is involved (*see* page 324).

When the cystitis is not of renal origin there will, of course, be no meatal change other than that common to the whole of the mucosa. Occasionally concentration of œdema over the prostate and round the urethral opening may indicate the mode of access of the organism to the bladder, though this is by no means constant, and its absence does not exclude ascending infection.

Chronic Cystitis.—Chronic cystitis due to the *B. coli* is very common. Here again the changes are less marked than would be anticipated from the vesical symptoms. Various degrees of vascular dilatation and swelling of the mucosa are found, and occasionally widespread bullous œdema is seen (*see* page 83). When the disease is of renal origin the ureteric manifestations may be slight, but at other times the ureter has a dull-red colour, or shows evidences of chronic induration and perhaps epithelial proliferation (*Plate XIV* C, page 328).

III. GONORRHŒAL CYSTITIS.

Acute and subacute urethritis interdict cystoscopy, and for this reason the bladder usually escapes exploration when symptoms of cystitis supervene in the course of an attack of gonorrhœa. Discretion should be exercised in making the diagnosis of cystitis during the course of this disease, for posterior urethritis often produces symptoms which closely mimic those of cystitis—namely, frequent and urgent micturition, and occasionally terminal hæmaturia and febrile disturbance. It should be remembered that the bladder is very resistant to the incursion of the gonococcus and is involved in only a small proportion of cases. The fact that it tolerates treatment by 'grand lavage' is evidence of its resistance, as many gonococci must thereby be washed into its cavity. Three types of cystitis occurring in this disease require description: (1) Cystitis due to the gonococcus itself; (2) Cystitis due to secondary organisms which have contaminated the original urethral infection; and (3) Cystitis that is the consequence of late complications, such as stricture, chronic prostatitis, and so on.

Of these groups, the second may be an acute, a subacute, or a chronic process, but generally tends to resolution. It has no special features calling for portrayal. The third group will be found dealt with in the appropriate sections. Cystitis due to the *gonococcus itself* may take one of several forms, and may be classified as: (1) *Acute*; (2) *Chronic.*

1. **Acute.**—Of the acute form the following varieties may be described : (*a*) Cystitis of the neck ; (*b*) Cystitis of the body—acute, hyperacute.

a. Cystitis of the Neck (*Cystitis Colli Gonorrhoica*).—This occurs during the stage of acute posterior urethritis, and should be regarded as an area of vascular engorgement abutting on that acute inflammatory process. It is not a true infective cystitis. To the cystoscope the cervical mucosa appears to be thrown into folds. It may be intensely congested and bleed freely as the result of instrumentation. The remainder of the bladder is healthy, or perhaps slightly hyperæmic owing to the neighbouring irritation.

b. Cystitis of the Body (*Cystitis Corporis Gonorrhoica*).—This is much less common. It is peculiar in that it involves isolated islands of the vesical wall, leaving intervening areas of healthy mucosa. The bladder is therefore marbled or mottled with zones of cystitis, and these tend to affect the roof of the viscus rather than its base. Both these facts distinguish it from other forms of cystitis. The affected areas show a strong propensity to bleed (hæmorrhagic cystitis).

The *hyperacute* variety is most commonly seen in the course of the subacute or chronic phase of the urethritis, and neglected and untreated cases are the most often attacked. The urethral infection is liable to be masked and overlooked owing to the vesical pus and strangury, so that the diagnosis may first be made with the cystoscope. The disease runs a severe course and may terminate fatally as the result of renal infection. The essential features correspond to those of the last described variety. The isolated areas have, however, become confluent, and the whole bladder is affected, though the disease predominates in the upper zone. The bladder capacity is signally diminished, 3 oz. or less being all that it will tolerate, and any attempt to increase the distension immediately excites hæmorrhage. The tendency to bleed is pronounced, and numerous ecchymotic spots may generally be observed on the parietes and especially on the roof. Adherent sloughs and precipitation of phosphates are little marked, as the cystitis occurs with an acid urine. The ureters are easily identified in spite of the intense engorgement and swelling and the decrease in bladder capacity.

This variety of gonorrhœal cystitis simulates the late stages of the tuberculous bladder more closely than does any other type of cystitis, its small size, intense irritability, and proneness to bleed, together with the large amount of pus contained in an acid urine, all suggest a tuberculous origin; but the cystoscopic findings—namely, the absence of ulceration, the implication of the roof rather than the base, the ease with which the ureters are discovered, the results of ureteric catheterization and renal function tests—combined with the failure to find the tubercle bacillus or the discovery of the gonococcus, serve to distinguish the two.

2. **Chronic.**—Chronic cystitis due to the gonococcus is a milder variant of the conditions above described, the mosaic-like appearance still persisting. Marion and Heitz-Boyer state that this form often produces polypoid granulations, the occurrence of which is but little known. They exist as mushroom-shaped elevations, with smooth, rounded, club-shaped summits and a pedicle which is almost as large as the summit. Their colour is brownish or violet, and therefore darker than that of true polypi. The combination of a polypoid mass and hæmorrhage will naturally suggest a neoplasm, but one should be put on one's guard by the multiplicity and the apical situation of the lesions, and by their deeper colour, whilst the beneficial effects of vesical lavage with silver nitrate will substantiate the diagnosis.

SIMPLE ULCERATION OF THE BLADDER.

Ulceration of the bladder, apart from that due to tuberculosis, syphilis, and neoplasm, was, prior to the use of diathermy for intra-vesical work, rarely seen, but simple ulceration of thermal origin is now quite commonly observed. Cystoscopic conditions, as a rule, are not favourable to the easy recognition of ulceration. Seen through fluids, the hyperæmia of the base of an ulcer may be indistinguishable from that of a patch of highly inflamed mucous membrane; moreover, the surface is frequently covered by a slough, membrane, or foreign body which hides the actual ulcer; so that from one or other of these various causes simple ulceration probably escapes recognition fairly frequently.

Five varieties of ulcer may be described: (1) *Ulceration due to thermal agencies, especially following diathermy;* (2) *Ulceration due to pressure, as from a stone, foreign body, or an in-lying catheter;* (3) *Ulceration occurring in simple infection of the bladder*; (4) *Solitary ulcer* (Hurry Fenwick); (5) '*Hunner's ulcer*'.

1. **Thermal Ulceration.**—This is more frequently observed at the present time than any other form of simple ulceration of the bladder, owing to the use of diathermy in the treatment of bladder tumours and other vesical lesions. For this reason it will be described first. The description may be taken as typical of that of simple vesical ulceration in general.

After a tumour has been destroyed and its site of implantation has been burned, a period elapses during which the resulting slough is being separated (*Plate X* D, page 178). Seen during this time, the area of actual tissue loss is covered by a bright white or yellowish membrane with clearly-defined borders. Sometimes this slough is of even texture, like chamois leather; at others it is shaggy. It is usually of small extent—less than a threepenny piece—is slightly elevated above the general bladder surface, and surrounded by a rampart of red and swollen mucosa, upon which may be seen a few bullæ. On passing away from the margin of the ulcer the œdema and hyperæmia rapidly diminish in intensity and merge into the normal vascularity of the bladder.

The slough is not shed until the subjacent healing is well advanced and the vascularization is on the wane, so that an area of actual erosion, uncovered by sphacelus, often evades observation. When visible, however, it resembles a patch of fine, red, healthy granulation tissue. The point at which the ulcer proper meets the marginal mucosa is not easily discerned, presumably owing to the high colouring of each, to the wetness of their surfaces, and to the uniform gradual declination of the ulcer edge. I have never seen a ring of bluish epithelium at the margin of a bladder ulcer comparable to that which occurs at the edge of a healing cutaneous lesion. As was first pointed out by Hurry Fenwick, the apparent depth of a bladder ulcer varies with the vesical distension. This regulates the extent to which the diseased area is extended or relaxed. When on the stretch it looks shallow and superficial, but when relaxed it appears smaller and deeper, whilst its base becomes rugose and its margin heaped up and irregular.

2. **Ulceration due to Pressure.**—This occurs in the situation where that pressure is exercised. In the case of stones and foreign bodies this is generally the vesical base, and with an in-lying catheter it is the mid-line of the trigone. When a foreign body is of elongated shape, ulceration occurs in the region of its extremities. Ulceration occurring from these causes often escapes observation owing to the interposition of the foreign body between it and the cystoscope. It is usually superficial, and its extent and shape are determined by those of the causal agent.

When an in-lying catheter is properly fixed its eye lies just within the urinary meatus, but frequently it is inserted for a greater distance, and its tip then encounters the fundus or apex of the bladder. As that viscus is continually drained by the presence of the catheter, the instrument may act like a tent-pole and a good deal of pressure may be brought to bear by its point, especially when it is made of rigid material—gum elastic, or more particularly metal—and I have seen quite well-marked ulceration arise therefrom.

3. **Simple Cystitis.**—Ulceration is rarely produced by simple cystitis if the desquamation described on page 81 is excluded. Occasionally, however, in *B. coli* infection of the bladder a round or oval

ulcer of small size is observed, having a slightly excavated base and margins which are undermined. It is usually single, but may be multiple. Ulceration occurs also in typhoid fever, the lesions having characters similar to those seen in the intestine.

4. **Solitary Ulcer.**—This was first described by Fenwick (1896). It is very rarely seen. Its site of election is the trigone, though it has been observed farther back. It is generally deep and crater-like and its base is covered with a slough. Its margins are raised, clean-cut, or undermined, and it is surrounded by a hyperæmic areola. Its evolution is slow. Fenwick in his classical description recognized three stages in its evolution : (*a*) The simple ulcer, the remainder of the bladder being healthy ; (*b*) Ulceration associated with cystitis and incrustation; (*c*) Infiltration of the muscular coat with vesical contraction. Occasionally a contact ulcer forms on the opposing wall of the bladder. Fenwick regarded the condition as amenable to appropriate treatment.

Ulcers having characteristics similar to those described above were not uncommonly seen in the old days prior to the introduction of the modern cold cystoscopic lamp, and owed their existence to the burns produced on the mucosa by its predecessor, the hot carbon filament lamp.

5. **'Hunner's Ulcer'** (Synonyms—'cystitis parenchymatosa' (Nitze), 'panmural cystitis' (Stevens), 'submucous fibrosis').—This is an important, though not very common condition and appears to be a definite pathological entity to which perhaps sufficient attention is not paid in this country. It was well known to Nitze, whose admirable description of it embodied most of the facts available even at the present day regarding its cystoscopic and microscopical appearances and its symptomatology (*Lehrbuch der Kystoskopie*, 2nd edition, p. 207). The disease was re-described by Hunner in 1914, and is most often referred to by his name. Paschkis regards this and Fenwick's ulcer as quite different conditions.

The distinctive lesion is an inflammatory focus which develops in the middle layers of the bladder wall and appears to have its beginnings in the submucous coat. Papin says that it is a special affection of unknown pathology, which is neither tuberculous, specific nor neoplastic and which cannot be accounted for either by traumatism or lesions of the central nervous system. The microscopic features are those of any small area of inflammation, there being vascular engorgement, thickening of the basement membrane, and round-celled infiltration, the latter being, as a rule, particularly in evidence. As the focus enlarges, it extends on the one hand to the muscular coats, and it may involve the perivesical tissues, even giving rise to a perforation which has been known to implicate the pelvic cellular tissues or peritoneal cavity. Advancing towards the bladder cavity on the other hand, the inflammatory area affects the mucosa and produces a central ulcer. Ulceration is therefore a secondary phenomenon. According to the size of the inflammatory focus, it will be seen that it may remain localized to the submucous area or involve any part, or the whole thickness of the bladder.

Two theories are advanced to account for this pathological entity :—

a. That it represents an unhealed remainder left after an attack of acute cystitis. The facts, however, that few of the subjects give a history of acute cystitis and that the usual onset is insidious, appear to belie this view, a view that regards the mucosal inflammation as primary and the submucosal condition, which is the peculiar feature of the disease, as secondary and residual.

b. Some evidence exists to support the hypothesis that the foci are caused by blood-borne organisms, though here again the proof is lacking. Septic foci in the urethra, teeth, tonsils, nose, gall-bladder, etc., have been alleged as absorption grounds, and attention directed to the cure of these has appeared to react favourably on the bladder lesion ; sometimes indeed a relapse of the primary lesion has been followed by recrudescence of bladder symptoms. Meisser and Bumpus have grown organisms from the teeth and tonsils of affected patients and have experienced some success in reproducing similar bladder lesions in the lower animals. Streptococci are apparently the offending pathogenic organisms. This theory of blood-borne infection of the deep bladder structures enjoys a good measure of support at the present time. It appears especially likely that urethral sepsis is a site from which absorption may arise.

Cystoscopic Appearances.—The ulcer is usually, though not invariably, single, and its site of election is the vesical dome. Very few have been observed in the periureteric area, and none, so far as the writer knows, on the trigone itself. The margins of the actual ulcer are ill-defined and merge insensibly into the surrounding redness and œdema. A few ragged sloughs may be seen on or near the ulcer. The whole area of involved bladder wall may be no larger than a threepenny piece. The bladder capacity is severely reduced and the organ may refuse anything above 2 oz. of lotion. Attempts to exceed this acquired maximum cause intense pain and are very liable to give rise to bleeding. Nitze, employing an irrigating cystoscope, gently over-distended the bladder whilst the ulcer was under inspection and actually watched the surface of the ulcer tear and start to bleed, an observation which accords well with the patients' statements that if they attempt to retain urine too long they suffer from hæmaturia.

I have myself touched such an ulcer with a ureteric catheter and have noted how readily it bled.

The remaining portions of the bladder may be perfectly healthy, and this, in fact, constitutes the customary picture. There is then little or no sediment in the urine, and the microscope reveals only a few erythrocytes, an odd leucocyte, and no organisms. In such patients the slightness of the deposit in the urine is in striking contrast with the severity of the patients' discomfort (Nitze).

In other cases, however, the whole of the bladder is inflamed, and this has the important disadvantage that it masks the actual ulcer. Perhaps that was why Hunner christened them 'elusive ulcers', a term which, though it has had some vogue, does not commend itself to the writer. The more important part of the cystoscopic picture is therefore overlooked, and doubtless many such cases are labelled as simple cystitis. The urine in such events contains a deposit resulting from the cystitis, but the severity of the symptoms should proclaim a lesion more grave than a simple cystitis.

Almost all patients are in mid-life, falling between the ages of 25 and 55, and a marked preponderance of females is found amongst them—about 5 women to 1 man. The onset is insidious and at first there are intermissions, but eventually the symptoms become severe. Micturition is increased in frequency to so great a degree that the case forcibly recalls one of urinary tuberculosis, the bladder incessantly demanding to be emptied day and night. It admirably illustrates the distressing effect of bladder ulceration on capacity (*see* page 38). Suprapubic and urethral pain are marked and hæmaturia is often observed. The menstrual flow causes an exacerbation in the severity of all symptoms.

Treatment.—Hunner lays emphasis on the localization and eradication of any possible source of absorption as the first step in the treatment of this disease. In practice it rarely proves sufficient, so that resort must be had to destruction of the ulcer either by excision or by fulguration. The former has been the practice of many surgeons in the recent past, but it is at present somewhat under a cloud as there have been some deaths and many recurrences (up to 50 per cent—Gilbert Smith). It is simplified in some measure because the ulcer usually occupies the bladder vault, but on the other hand the shrunken size of the viscus and the large extent of wall involved—always greater than that suggested at cystoscopy—actually render the operation one of considerable difficulty. Hunner attributes recurrences after excision to incomplete removal of the affected area, but Furness remarks on the difficulty of seeing the extent of the ulcer at operation and the consequent danger of leaving affected bladder wall behind.

In America, where these ulcers appear to be much commoner than they are in England or on the Continent, the modern tendency is towards treatment by perurethral fulguration in the first instance. Recurrences are also common with this line of action, but the burning can be repeated. Gilbert Smith states that " with each recurrence the number of treatments required to give relief becomes less ". Most surgeons now reserve resection for those cases in which fulguration fails. Whatever the treatment, there appears to be a strong disposition to recurrence.

CHAPTER VI.

TUBERCULOSIS OF THE URINARY TRACT.

URINARY tuberculosis is one of the most interesting and important diseases coming within the province of the urologist, and its interest is maintained pathologically, clinically, operatively, and cystoscopically. The intravesical picture takes a number of various forms and requires careful interpretation, whilst on the estimations of renal function which are made with the aid of the cystoscope depend the indications for surgical interference.

Technically the disease is a difficult one from the cystoscopic point of view, particularly in its more advanced phases, for then the organ becomes much reduced in size and may be extremely irritable. These features may loom very large in the handling of a case of vesical tuberculosis, and occasionally they render cystoscopy impossible. It is thus a sphere in which a good cystoscopist may display his skill to advantage, and in which his experience may carry him to success, when a less accomplished operator would have failed. Having regard to the importance of the examination and to its possible difficulties, the writer holds that none save those who have considerable experience in the use of the cystoscope are justified in undertaking the diagnosis and treatment of a case of urinary tuberculosis.

Importance of the Preliminary Diagnosis by Clinical and Pathological Means.—From amongst the cases of cystitis which present themselves the surgeon should attempt, prior to cystoscopy, to single out, by clinical, pathological, and radiological means, those which are of tuberculous origin. The importance of this preliminary diagnosis is twofold :—

1. This type of bladder surpasses most others in its demand for skilful and gentle handling. Once it is over-distended by lotion, hæmorrhage may put out of court all possibility of cystoscopy for that day. Occasionally also a viscus which has a diminished capacity, yet one in which cystoscopy is quite feasible, will, if roughly treated, become so reduced in size as to render the examination impossible. An organ which the surgeon knows to have these characteristics will be handled with becoming respect from the beginning.

2. The tuberculous bladder should never be submitted to examination for longer than the minimum of time requisite to acquire

the various indications for treatment. All investigations should therefore be carried out quickly and efficiently at a single sitting.

These desiderata are more likely to be complied with if the operator is forewarned of the nature of the disease. He will then be able to proceed with greater rapidity to acquire his various data. The preliminary examination is therefore important, and it may not be out of place to enumerate briefly some of the points in the evidence which lead us to form the opinion that the process is tuberculous. Ultimately, of course, the finding of the organism is the essential thing, and that is a pathological problem. In the search for it the bacteriologist should employ not only the microscope but also, in case of doubt, guinea-pig inoculation. It is, however, the clinician's duty to suspect the nature of the disease, and of the pre-cystoscopic factors which are the most helpful to him the following are specially significant:—

1. Symptoms of cystitis, which are generally well marked. The most distinctive feature about this cystitis is the insidious nature of its onset, the patient being unable to tell exactly when the disease started.

2. The progressive nature of the disease, it being for the most part uninfluenced by medical treatment. This, however, is sometimes masked by temporary intermissions in the symptoms.

3. The age incidence is almost confined to the years between 20 and 45.

4. The presence of pus in urine, which is generally acid and is sterile on culture. I always suspect a purulent urine which is found to be sterile on culture.

5. The presence of other tuberculous lesions, or a family history of tuberculosis.

6. Polyuria, which is best marked in the early stages.

Unfortunately it is not always easy to make the diagnosis prior to the cystoscopy, and in such circumstances the cystoscope may supply the first hint that the process is tuberculous. Whenever one examines a bladder for cystitis of unknown origin, and especially if the case has run a protracted and resistant course, the possibility of the lesion being tuberculous should be borne in mind during the study of the vesical mucosa.

Preparation of the Patient.—

Anæsthesia.—Good anæsthesia is more than usually important in the cystoscopy of a tuberculous bladder owing to its size and to the liability which it shows to empty itself involuntarily. Sacral anæsthesia is generally more satisfactory than local anæsthesia as it controls a wider area, and it will be found quite suitable for mild cases. It may, however, be insufficient for the more advanced types of cystitis, and general anæsthesia may then be employed. In the worst cases, however, spinal anæsthesia will be more efficient than any other form. It gives the deepest relaxation obtainable owing to the fact that it controls those bladder centres situated in the lumbar region more effectively than do the other methods. It is, however, rarely required.

Preparation of the Bladder.—The damaged mucosa of these tuberculous organs is particularly susceptible to any secondary sepsis which may be introduced. The possibility of contamination calls for the most rigid aseptic ritual, as its advent will greatly augment the sufferings of the patient.

In bladder lavage over-distension must be avoided, as it is liable to lead to further reduction in the capacity of the organ and to hæmorrhage. The lotion should be injected very slowly and rise in quantity by easy stages, the first wash being 1 oz., the second 2 oz., and so on (page 51). The surgeon will note on the piston of his syringe the quantity which can be safely employed, and will limit his subsequent injections accordingly. If hæmorrhage occurs, it may be disastrous to the procedure, though it can as a rule be controlled by adrenalin.

Even when the bladder is very small ('thimble bladder') a satisfactory examination may generally be attained, provided the viscus can be cleared of pus and kept free from hæmorrhage. Actually the reduction in size has its compensations, in so far as the walls are closer to the lamp and prism, and therefore the illumination and magnification are good. I have on several occasions catheterized both ureters in a viscus whose capacity was less than 3 oz.

Intolerance of the bladder during preparation, and its small size, have often been responsible for rousing one's suspicions as to the nature of the disease. Their degree cannot always be accurately forecasted prior to commencing the preparation of the bladder, for they do not necessarily run *pari passu* with urgency of micturition ; in fact some patients whose diurnal frequency and nocturia are very distressing will yet be found to have bladders of normal, or almost normal, capacity. Nevertheless, the severer grades of urgency will usually be found in the more profoundly damaged and diminished bladders. Early ones are in most instances easy to prepare and examine, whilst the late ones are troublesome.

Sometimes, in spite of all care and patience, the examination is unsuccessful. The patient should then be put to bed for a week or ten days on a fluid diet and have frequent fomentations to the hypogastrium and perineum. Two drachms of cod-liver oil three times a day and bladder sedatives should be administered by mouth. At the end of this time cystoscopy should be repeated under spinal anæsthesia, when it will probably be found that the organ is easier to deal with, and the examination will prove successful.

Object of the Cystoscopic Examination.—The predominance of symptoms of cystitis, which is such a marked feature in this disease, was responsible for the view, held up to twenty-five years ago, that the bladder was the primarily affected organ, and that the kidney became secondarily infected. This led to surgical energy being directed to the bladder instead of the kidney. Now we know that the kidney is primarily at fault, that almost invariably the disease is unilateral in its early stages, and that the bladder is affected secondarily. We know also that the other kidney will become affected in a large proportion of cases at a later date, and that if we remove the primarily involved organ the prognosis of the disease will be good, both as regards the bladder, which will heal, and as regards the other kidney, which is not very likely to become secondarily infected.

These elementary statements foreshadow the data required of the cystoscopic examination. From them it will be seen that the surgeon :—

1. Must *confirm the diagnosis* of tuberculous mischief by noting the cystoscopic appearances. (In the event of this not having been suspected up to the present, he should be led by the vesical examination to a diagnosis of the same.) Whilst this confirmation rests mainly on the intravesical manifestations—which will be studied later—much useful information may be gained by observing the behaviour of the bladder during preparation.

a. Its small size and irritability have already been referred to.

b. The speed at which the organ washes clear frequently indicates that the pus present in the urine has been derived mainly from the kidney. If the bladder itself is little involved, it will be possible to obtain a clear wash-out after the first two or three attempts have been made.

c. The type of urine obtained has certain peculiarities. It is generally acid. Its appearance is modified by the presence of tuberculous pus, which has a pale yellow-ochre tint. As there is usually a comparatively slight admixture of mucus owing to the small area of vesical involvement, the pus settles quickly to the bottom of a specimen glass as a flat creamy layer with no flocculent mucus above it, such as occurs when the cystitis is diffuse. The inference is that it is derived from a renal lesion. However, isolated flocculent masses suspended in the urine above the deposit, or adhering ubiquitously to the sides of the containing beaker, are somewhat characteristic, but they are quite different from the billowy appearance which is presented when pus is floating on mucus.

2. He must seek evidence as to the *kidney primarily affected.* This again is almost invariably the work of the cystoscope (*see*, however, page 120, 'Excretion Urography'). Occasionally, however, as will be seen later, the bladder picture is inconclusive, and therefore it is desirable, *before* the examination is undertaken, that as much evidence as possible should be collected clinically regarding which kidney is the one primarily involved. Three methods of examination should be employed :—

a. Renal palpation. In this examination it should be remembered that there is some danger of mistaking a hypertrophied and possibly tender, healthy kidney for the diseased one. In many instances the tuberculous organ is actually diminished in size.

b. Rectal or vaginal examination, whereby the thickened lower ureter may be palpated.

c. X-ray examination, which may show disease of the kidney,* especially when calcification has occurred (*see Fig.* 68) ; the presence of the opposite kidney, and the existence of tuberculous foci in the lung, mediastinum, or retroperitoneal tissues.

The cystoscopic methods of diagnosis are discussed later.

3. He must examine the *condition of the opposite kidney.* This is dealt with on page 110, and in Chapter XXIII.*

BLADDER APPEARANCES IN URINARY TUBERCULOSIS.

The lesions regarded as characteristic of tuberculosis of a mucous membrane are the so-called tubercle and tuberculous ulceration. In the bladder the picture observed through the cystoscope may or may not show these lesions. It is popularly believed that the diagnosis of urinary tuberculosis is made by observing such specific manifestations, and particularly the tubercle itself, on the mucosa. This is not so. An actual tubercle is somewhat rare, and tuberculous ulceration is often masked by other pathological changes in the mucosa, so that the cystoscopic diagnosis is generally arrived at by observing the distribution and severity of the vesical lesions rather than by their specific nature. In practice it is found that the bladder picture in vesical tuberculosis is similar to that of other forms of severe cystitis in which ulceration and polypoid hypertrophy occur. The cystitis is limited as a rule to the neighbourhood of one or other of the ureteric orifices up to the time that secondary infection with pyogenic organisms is superadded, when it spreads to the remainder of the bladder. It is unfortunate, but nevertheless true, that the

* Excretion urography as a means of showing the affected kidney and the state of the opposite organ is discussed on p. 120.

characteristic early tubercle, as well as tuberculous ulceration, are generally lost amongst lesions common to other forms of cystitis.

Vesical changes may be absent. Before discussing the vesical changes it should be pointed out that a number of cases of renal tuberculosis occur in which there is no intravesical manifestation of the disease. A few of these are early cases where the bladder appears hitherto to have resisted infection. Most of them, however, result from ureteric occlusion.

A closed ureter in renal tuberculosis occurs in about 10 per cent of cases. Not only does it shield the bladder from infection, but it also hinders the diagnosis by excluding pus and bacilli from the urine. Investigation of the renal function will, however, demonstrate the absence of excretion from that side, and may lead to a correct diagnosis when taken in conjunction with other signs pointing to the development of a pyonephrosis. Occlusion of the ureter is due to sclerosis and is therefore a moderately late phenomenon. Generally some bladder infection will have occurred before the closing down of the tube. Further, when sclerosis has occurred to such an extent there will usually be some shortening of the ureter, which will give rise to retraction at the meatus and deformity of the bladder. Therefore it is only in comparatively rare instances that there is a complete lack of cystoscopic evidence. Nevertheless a good many of these cases with occluded ureters remain undiagnosed until late, whilst in some the tuberculous origin is not appreciated, though the diagnosis of pyonephrosis may be made.

Hœmaturia is the first symptom in a few instances, and may occur before there is any vesical involvement. It is then renal in origin and occurs principally in that type of disease which primarily affects the renal papilla. In order to trace it to its anatomical source, cystoscopy must be performed during an attack of bleeding. It may even then be difficult to attribute it to its correct pathological cause, though in this type the bacilli will probably be found abundantly in the urine.

Pyuria is also occasionally observed before bladder changes have supervened, and before any symptom has shown itself, though as a rule it is preceded or accompanied by frequency of urination. Unless the pus is unusually copious for so early a stage it will escape detection by the cystoscope (*see* page 327). Ureteric catheterization would, however, locate its source.

Early Lesions.—

Hyperœmia.—Hyperæmia at the ureteric orifice is the earliest vesical manifestation of the presence of a tuberculous kidney. This, of course, may occur in any form of renal irritation and is not pathognomic of tuberculosis. It may be due in part to the irritation of abnormal and infected urine, and then shows itself as a cone-shaped area of redness, having its apex at the ureteric orifice, and its base towards the meatus.

As time goes on the meatal hyperæmia becomes more evident from the continued passage of irritating fluid along the ureter. Infiltration and stiffening of the orifice follow, and the ureteral wall is soon invaded by tubercles. It becomes raised above its usual level in relation to the bladder wall, and at the same time its mobility disappears, so that when an efflux occurs it is unaccompanied by the characteristic elevation and contraction, and the orifice becomes inert and assumes a passive rôle. The effluxes, however, at this stage are abnormally frequent, owing to the polyuria which occurs from the diseased organ at this period, and also on account of the irritating qualities of the urine.

Tubercles.—It may be repeated that though the tubercle and tuberculous ulceration are the lesions typical of this disease, they are

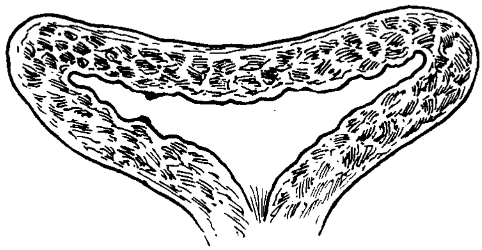


Fig. 66.—Shows how infection by contact is responsible for the involvement of the summit of the bladder.

not frequently observed, that, in fact, they are generally lost amongst other lesions which are in no way characteristic of the complaint.

Tubercles when seen occur in the first instance near the ureteric orifice which corresponds to the diseased kidney, and often on its very margin. Usually they involve the mucosa of the bladder proper rather than that of the trigone—a fact which would seem to indicate considerable resistance on the part of the latter structure, for the jet of infected fluid travels downwards and inwards over its surface. They show a predilection for the mucosa overlying and surrounding the intramural ureter, where their presence is probably accounted for by direct spread from that infected tube. From the vicinity of the meatus the disease travels upwards and inwards towards the fundus, where it may develop freely. For some time, however, it remains limited to the same side of the bladder as that from which it sprang.

Next in frequency to the above-mentioned areas, tuberculous infection involves the summit of the organ (*Fig.* 66). Probably this occurs even more commonly than has been recognized, for the attention of the surgeon being absorbed with the area of ureteric involvement, he is liable to neglect the apex of the viscus. It often repays a search, and should never be overlooked, for the picture presented there is of more recent development, and on that account may be more characteristic than the one in the neighbourhood of the ureter. On one or two occasions when in doubt I have obtained valuable confirmatory evidence from an inspection of this area. Pilcher reported a case in which it was the only one involved, and I have recently seen a similar occurrence. The infection of this region is probably due to tissue contact when the viscus is empty, and as micturition occurs frequently the two areas of mucous membrane are often in apposition.

Genital tuberculosis which is involving the bladder may spread from the seminal vesicle and then involves an area lying immediately behind the ureter on the same side. The ureter itself shows no change until encroached upon secondarily by the extension of the process. It may also spread from the prostate (*see* page 252).

PLATE IV.

A, Four closely set tubercles near a vessel. Mucosa pink. Note stippled appearance of the membrane. B, Tuberculous ulceration on fundus. Upper margin slightly undermined. Tubercles on lower edge and at lower and outer margin of circle. Small slough on base of ulcer. C. Numerous tubercles on a much swollen and pleated mucosa. D, Right ureteric orifice—ulcerated and excavated. Tubercles and purulent slough on margins. Bullous œdema below and external. Cystitis of moderate severity. E, Tuberculous ulceration. Intense cystitis. Translucent bullæ. F, Catheter in ureter corresponding to healthy kidney. Cystitis has spread across and surrounds this orifice. Polypoid swelling, such as may be encountered in any form of severe cystitis, is well depicted.

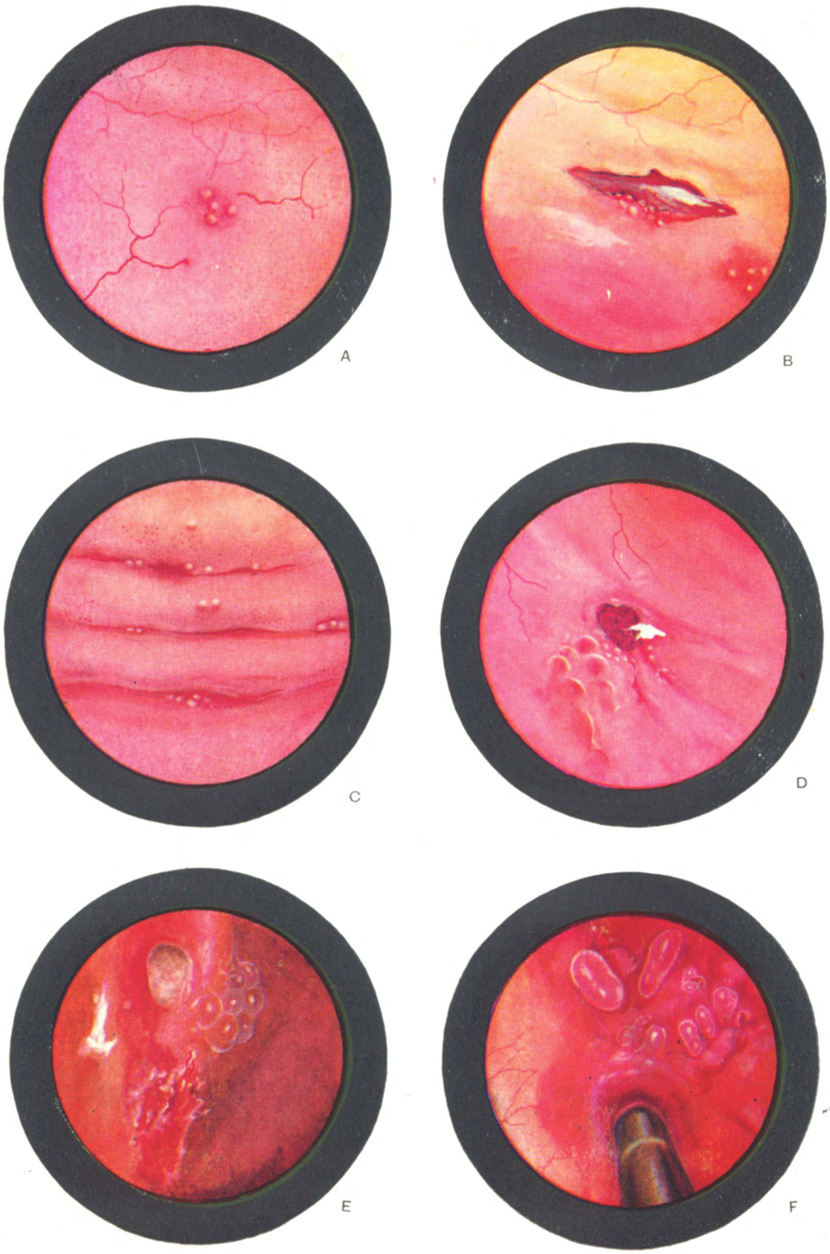
In the very earliest stages the tubercle is said to be translucent, but it is rarely seen in this condition. Later it progresses through white, grey, and finally yellow, as caseation advances (*Plate IV* A). It is surrounded by a narrow ring of congestion quickly fading away into the normal, healthy or perhaps slightly injected, vesical mucosa. Close inspection with the cystoscope can detect the small vessels entering into the formation of these areolæ.

The relationship of tubercles to the blood-vessels is generally intimate. A solitary tubercle may be perched on a large vessel, or more frequently at the junction of two vessels, and according to Marion and Heitz-Boyer multiple lesions may be seen like granules situated along the ramifications of a branching artery.

Single tubercles are uncommon; they usually occur in groups, and these are never widely disseminated over the bladder surface, but are, as a rule, confined to a few fairly circumscribed areas.

PLATE IV.

TUBERCULOSIS OF THE BLADDER



Ulceration.—Rupture of the tubercles occurs sooner or later, leaving an area of ulceration similar in extent to that previously covered by tubercles. In the bladder the ulcer displays the same characteristics as tuberculous ulceration seen elsewhere on mucous membranes, presenting a shallow, crateriform cavity with undermined margins. The edges are, as a rule, irregular in outline, but may be difficult to discern clearly. The base is frequently covered with slough, and this may be sufficiently extensive to hide the ulcer. On the margin of the ulcer at irregular points, and sometimes surrounding it completely as a ring, may be seen tubercles which have not yet ruptured but which will shortly do so, thereby enlarging the area of ulceration. When first formed the ulcers are shallow, but as time passes they increase both in depth and in superficial extent, and they may coalesce with neighbouring ulcers. The sites where progress is most evident are the immediate vicinity of the ureteric orifice and the fundus.

Bullous Œdema (*Plate IV* E).—The tuberculous bladder is a favourite site for the development of bullous œdema. Few bladders are seen in which some is not present, and it may be extremely marked. It frequently surrounds the ureteric orifice and may entirely hide it from view. Occasionally it protrudes into the bladder cavity like a mass of spawn.

When cystitis is severe it is accompanied by the formation of numerous polypoid excrescences (*Plate IV* F) similar to those described on page 83. These often reach from the neighbourhood of the ureter up into the fundus and may involve large areas of the viscus.

Late Lesions.—Finally, secondary sepsis may be added. When this unhappy complication has supervened the mucosa becomes uniformly reddened, swollen, and velvety, and may show many œdematous masses. It bleeds easily, loses its lustre, and reflects light badly. The bladder diminishes rapidly in capacity and becomes more refractory than ever. Indeed, it now presents one of the most difficult problems which the cystoscopist ever encounters, and requires much tact and judgement in its handling. Unhappily this is a stage at which too many patients, especially amongst the hospital class, reach the surgeon. In several instances I have been told that the bladder has been 'sounded for stone', and cannot escape the suspicion that the superimposed infection may date from that unfortunate and misguided adventure.

Changes around the Ureteric Orifices.—The changes occurring at the ureteric orifice as a result of infection from a tuberculous kidney have already in part been described. Hyperæmia, swelling, and tubercle formation have been noted. It has been shown that the tubercles affect the lips of the meatus. When these ulcerate the orifice assumes a variety of appearances according to the relative parts played by ulceration and œdema. If ulceration takes the chief rôle, the margins are irregular in outline and appear moth-eaten, the meatus is open and may be conspicuous. If, however, œdema is marked, the meatus is encroached upon, and may be quite closed, so that great difficulty may be experienced in identifying it. In the worst cases the swelling goes hand in hand with the formation of polypoid inflammatory masses, and then the ureter may be unrecognizable amongst the numerous crypts, recesses, and other irregularities which intervene between these polyps.

When the tuberculous process is well established in the ureter the walls become thick, rigid, and tube-like. This is reflected in the appearance of the orifice itself, for now, in addition to being elevated, the mouth is gaping, rigid, and motionless. Tubercles may be seen on its margin, and it may be likened to the orifice of a crater. Finally, when the ureter is sclerosing and so becoming shortened the orifice is dragged up towards the kidney and lies at a higher level on the bladder wall, causing the trigone to become distorted. It often appears to occupy the deepest point of a conical recess and its lips are no longer elevated as formerly. The term 'golf-hole ureter' has seized the imagination of the medical public and is often incorrectly applied to the elevated and gaping crateriform orifice of the middle period. Its correct application is to this retracted orifice of the late stage.

When secondary sepsis occurs it usually obliterates all characteristic features completely, and brings the second ureteric orifice to a common level with the primarily affected one, the only cystoscopic appearances presented being those of intense cystitis. Inspection alone may be unable henceforth to decide which is the affected kidney. To the cystoscopist both ureters now appear to have changed their position, and to lie high on the posterior wall facing him, an impression which results from the fact that when the radii of the bladder diminish the trigone takes little or no part in the contraction (*see also* page 88 and *Fig.* 65).

It will be seen from the above description that the cystoscopic appearances may be either characteristic or non-characteristic. In the former class lie the tubercle and tuberculous ulceration, though the latter may be mimicked closely by simple ulceration, which of course is rare. In the latter category lie the early and the late phenomena—namely, total absence of change, ureteric hyperæmia, bullous œdema, and the manifestations of secondary infection—all of which may occur in other urinary diseases. The distribution and severity of the pathological changes, however, are suggestive up to the time when secondary contamination reduces all parts of the organ to a common level. However, the cystoscope may fail in making a diagnosis not only on this account but also because even the characteristic lesions are frequently hidden ; tubercles may be lost from view between folds of œdematous mucosa, and ulcers may be covered with sloughs and débris, or bleed as the result of manipulation, so that clots hide them from view.

DIAGNOSIS OF THE KIDNEY PRIMARILY AFFECTED.

The cystoscopic features above enumerated serve as the first and most important indicators in the search for the primary focus of urinary infection. Cases will, however, fall naturally into one of two classes according to whether they are examined before or after generalized cystitis has supervened. If definite ulceration or tuberculous change at one ureteric orifice can be seen, the corresponding kidney may, without doubt, be impeached. The diagnosis is then easy. When, however, the cystitis has become generalized, and ulceration can no more be recognized owing to widespread œdema, bilateral catheterization and the study of the cellular elements derived from the kidneys must be resorted to.

Catheterization of the *diseased* ureter may be complicated in several ways. It is often impossible to see an orifice which is hidden by ulceration, pus, or œdema. Where the area of pathological change is small and is obviously covering the site of the ureter, a catheter may sometimes be passed by palpating the surface of the diseased area with the tip of the instrument. Frequently it runs home at the first or second venture. Chromocystoscopy (*see* page 375) may be employed as a colour indicator in the hope that it will show the position of the orifice, but though very valuable in assisting the discovery of the ureter corresponding to the healthy kidney, it is less successful in showing that on the diseased side owing to its excretion being late and feeble.

Even after penetration has been accomplished, difficulties may still be encountered. The ureter may be strictured, and the catheter will then be obstructed. Tuberculosis of the ureter affects the upper and lower segments of that tube first; the middle section is involved later. Strictures, therefore, occur in the upper and lower thirds of the tube rather than in the middle. Even where the catheter does not pass it will sometimes be possible to collect urine, as the stricture, though impassable to a catheter, may yet be permeable to fluids. Conversely, the ureter may be dilated so that urine and pus elect to escape into the bladder alongside the catheter rather than through it, and little or nothing will be collected. Again, if the catheter passes freely to the renal pelvis, it may be blocked by débris which it has collected during or subsequent to its passage. It is always expedient, therefore, to force a few minims of sterile lotion through the lumen by means of a syringe as soon as the instrument is *in situ.* Fortunately catheterization of the diseased side is not necessary in all cases, as will be pointed out immediately.

EXAMINATION OF THE OPPOSITE KIDNEY.

There are three possible methods of obtaining information concerning the function of the opposite kidney: (1) *Chromocystoscopy*; (2) *Ureteric catheterization*; (3) *Excretion urography.*

1. **Chromocystoscopy.**—This method serves to indicate the presence of a kidney on that side, and will, if the efflux is copious, be fair evidence that it will carry on the work of the body. Care must be exercised lest undue importance is given to the period of onset of the elimination of indigo-carmine, for this drug is sensitive to insignificant lesions in the kidney, and it is well known that the second organ in renal tuberculosis is almost invariably affected by some degree of secondary nephritis. The dye should be administered intravenously, and particular attention should be paid to the copiousness of the efflux when it has reached its height.

The disadvantage of the method is that it gives no information regarding the cytology of the urine derived from the organ which is expected to carry on after its diseased neighbour has been removed. This may be of little moment in a disease which has no tendency to become propagated to the second kidney, but it is a vital matter in one such as renal tuberculosis, which sooner or later affects the opposite gland.

2. **Ureteric Catheterization.**—This method should be employed even when the side of incidence can be diagnosed by meatoscopy. Here it must be applied to the *opposite* ureter, with the dual object of estimating: (*a*) The function of the kidney; (*b*) The cell content of the urine obtained.

In practice it is convenient to slip in the catheter after the indigo-carmine test has been utilized. If the latter is satisfactory, the only object of the catheterization will be to collect a specimen for cytological investigation. Examination of this specimen is made especially for leucocytes and tubercle bacilli. The former must always be regarded with suspicion, especially if present in any quantity, and the guinea-pig test should then be applied before nephrectomy is decided upon. If tubercle bacilli are found, the disease is already bilateral and unsuitable for operation. Casts and albumin are often found, and do not in themselves constitute a contra-indication to operation. They are evidence of the effect produced on the opposite kidney by the disease in its fellow. They generally disappear in course of time after nephrectomy.

Double Catheterization.—Many authorities advise double catheterization. I do this on some occasions, but am not greatly in favour of it. Its advantage is that it confirms the presence of disease in the suspected kidney, but this benefit is, I think, more than counterbalanced by the danger of constitutional disturbance, which is occasionally severe.

The quantity of urine obtained from the two opposite sides if catheterized will rarely be identical. In an early case the diseased organ secretes an abnormal quantity of pale fluid of low specific gravity. Later, as destruction advances, the amount of urine diminishes and the pus increases. At this period false readings are liable to be obtained owing to the catheter being plugged. The diminution of urine obtained from the affected kidney is compensated by an increase from its fellow, and this is generally of low specific gravity, frequently slightly albuminous, and may contain hyaline and granular casts. When the disease has become bilateral, it, of course, contains tubercle bacilli and leucocytes.

3. **Urography.**—The subject of urography in renal tuberculosis is discussed on p. 112.

Renal Function.—Following the collection of specimens for the microscope will come the application of a test to establish the functional efficiency of the second kidney. This important matter will be best studied in Chapter XXIII.

HEALING OF THE BLADDER.

When the supply of infected material is cut short by nephrectomy the bladder tends to heal. For a time, however, it remains hyperæmic though relatively free from deposit. When the ureter has undergone much retraction this persists, the trigone being permanently asymmetrical. Puckers are sometimes observed on the vesical wall radiating from the situation of the ureter and indicating the distortion to which the viscus has been subjected. Occasionally actual cicatrices may be seen on the vesical wall. These follow patches of localized ulceration, and present the weak appearance which is characteristic of healed tuberculosis elsewhere. Sometimes healing may occur at one point whilst spread occurs at another, a serpigenous ulcer resulting.

Persistence of Bladder Symptoms.—It has been said that bladder symptoms take as long to disappear after nephrectomy as they had persisted before operation. This rough generalization is useful to keep in mind, but is nevertheless inaccurate. Where severe lesions have been present and bladder contraction has become well established a permanent reduction in its size will remain which is largely due to interstitial change in its wall. Pyuria of vesical origin is also a frequent aftermath of the disease, especially where secondary infection has grafted itself on to the tuberculous lesions. It may give rise to persistent bladder symptoms.

Another cause for vesical irritability is tuberculous ulceration unassociated with much surrounding cystitis. In 1913 Heitz-Boyer reported three cases in which he had destroyed such areas by what practically amounts to the high-frequency current ('l'étincelage'), taking in at the same time an area of surrounding tissue about 1 c.m. in extent. After a period of reaction and sphacelation the membrane detached itself and fresh epithelialization was complete in about one month.

Parisi, reporting 21 cases from Marion's Clinic, gives these localized patches of ulceration as the chief indication for the employment of this form of treatment, though he remarks that good results are

PLATE V.

A, Study of ulcerated calix. Note lines of tubercles radiating to capsule and also subcapsular foci (cf. *Fig.* 67, a). B, Acute renal tuberculosis. Ulceration rapid. Pus was fluid and fœtid, indicating a mixed infection which accounted for the rapid, destructive process (cf. *Fig.* 67, c).

also to be obtained in secondary infections, especially when not too diffuse in distribution, and he attributes the improvement to the fact that the high-frequency current has well-recognized antiseptic properties.

Patients who have been submitted to nephrectomy, and especially those who have a severe grade of cystitis, should be kept under observation in the Out-patients' Department in order that satisfactory healing of the bladder may be ensured. When symptoms persist for more than a reasonable length of time, cystoscopy should be advised so that the cause of failure to heal may be ascertained. The examination may bring to light lesions which are quite insignificant as compared with the symptoms which they are producing, and which may be amenable to treatment by diathermy.

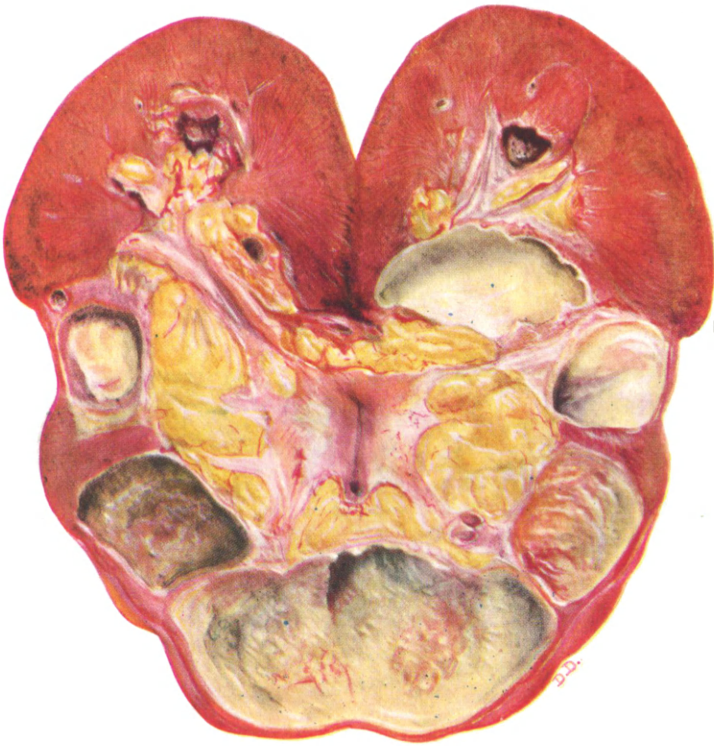
UROGRAPHY IN RENAL TUBERCULOSIS.

Ascending Urography.—In the early days of ascending urography renal tuberculosis was regarded as a risky field for its use and it was not practised freely. Experience has fortunately shown these fears to be exaggerated, though it is still a disease in which ascending

PLATE V.

RENAL TUBERCULOSIS

A



B

urography should be employed with discretion. The principal dangers are : (1) Catheterization of the ulcerated ureter may be followed by a reaction, and though this is occasionally to be risked in the actual investigation of the disease, it should be avoided where possible. (2) The ulcerated papillæ allow easy access of the urographic solution to the tubules, and in some instances lines on the plate may be observed following the course of the tubules and radiating from the situation of the ulcer to the capsule. Papin points out that it is difficult to estimate the amount of pressure required, for the tuberculous kidney is not very sensitive to distension. (3) The trauma caused to a severely diseased organ would appear to be a ready method of disseminating organisms.

Urography in renal tuberculosis was first employed by von Lichtenberg and Dietlin, who reported 11 cases. Braasch and Papin have employed it in a fairly large number of patients. The latter considers that the information which is obtainable thereby is not to be disregarded, but he takes the precaution of performing the examination on the eve or on the actual morning of the operation. Braasch says that " only when the diagnosis is in doubt should pyelography be employed ".

The picture obtained will vary widely with the stage and type of the disease. There is no typical or characteristic picture. Having learned the nature of the complaint from preceding examinations, we must interpret the plate in the light of our knowledge of the anatomical types of the disease. I have attempted to illustrate some of the most characteristic features of this disease in *Fig.* 67, to which are related *Figs.* 68–70 and *Plate V.* These should be most carefully studied during the reading of the succeeding paragraphs.

1. In the early stage only a minor inflammatory dilatation of the pelvis is observed.

2. In the common ulcero-cavernous form the erosion of the papillæ will be outlined as single or multiple, rounded irregularities occupying the sites of the papillæ (*Fig.* 71). These are generally more or less filled with purulent or putty-like débris, and the admixture of this with the solution gives an irregular moth-eaten margin to their shadow (*Fig.* 72). When the cavities are completely occupied by such débris access will be forbidden to the solution, so that they will not be outlined.

3. The tuberculous abscess often develops deep in the cortical parenchyma, and may communicate with the pelvis by a free opening or by a tortuous and narrow channel, or may be completely shut off. The pyelographic picture will vary according to the freedom of access afforded to the solution, to the size and depth of the deformities, to the degree to which they are occupied by necrotic débris, and to their position and number.

4. The *ureter* is invaded early in the disease and undergoes changes which produce characteristic and pronounced pictures on urography. At the period when tubercles are invading the musculature of the ureter the tube becomes atonic and the nodes and spindles of the healthy ureter disappear. Dilatation of the ureter supervenes in many cases, and the lumen, seen radiographically, may show several times its customary breadth. Some of the most severe examples of

Fig. 67.—Diagram to show : (1) Several principal types of renal tuberculosis. (2) The way they would be represented on ascending and descending urography. (3) Six varying grades and types of ureteric tuberculosis. The ureter in each instance is appropriate to the kind of renal lesion presented. a is drawn from *Plate V*, A ; b from *Fig.* 69 ; c from *Plate V*, B ; and e from *Fig.* 70.

a, Ulcero-cavernous type, early (cf. *Plate V*, A). Erosion of one pyramid, also a single deep-lying focus embedded in the parenchyma at the base of a pyramid and having no communication with the pelvis. Middle and lower portions healthy. On ascending urography would show erosion of the single pyramid and no other lesion.

b, Ulcero-cavernous type—disease more advanced (cf. *Fig.* 69). Many large cavities in each pole which would be obvious with ascending urography.

c, Rapid and destructive lesion (cf. *Plate V*. B, appearance of which is characteristic of mixed infection). Pus, fluid and fœtid. Cavities contain little caseous material and are very accessible to urographic media.

d, Mixed lesion. Tuberculous hydronephrosis above, ulcero-cavernous type below. Ascending urography—large cavities easily outlined above, eroded pyramids below.

e, Mixed type (cf. *Fig.* 70). Two cavities which are entirely cut off from the pelvis and are filled with putty-like caseous débris. Three empty cavities are seen which communicate with the pelvis and which are lined with tuberculous granulation tissue. These would show with ascending urography if the ureter proved to be permeable. Middle portion of the kidney converted into a fibro-fatty mass.

f, Putty kidney (*rein mastic, Kittniere*). Masses of caseous material occupy the intervals between the columns of Bertini. Ureter closed. Ascending urography impossible. Lime salts, representing a healing process, are present in greater or less degree in almost all such kidneys, which, therefore, throw good shadows on a skiagram. The kind of picture shown in *Fig.* 68 invariably indicates this type of the disease.

Descending Pyelography.—a, Excretion good but a little retarded. Erosion much less obvious than with ascending pyelography and might be overlooked. b, Excretion later and weaker, cavities well displayed. c and d, Excretion definitely delayed and feeble, but contrast medium lodges in cavities and therefore throws good shadow. e and f, Functionless. No excretion.

Ureters.—a, No obvious anatomical change. b, Moderate uretero-pelvic dilatation. c, Ureter severely ulcerated and dilated. Not thickened or contracted. d, Ureter dilated and thickened. e, Thick walls with much peri-ureteritis. Much ulceration of the mucosa. Contraction taking place lower down. Shortening marked. f, Ureteric walls very thick, lumen filled with caseous débris above. Complete obliteration of lumen occurs below the first inch or two.

inflammatory dilatation ever seen occur in tuberculous pyelo-ureteritis. Dilatation is sometimes punctuated by strictures. The resulting alternating contractures and dilatations (*Fig.* 73) are coarse in their development, constant in their position, and can scarcely be confused with the delicate and ever-changing variations in calibre seen in health. When the ureter becomes strictured it may prove impossible to outline the pelvis at all—by instrumental urography, because the fluid will not pass the stricture; by excretion urography because the kidney is functionless. In some cases the ureter above a stricture is choked

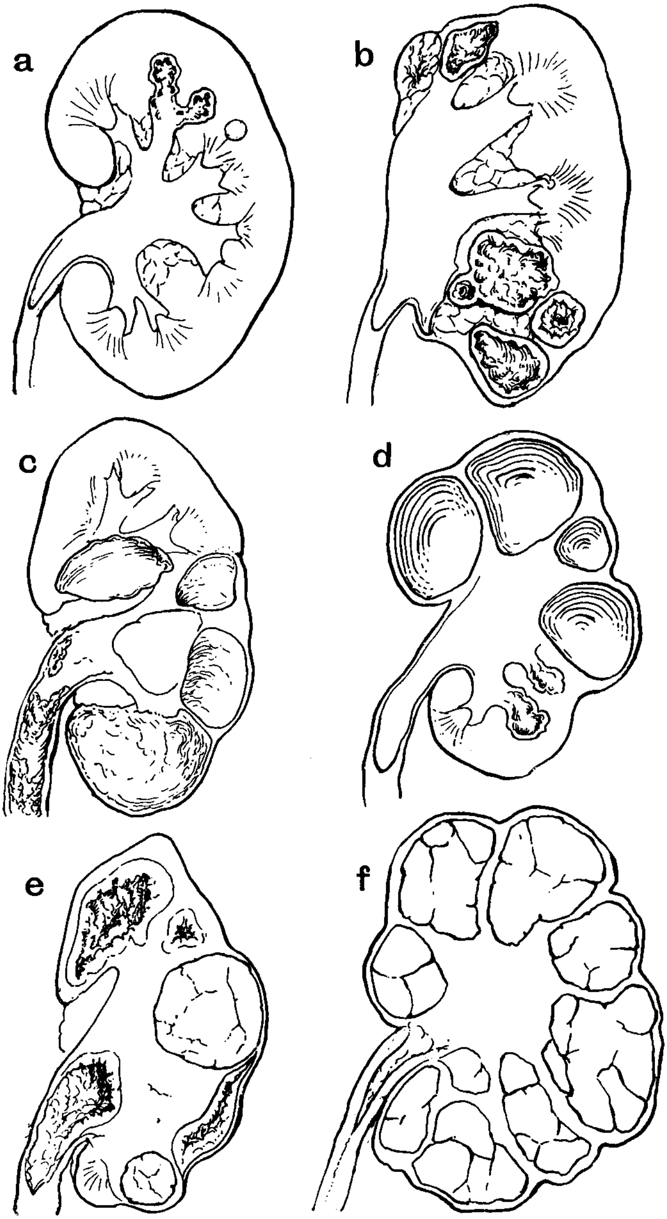


Fig. 67.

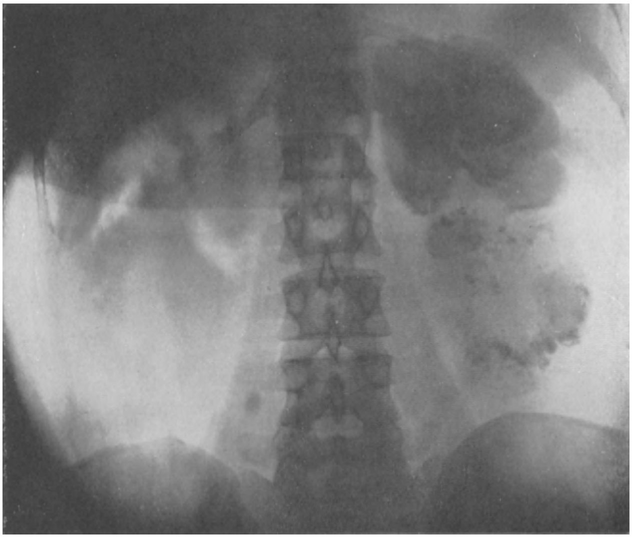


Fig. 68.—Marked calcification of a large tuberculous kidney. Nephrectomy by the transperitoneal route : recovery. (*Radiogram by Drs. Barclay, Paterson, and Twining.*)

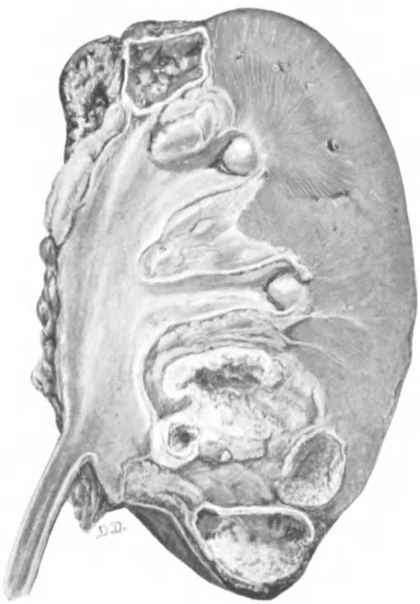


Fig. 69.—Renal tuberculosis, ulcero-cavernous type (cf. *Fig.* 67, b).

Fig. 70.—Advanced and chronic renal tuberculosis. Mixture of ulcero-cavernous and 'putty' varieties. The central portion of the organ is converted into a fibro-fatty mass. Ureter and pelvis are thickened, ulcerated, pipe-like, and contracted (cf. *Fig.* 67. e).

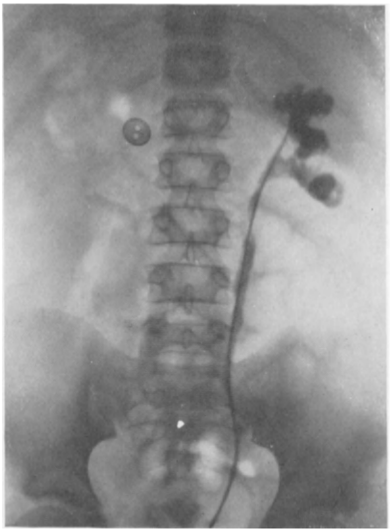


Fig. 71.—Renal tuberculosis. Marked erosion of all calices. Instrumental urogram.

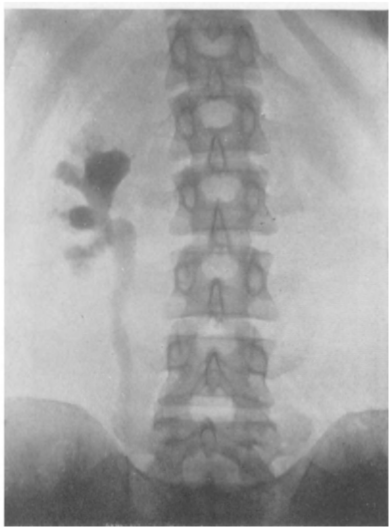


Fig. 72.—Right renal tuberculosis. Note the moth-eaten appearance presented by the ulcerated calices. The ureter is dilated and atonic. Instrumental urogram.

Fig. 73.—Left renal tuberculosis. Severe dilatation and excavation. Cystoscopic urogram.

with putty-like débris which completely fills and obstructs not only the ureteric, but also the renal, cavities. In these cases the kidney is completely destroyed and functionless, its parenchyma being reduced to a shell (*see Fig.* 67 f). The contents of this so-called 'putty kidney' are invariably impregnated with calcium salts, which throw a good and distinctive shadow, unmistakable for that of any other condition (*see Fig.* 68).

Perhaps the most constant late ureteric manifestation is that shortening which produces the well-known 'golf-hole' ureter. The shortened ureter takes the most direct course between the kidney

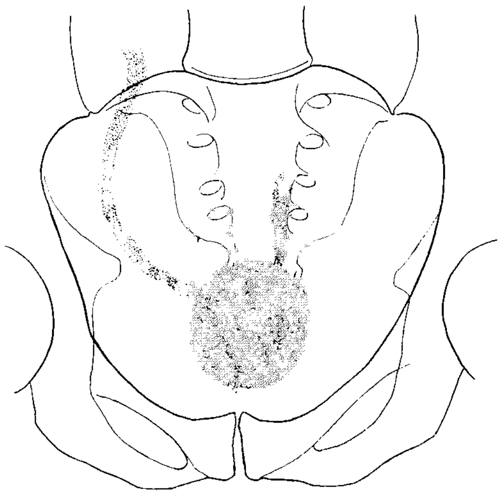


Fig. 74.—Left renal tuberculosis. Tracing from an intravenous urogram. There was no secretion by the left kidney though the drawing shows opaque fluid in the left ureter. This has regurgitated through an incompetent, diseased valve. Compare the line of the healthy, right ureter with that of the diseased and shortened one. The shape of this small bladder, which is quite different from that of a healthy bladder with a corresponding amount of contained fluid, denotes that it is pathologically reduced in size and that it is already filled to capacity.

and the bladder. All the usual sinuous curves are replaced by a straightened shadow. The absence of the wide sweep opposite the ischial spine is particularly striking, the ureter approaching the bladder almost vertically instead of swinging in with an ample curve. *Fig.* 74 is a tracing from an excretion urogram in a case of left renal tuberculosis. The normal course of the right ureter can be seen, and it approaches the bladder almost horizontally. There was no excretion by the left kidney, but the bladder contained drug-laden fluid from the healthy kidney which regurgitated through the incompetent valve and displayed the altered course of the pipe-like terminal ureter. The small capacity and modified shape of this bladder is likewise evident and instructive. The amount of fluid in this bladder is probably about 2 oz. A healthy bladder containing only 2 oz. would not have this globular shape. It would be flattened from above downwards, the roof folding down close to the floor (*see Fig.* 62, p. 67, and *Fig.* 65, p. 88).

Excretion Urography.—Because of the technical difficulties and the dangers of cystoscopy in urinary tuberculosis, that disease proves itself a very important field for the application of descending urography, which may be employed :—

1. *Before* cystoscopy. On page 100 it was laid down that any information which could be acquired before cystoscopy pointing to the kidney primarily involved would be valuable, if only in shortening the duration of the examination. Excretion urography used before cystoscopy comes into this category as it enables us at a glance to survey the field, to make a quick reconnaissance which may establish the enemy's position and perhaps his forces, and so speed the subsequent cystoscopy.

2. Excretion urography may *replace* cystoscopy when, but only when, the bladder conditions are impossible or at least unduly difficult. It should not be supposed that it can legitimately supersede the properly designed investigation already described. The difficulties must be unusual before we rely on it solely, and even then we recognize the limitations of our knowledge.

Excretion urography, whether used before or to replace cystoscopy, is expected to yield data regarding which kidney is affected and should show the function of each kidney.

The Diseased Kidney.—This is revealed by changes in morphology (pelvic and ureteric) or in its function—probably in both.

1. Changes in the *morphology* of the diseased organ and its ureter are responsible for modifications in the urographic shadow which have been described above (p. 113).

2. The *function* of the affected kidney. Tuberculosis is usually well established in the urinary tract before it reveals itself, since the frequency of micturition which calls attention to it depends mainly on bladder involvement. Some impairment of function will, therefore, have developed when the patient first comes under inspection, and the function will further deteriorate as the disease advances. Weakness or delay in excretion will thus be discernible on the affected side as compared with the healthy in early cases, and it may amount to complete absence of shadow formation in advanced cases (*Fig.* 75—left kidney). Loss of renal function carries with it its own significance to which the surgeon will give due weight. A great difference between the

function of the two sides is more convincing than minor differences. If both sides have late and weak excretion, it is very inauspicious.

At other times the shadow on the affected side is denser than that of the healthy kidney owing to the defective drainage of contrast fluid which follows the tuberculous invasion of pelvis and ureter. This feature is illustrated in *Fig.* 76, where, in addition to the good pelvic and ureteric shadows, the strong image of the renal parenchyma is worthy of remark.

Ravasini and d'Agnolo have independently studied cases of urinary tuberculosis, both with the indigo-carmine test and with

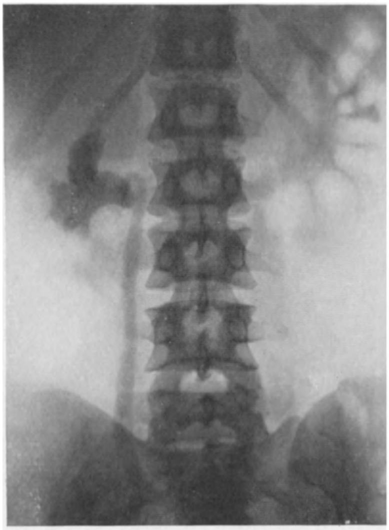


Fig. 75.—Bilateral renal tuberculosis. Excretion urogram. The left kidney completely destroyed—functionless—no shadow. Right kidney excavated. Ureter and pelvis dilated and atonic. The ureter appears to loop upwards near the uretero-pelvic junction. This does not really happen. The appearance is produced by the silhouette of the ureter as it climbs forward on to the belly of the psoas muscle. The margin of this muscle can be seen on the radiogram.

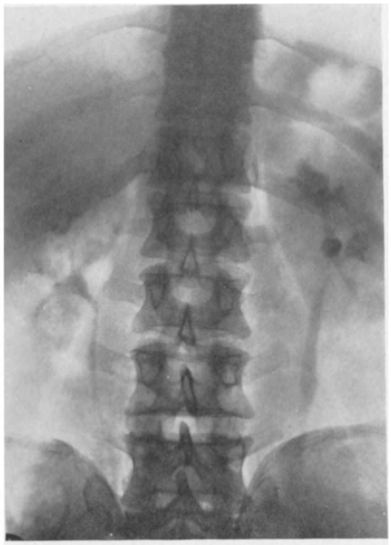


Fig. 76.—Early left renal tuberculosis. Excavation and dilatation of the upper and middle calices. Excretion of quite good quality. Note the good depth of shadow of the renal parenchyma on the left side, also the ureteric atony and dilatation. On the right side the pelvis and ureter are normal. Observe the relatively narrow ureter. Drainage on the right side is more rapid than on the left. Therefore the shadows are weaker. Intravenous urogram.

excretion pyelography, and state that in this particular disease the results do not run parallel, which difference they attribute to the fact that uroselectan is excreted at the glomerulus and indigo-carmine by the tubules.

Advanced disease produces greater renal deformity, but at the same time greater disturbance of renal function. Change in the uretero-pelvic outlines may therefore exist even when not portrayed because of weak excretion (*Fig.* 75—left kidney), but in one or other or both of these ways the affected organ will be detected.

The Healthy Kidney.—The question next arises whether an early and copious excretion and a normal pelvic and ureteric outline (*Fig.* 76—right kidney) may be accepted as proving the soundness of the supposed healthy kidney. That this evidence is less satisfactory than that supplied by the accepted methods, including ureteric catheterization, is

Fig. 77.—Contracted bladder from case shown in *Fig.* 75. Note dilated atonic right ureter. No ureteric shadow on left.

admitted, but that it is valuable is nevertheless unquestionable. I have on several occasions removed kidneys on this evidence combined with satisfactory tests of blood retention and urea concentration, with so far invariably happy results, but I do it only under compulsion. I judge from the literature that several surgeons are tentatively pursuing the same practice. Von Lichtenberg, indeed, is responsible for the statement that excretion urography, the presence of the pathological bacillus in the urine, and satisfactory blood-retention tests are all the findings needed.

CHAPTER VII.

SYPHILIS OF THE BLADDER.

THIS is a very rare condition. In 1914 Lévy-Bing and Durœux reviewed the literature and showed that cases had never been recorded by any of the leading cystoscopists up to that time, including Nitze, Finger, Casper, Frisch, and Zuckerkandl, though undoubted examples had been observed by others. This disease has, however, received increasing attention in recent years.

Historically syphilis of the bladder falls into three periods (Fowler). The first terminated in 1879, when Proksch discovered 6 cases which he considered authentic, where subjects had come to necropsy with ulcers, perforations, or growths of the bladder which proved to be syphilitic in origin. From that period until the end of the century a few cases were recorded where the diagnosis was made and symptoms disappeared under treatment. The third period begins in 1900, when Matzenauer described the cystoscopic appearances of tertiary syphilis of the bladder for the first time. Most of the recorded cases, even to the present time, have occurred during this stage, probably because the severity of the symptoms draws attention to the vesical lesion, whilst the secondary period is generally symptomless. In 1909, however, it was shown that the secondary period is not immune, but only 9 cases had been reported up to 1918. Recently several urologists have undertaken routine cystoscopy on large numbers of syphilitics in both the secondary and tertiary stage, and have found distinctive lesions associated with each period. Prominent amongst these may be mentioned Chocholka, who investigated 705 cases and found lesions present in 32.

Symptoms.—These may be epitomized as follows :—

The secondary period is generally quiescent, but there may be 'ardor urinæ' in a few cases, especially when the lesions are situated near the vesical neck. Bleeding is slight or absent. In the tertiary period the symptoms are severe, and often quite out of proportion to the cystoscopic findings. Hæmaturia is the most constant manifestation ; it is sudden in onset and profuse, but may suddenly subside. Strangury and tenesmus are generally well marked.

The *cystoscopic technique* is easy in the second stage, but may be difficult or impossible in the tertiary, owing to vesical irritability or to persistent hæmaturia.

Cystoscopic Manifestations.—The cystoscopic appearances must be separately described for the secondary and the tertiary periods. In some measure they resemble those found on other mucous membranes. In the bladder syphilis retains its character as the great imitator. Its aspects are very diverse and they may closely simulate the lesions of tuberculosis, neoplasms, etc. Chocholka says that it is the polymorphism of vesical syphilis which makes the disease appear to be so rare. It is uncommon for it to present a picture which can be regarded as characteristic.

SECONDARY PERIOD.—In this there are two lesions—macules and ulcers. *Macules* consist of areas of deep-red engorgement, generally superimposed on an already hyperæmic mucosa. They are occasionally elevated (papules). From 1 to 3 or 4 mm. in diameter, they elect to overlie the terminals of small arterioles. *Ulcers* are, as a rule, multiple and quite small, rarely reaching the size of a threepenny piece. As many as a dozen have been observed. Their site of election is the bladder base, and especially the ureteric and interureteric region, but they may be found elsewhere. Though generally clustered together, they may be widely disseminated. When situated near the vesical outlet they give rise to symptoms suggesting cystitis. They are rounded or oval, but their margin is often irregular, slightly elevated, and may be thin or infiltrated. The base may be covered with a whitish slough, or may be exposed and red. The ulcers are usually surrounded by an area of hyperæmia and œdema.

TERTIARY PERIOD.—The tertiary lesions are more often encountered; four principal types may be described: (1) Œdema; (2) Gummata; (3) Gummatous ulceration; (4) Papillomata (false).

1. *Swelling* of the vesical wall is fairly common and it often takes the form of thick, coarse, cerebriform folds which are very vascular and may be red or violet-coloured. They may be found in various situations, and in one instance were confined to the upper half of the bladder (Nilsson).

2. *Gummata* occur as spherical elevations of yellowish colour, and show a preference for the ureteric area. They are surrounded by a narrow ring of hyperæmia and undergo ulceration. Necrosis appears, in fact, to be an early event, and the stage of true unulcerated gummata is only occasionally seen. According to Israel, symptoms do not arise till ulceration has taken place.

3. *Ulcers* may be single, but as many as three have been noted. They are rounded or oval, and may attain the size of a sixpence. Their edges are jagged, infiltrated, and may be considerably elevated. The base is usually whitish or grey in colour and contains the typical

adherent wash-leather slough. It bleeds if touched. Irregularities of the floor from which blood constantly oozes have been described. Around the ulcer is an area of engorgement and œdema in which sinuous blood-vessels are unusually evident. Perforation into other hollow organs with the formation of fistulæ occasionally occurs (Uva, Thruster, Wyeth, etc.).

4. *Papillomata* (*false*) are very rare (Lévy-Bing), but were found on four occasions by Chocholka. They may be quite indistinguishable from the true villous neoplasm, except in so far as they yield to anti-syphilitic remedies. They are usually smooth in surface, implanted directly on the mucous membrane, and are reddish or reddish-grey in colour. They may be multiple and do not exceed a monkey-nut in size. Their appearance sometimes closely simulates that of a villus-covered carcinoma which has undergone ulceration. These various tertiary lesions may coexist, and are often superimposed on one another (Asch).

Diagnosis.—The diagnosis is made by the finding of: (1) Marked ulceration, etc., in the absence of tubercle bacilli; (2) A positive Wassermann and other syphilitic evidences; and (3) Speedy recovery under antisyphilitic treatment when other remedies have proved unavailing. In practically all the cases recorded improvement under antisyphilitic treatment was remarkably rapid and complete. Hæmaturia generally subsides after a few days, and eventually all lesions vanish, except where fistula formation has occurred.

CHAPTER VIII.

BILHARZIASIS OF THE BLADDER.

Bilharziasis is a disease which is only seen in this country when soldiers or others who have been infected abroad return home. The majority of patients whom I have seen have served in the South African War or the Great War, or have been stationed in India, Egypt, etc. The disease is endemic in many tropical countries, of which Africa, South America, and some parts of China and Japan may be mentioned. In Egypt alone, according to the Egyptian Government report, 6,000,000 people are infected, and Ferguson in a long series of necropsies found bilharziasis in more than 60 per cent.

The life-history of the trematode which is responsible for the disease was worked out by the War Office Expedition under Leiper in 1915. That Commission showed that the parasite has an asexual and a sexual phase. The former takes place in the liver of a mollusc where sporocysts and daughter-sporocysts develop. Either of these can give rise to cercariæ—larval structures which the mollusc discharges into the fresh water of ponds, canals, etc. Cercariæ are capable of movement and attach themselves to any available mammal, human or other (definitive host). Passing through the unbroken skin they arrive in the liver of the host, and there develop and differentiate into male and female adult worms (sexual phase). These together migrate via the inferior mesenteric vein to the vesical and ureteric terminals. The female lays eggs in clumps under the bladder and ureteric mucosa, which clumps constitute the specific lesions as seen through the cystoscope. Rupturing into the vesical cavity the eggs are discharged with the urine and hatch out into miracidia, motile bodies which seek out a suitable mollusc (planorbis) and recommence the life-cycle above described. The discovery of the ova and motile miracidia in the urine of a patient is positive evidence regarding the nature of the complaint.

Cystoscopic Manifestations.—When the ova are laid in the submucosa they cause small areas of œdema and hyperæmia together with petechiæ of the overlying mucous membrane, and these are the *earliest* cystoscopic findings. As the egg clumps approach the surface they become visible immediately subjacent to the mucosa. The appearance is figured in *Plate VI* E, page 130. Small, bright, whitish objects, of rounded or oval form and elevating the mucosa, are seen scattered irregularly over the bladder surface or clustered together in groups. At certain places ill-defined irregularities (superficial ulcers) of the mucosa indicate the spot at which ova have ruptured into the cavity. There may or may not be a ring of surrounding inflammation. Owing to the situation occupied by the adult worm, the ova predominate in the neighbourhood of the ureteric orifices.

The appearance of this early lesion is characteristic, and once seen is not likely to be mistaken. There are only two conditions with which it can be confounded. One is the early tuberculous bladder. The masses of ova are larger, brighter, more numerous, and more disseminated than are tubercles. To the uninitiated the ova might suggest the minute purulent spots observed in cystitis, described on page 85; the latter are irregular in size and shape, more granular, duller, surrounded by more diffuse vesical hyperæmia, and can be removed by persistent irrigation. The discovery of the ova or miracidia in the urine will settle the diagnosis.

At a *later* time (*Plate VI* F) the normal vesical mucosa is replaced by irregular areas of reddened mucous membrane from which numerous ova have escaped, leaving a red, ragged surface, comparable with that of granulation tissue. Other parts of the mucosa are paler than usual and over large areas there may be no trace of any blood-vessel (Makar). Calcification of the eggs and their surroundings is common, localized areas of the bladder becoming flecked with gritty and sometimes brilliant particles which produce an appearance like sandpaper—the so-called 'sandy patches'.

Agglomerations of bilharzial eggs and granulation tissue cohere to form the bilharzial 'node', a structure whose appearance has been happily compared with that of a mushroom, which, indeed, it resembles in its brownish colour and often in its shape. Bilharzial nodes, however, are not infrequently red or purplish in colour, which causes them to resemble a cock's comb, a likeness which has often been remarked. So long as the disease is active, recently laid eggs are to be seen.

Complications.—The complications of bilharziasis are cystitis, stone, papillomata, and fistula.

Cystitis.—Sooner or later the bladder becomes infected, and all the lesions of cystitis are engrafted upon those of bilharziasis. The cystitis may conform to any of the types discussed in Chapter V. It may be mild, but is often of great severity, and the whole wall, thickened and contracted, may be lined with phosphate-covered papillomata, bilharzial tissue, and degenerating masses of stinking débris. Cystoscopy under such circumstances is impossible.

Calculi.—Stones are present in about 50 per cent of cases. When examined the stones may be found to have formed around a nucleus of bilharzial ova (Looss and Ruffer) which were probably lying originally in a broken piece of bilharzial papilloma (Madden). The majority of stones met with in Egypt have a nucleus of uric acid or oxalate of lime, and are originally begun in an acid urine. In 100 operation cases 60 contained phosphates, but only 10 were pure phosphatic stones (Madden).

New Growths.—Papillomata occur late and often attain a large size. Masses of polypoid inflammatory tissue also will very commonly be observed, and may closely simulate a true papilloma. Carcinoma is a common lesion and presumably results from long-continued irritation. It closely simulates the types of cancer seen apart from bilharzial disease, the papilliferous variety being the most common. Sarcoma is not very rare.

Fistulæ.—Fistula formation to the surface or to other organs may occur. Perineal fistulæ are common.

Pyelonephritis and Pyonephrosis.—These conditions result from ascending infection.

CHAPTER IX.

TRABECULATION AND DIVERTICULA.

TRABECULATION.

THE normal bladder mucosa is smooth and even. An odd muscle bundle may elevate its surface here and there, but in general it is regular and flat. If the organ is over-distended, or for any other reason the patient experiences an urgent desire to micturate, a few bands may rise on the wall, but they are transitory, some appearing as others disappear. Under a number of conditions these muscular ridges become more evident, and the bladder is then said to be trabeculated.

1. **Trabeculation due to Hypertrophy.**—Hypertrophy resulting from obstruction is the chief cause, and the best examples are seen in prostatic enlargement and urethral stricture. It follows that trabeculation is more common in men than in women. In the latter, however, it is often well marked, the two principal etiological factors being cystocele and obstruction by fibroids. The more muscular habit of the male predisposes to the greater development of fleshy bands.

2. **Idiopathic Trabeculation.**—Occasionally trabeculation is found apart from obstruction or other disease, and appears to be idiopathic. It is more common in elderly people, though it may be met with in the young. In the latter it is usually found in subjects of inferior physique, and both in them and in the old is possibly due to scarcity of intermuscular tissue more than to hypertrophy of muscle. It is therefore apparent rather than real.

3. **Diseases of the Central Nervous System.**—Trabeculation occurs in certain diseases of the central nervous system, but as it then presents special characteristics, it will be dealt with separately (page 131).

Cystoscopic Appearances.—The following description relates particularly to trabeculation seen in hypertrophied organs. The appearance of the idiopathic variety is similar to the slighter manifestations herewith enumerated. The absence of obstruction will of itself distinguish the two classes.

In the early stage the meshwork is comparatively simple. A few muscle bands course here and there, widely separated by unaffected bladder wall. Intersections are few and minor bundles are not observed. Close inspection will generally reveal some fine graining of the slips, due to isolation of individual muscular strands. As the hypertrophy advances the reticulation becomes closer and stronger. The original bundles increase in breadth and height, and numerous secondary ones spring up between them. All of them intermix inextricably, forming a complicated lattice-work The bands divide and subdivide, and between them are to be seen the recesses known as false diverticula. The rounded prominence of the ridge catches the full force of the lamplight and is brightly illuminated, whilst the intervening crypts are thrown into shade. The more prominent the elevation, the deeper the shadow in the recess.

Blood-vessels run their normal course in the submucous tissue, irrespective of the development of the bundles which they may be seen to accompany or cross. Perhaps they are more numerous than

PLATE VI.

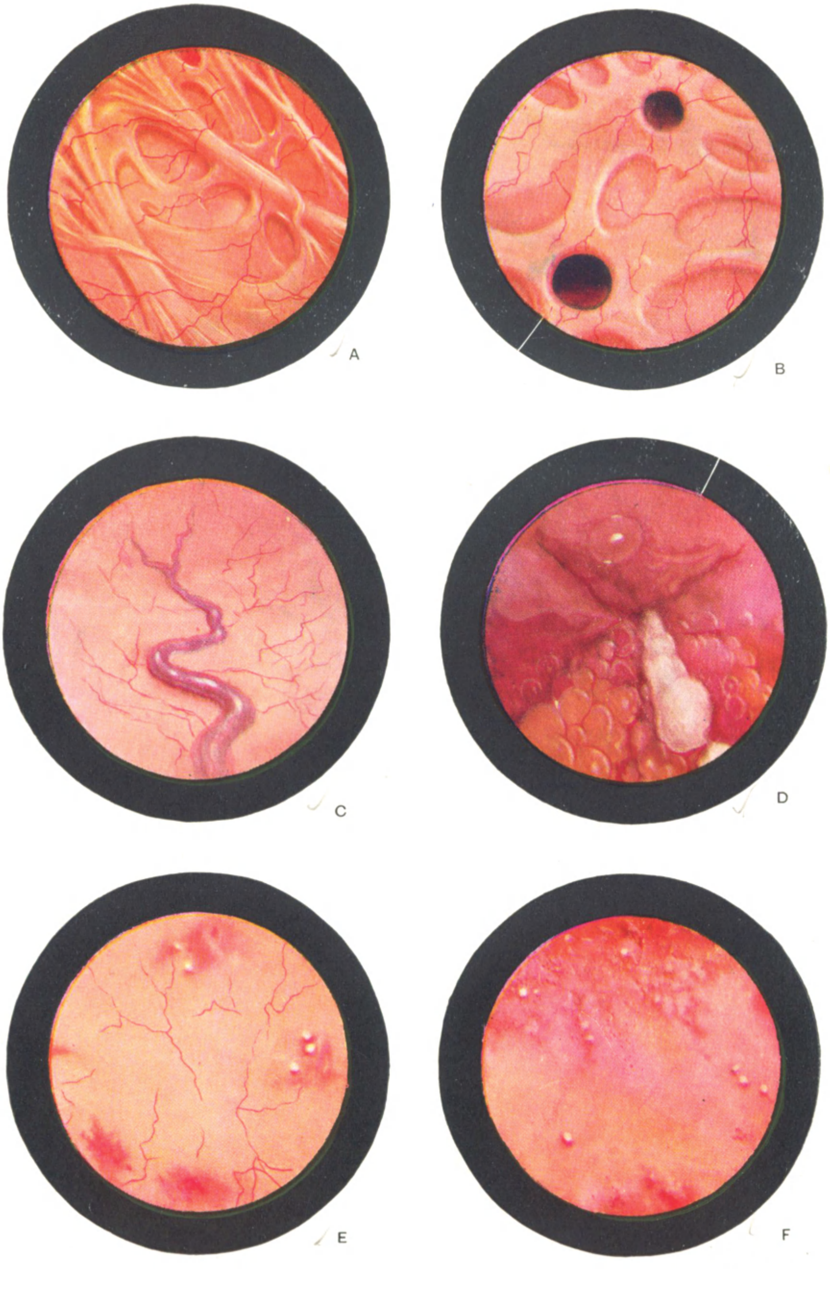
A, Trabeculation of the bladder of moderate degree. Muscular bundles of various sizes run in different directions and occasionally cross one another. Fine graining of the slips can be seen. The intervening recesses form false diverticula. The course of blood-vessels bears no relation to that of the muscular slips. Note bright illumination of edges of bundles. B. Orifices of two true diverticula. Bladder wall healthy but trabeculated. Muscular bundles radiate from the neighbourhood of the diverticula. A ring of muscle surrounds and supports the margin of each orifice. Blood-vessels pass over the margin into the recess. Depths of sac are generally quite black. C, Varix of bladder. D, Fistula of the upper wall of the bladder secondary to carcinoma of the colon. Pus entered the bladder intermittently as depicted, especially when suprapubic pressure was exerted. Note the severe cystitis, œdema bullosum, and the air bubble. E. Early bilharziasis. The white objects are groups of submucous ova on a hyperæmic base. In the lower section of the picture the ova have escaped into the bladder cavity, but the hyperæmic patch still remains. F, Bilharziasis of medium severity. Lesions as in E, but in upper section a raw area simulating granulation tissue is observed, from which many ova have been shed.

those of the normal bladder, as these obstructed organs are usually somewhat hyperæmic. When cystitis occurs, of course, blood-vessels increase markedly in number and size, and the vesical mucosa is frequently thickened, red, and velvety. The ridges then look coarser, their finer features are lost, and the crest of the muscle bands assumes a rounded and swollen appearance.

Position.—Trabeculation concerns only the detrusor; the trigone and ureteric bars are not affected. In the earliest stages it is confined to the lower segments of the muscle—namely, those in the retro-trigonal area and in the lateral recesses. As it increases it extends to the sides and eventually to the summit of the viscus. But as it spreads farther afield its development in the lowest area progresses, and it is invariably better marked here than in the dome. Though the ureteric bar is not itself involved, the close proximity of so many crypts and depressions may impede the discovery of the ureteric orifices.

PLATE VI.

MISCELLANEOUS BLADDER CONDITIONS



Cystography.—With suitable media cystography (*see* page 136) will show up these false or intramural diverticula if they are well developed, the bladder shadow appearing to be irregular or indented (Grape bladder, Traubenblase) (*Fig.* 78).

TRABECULATION OCCURRING IN DISEASE OF THE CENTRAL NERVOUS SYSTEM.

Nitze was the first to observe trabeculation in tabes dorsalis. It is now known that, whilst most characteristic in that variety of nervous disease, it is also seen in others—for instance, in atony from postero-lateral sclerosis and from spina bifida (Thomson-Walker). This author examined 31 cases of tabes in its earlier and irregular forms. According to him " trabeculation is generally present, but was occasionally absent. . . . The muscle ridges are fine and evenly set, and the branching is regular and orderly. Very fine twigs can frequently be seen branching and interlacing. A solitary muscle band may stand up sharply for two or three inches on the bladder wall. The interspaces are not so deep, and are saucer-shaped. . . . The side walls and apex are affected, while the trigone escapes." He holds that "the earliest change in these cases is atrophy, and that the prominence of some muscle bundles is largely due to atrophy of neighbouring bundles".

This type of trabeculation is distinctive and can be recognized immediately by those who know it. It is frequently present before other signs of locomotor ataxia have developed, and several times I have made the diagnosis by the vesical appearance. Trabeculation occurring in an unobstructed bladder requires further investigation, and the Wassermann test should be taken and the cerebrospinal fluid examined.

Another important pathological change visible by cystoscopy and suggesting nervous disease is an alteration of the bladder neck resulting in its becoming funnel-shaped. It is described in Chapter XVI.

FALSE DIVERTICULA.

False diverticula are the counterpart of trabeculation and hypertrophy. Between the muscle bundles are fossæ or recesses whose shape is determined by that of the adjacent bars. Their mouths are open and may be triangular or rhomboidal, circular or oval. Their depth is proportionate to the development of their boundaries, but is never great. Usually it can be explored cystoscopically. It may be thrown into deep shadow unless the lamp is held directly opposite the orifice. False diverticula are invariably multiple, and are often numerous. Their distribution corresponds to that of the trabecula. When well developed they are quite evident on a cystogram (*Fig.* 78.).

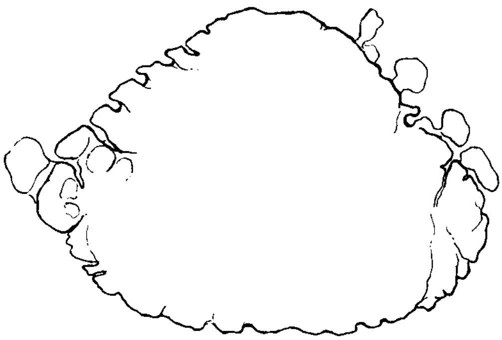


Fig. 78.—Tracing of a cystogram of a much trabeculated bladder (Grape-bladder, Traubenblase).

TRUE DIVERTICULA.

In a true diverticulum a portion of mucous membrane continuous with that of the bladder is projected through the vesical wall and forms a flask-shaped sac outside that cavity, but communicating with it by a narrow orifice (*Fig.* 79). Whether the condition is of congenital or acquired origin is a vexed question. One thing, however, is certain —that it grows as a result of increased intravesical pressure. This pressure is transmitted through the opening, and the walls of the diverticulum, practically unsupported by muscular tissue, stretch, dragging at the same time from the interior of the bladder fresh supplies of mucosa, pretty much in the same way as an inguinal hernia increases its size at the expense of the abdominal peritoneum.

Diverticula are observed with fair frequency in routine cystoscopic investigations. They are much more common than was believed prior to the general adoption of that exploration. They are often encountered unexpectedly, and may or may not be responsible for the patient's symptoms. They can be diagnosed only by the cystoscope, though they may be suspected when eccentrically placed or hour-glass shaped shadows are found radiographically in the pelvis, or where micturition in two parts is observed. Both phenomena are exceptional. Diverticula are commonest in obstructed bladders, especially therefore in elderly men, but a few cases occur in women (1½ per cent, Judd ; 12 females in 205 cases, Hinman) and they have been seen in children and young adults. Durrieux in 1901 collected 195 vesical diverticula ; 13 occurred in children below 10 years of age, and in 2 instances the diverticula were found in a fœtus.

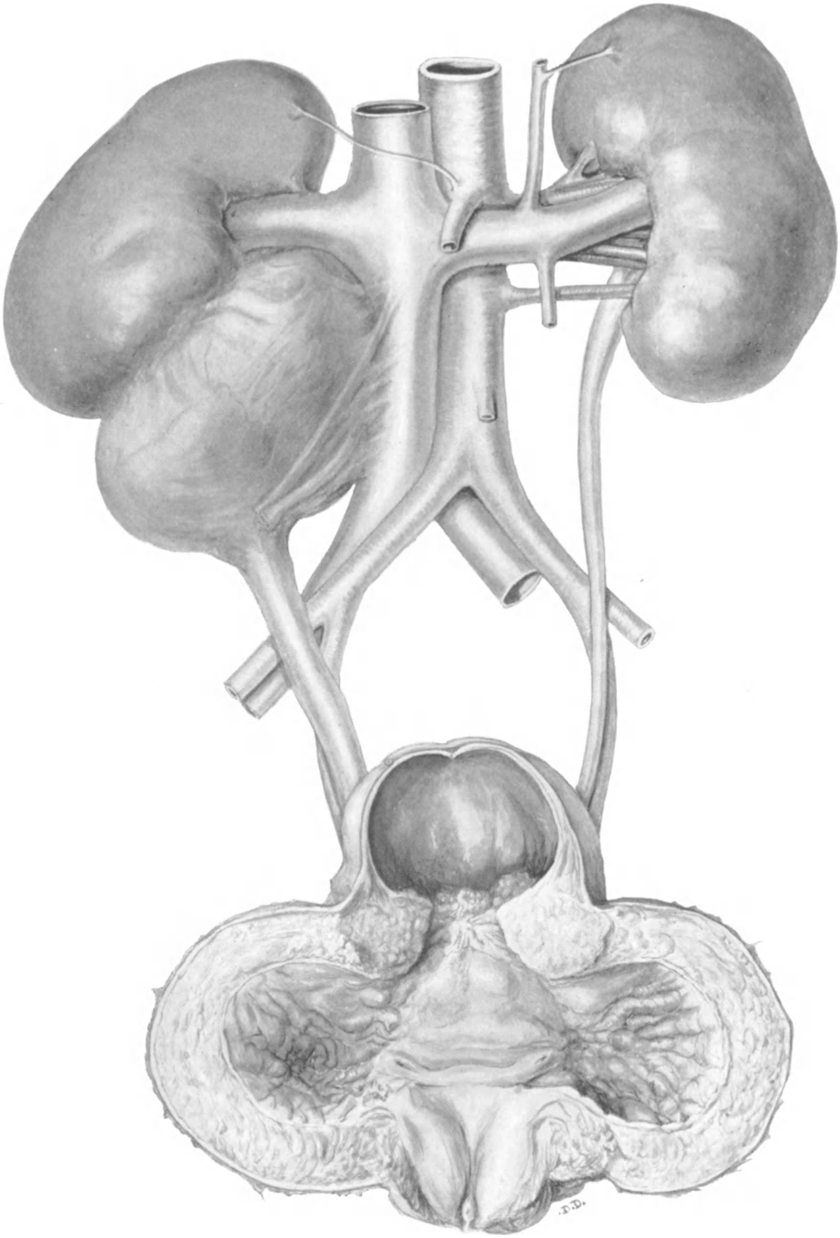


Fig. 79.—Diverticulum of bladder. Bladder, urethra, and diverticulum laid open anteriorly. Mucosa thickened and inflamed. Marked vesical hypertrophy. Powerful sphincter surrounds opening of diverticulum. Compare thickness of sac with that of bladder. Sac is adherent to right ureter, which is dilated. Right pelvis also markedly dilated. Note that the pelvis is adherent to the vena cava and that the right spermatic vessels traverse the adhesions. An accessory artery runs to the upper pole of each kidney. The patient died of uræmia, both kidneys being severely infected.

Cystoscopic Appearances.—The cystoscopic appearance is that of a hole cleanly punched out of the bladder wall (*Plate VI* B). It is generally rounded, but may be slit-shaped, and this latter appearance is occasionally due to its being viewed obliquely. Its orifice is small, usually of about such a size as would admit a lead pencil, and rarely appearing as large as a threepenny piece. Unless very shallow its depths are quite black and unilluminated. A firm muscular ring appears to support the edge of the ostium, and through it disappears the mucosa. The surrounding mucosa may be smooth, but often shows trabecula and false diverticula. Occasionally the muscle bands take origin and radiate from the ring like the spokes of a wheel. This trabeculation is usually limited to the neighbourhood of the opening,

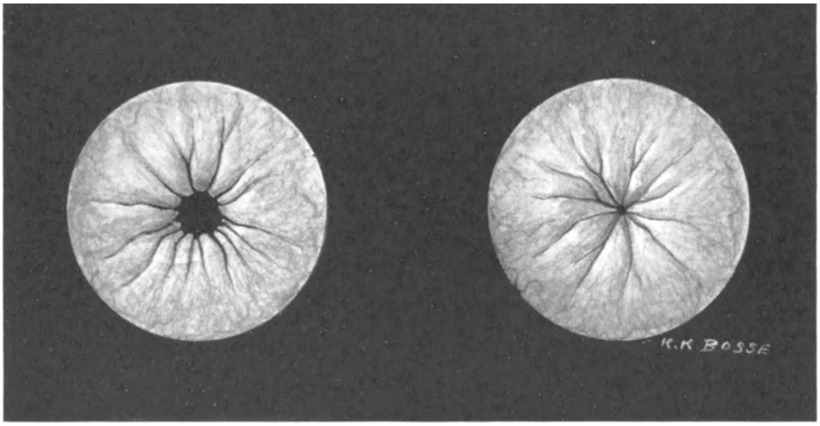


Fig. 80.—Cystoscopic appearance of diverticulum open and closed, demonstrating sphincteric action of orifice. (*Hyman.*)

though it may be generalized when there is urinary obstruction. As the mucosa escapes through the orifice it shows on its vesical aspect one or more pleats or folds, which suggest that it has been dragged into the opening. Vessels may be seen ramifying on the margin and passing into the pouch. Occasionally an ostium has been seen to exhibit sphincter-like action (*Fig.* 80). Buerger has illustrated a diverticulum which contained a papilloma, but was sometimes seen shut. I have examined a bladder and noted a diverticulum which at a subsequent cystoscopy was not to be discovered.

Situation.—The situation of choice for diverticula is the region surrounding the ureter and its bar (*Fig.* 81). For this reason some regard them as accessory ureteric buds which fail to reach the developing kidney. They may, however, occasionally open on any other part of the viscus, and are sometimes seen in the apex. In this position they are generally small and multiple. A single large pouch in this area is usually of different origin, being a remnant of the urachus. Sometimes the orifice appears to lie relatively high on the posterior wall and gives the impression that the diverticulum will be easily reached at operation. These sacs, however, are invariably found to droop down between the trigone and the rectum and are very inaccessible.

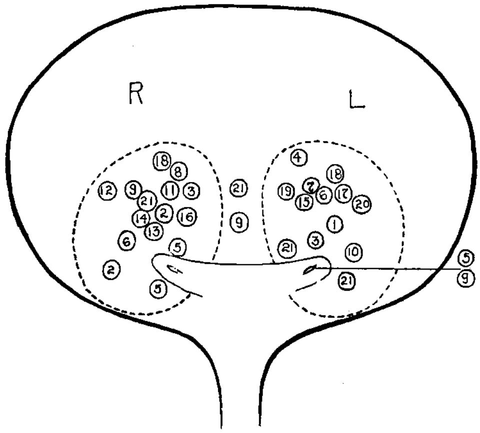


Fig. 81.—Graphic representation of the relative position of diverticular orifices in 21 cases. Cases Nos. 2, 3, 5, 6, 9, 18, and 21 have multiple diverticula. The only instances in which the base was involved are in two of these (9 and 21). A ureter opened into a diverticulum in only two instances, and again both were cases (5 and 9) with multiple sacs. (*Hinman.*)

When the opening occupies the usual situation the sac as it increases may drag on the ureter so that the latter gradually approaches the margin and, together with its ridge, is eventually swallowed by the pouch. It follows that the ureter may be found near the opening, on its very edge, or may not be discernible at all. Diverticula occurring in the neighbourhood of the ureteric orifice are liable to drag thereon, and so cause obstruction. Hydro-ureter and hydronephrosis (*Fig.* 79) will result, and if infection is added, pyelonephritis and pyonephrosis. Sometimes the bladder itself is small and the diverticulum may be several times its size.

Number.—Diverticula may be single or several may be present. They rarely exceed six or seven in number. When multiple they may be symmetrically disposed around the two ureteric orifices. In 17 cases Hinman found 11 single diverticula and 6 multiple. Of the latter there were two openings in four cases, and three and four each in one. Multiplicity appears to vary inversely with the size. Large ones are usually single (Negro and Blanc).

The Size of the Sac.—This cannot be estimated by cystoscopy, though in a few instances it has been possible to introduce the beak of the instrument through the aperture (*Fig.* 82) (Meyer). Such an operation should be easier in the female on account of the shortness of the urethra, but diverticula are very uncommon in that sex. To introduce the extremity of the instrument into the orifice in the male would necessitate a longer shaft and lens system than is routinely employed. The size of the orifice would often prevent its entry.

Cystography must be called in to complete the investigation and show the size of the pouch. Lerche (1911) was the first to suggest the taking of a radiogram with the viscus filled with an opaque solution. An ordinary X-ray photograph is first taken to demonstrate the presence or absence of a calculus. The bladder is then distended with the selected solution. Collargol, bismuth, and cargentos were formerly used, but sodium bromide or iodide (10 per cent) is now employed. Silver iodide (5 per cent emulsion) has become popular recently as it throws an excellent shadow, is a good antiseptic, and is soothing to the mucosa. In order to empty the diverticulum the patient should first be rolled over on to his face for a short time and then instructed to evacuate his bladder. The vesical cavity is now distended with solution until the patient feels a sensation of fullness, when the catheter is clamped and left *in situ*. An exposure will show the vesical shadow together with that of the pouch. The bladder silhouette may, by its broken outline, show evidence of false trabeculation (page 131 and *Fig.* 78). In many instances it overlaps and hides the shadow of the diverticulum. With the patient still in the dorsal recumbent attitude the catheter is now unclamped and the bladder contents flow out. The diverticula, occupying the most dependent position and being devoid of contractile elements, still retain their solution, and a fresh radiogram will show their outline uncomplicated by that of the bladder (*Fig.* 83). An interesting contrast cystogram can be obtained by distending the vesical cavity with air. In these ways the size, shape, and number of diverticula in the usual situation may be demonstrated. Those in the apex of the organ require the position of the patient to be reversed. The bladder is subsequently washed out, to avoid irritation.

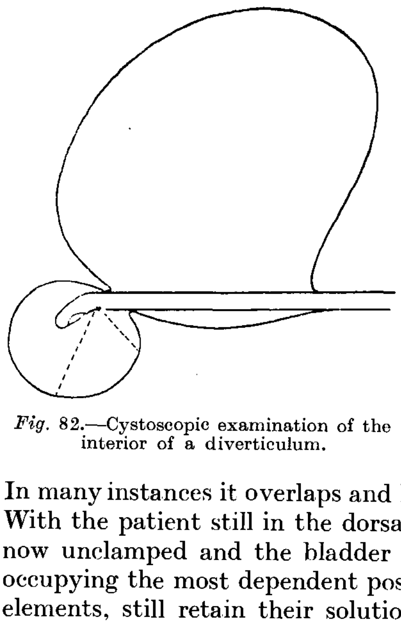


Fig. 82.—Cystoscopic examination of the interior of a diverticulum.

Another, but I think less satisfactory, method of demonstrating the dimensions of these cavities is recommended by Gilbert Thomas. A shadow-casting bougie is paid into the cavity with the aid of a catheterizing cystoscope, and is allowed to coil itself up inside the pouch (*Fig.* 84). If, instead of a bougie, a ureteric catheter is used, the diverticulum can be filled through it with opaque solution.

The capacity of these sacs varies widely. They may be as small as a pea or large enough to hold a gallon of fluid (Green, quoted by

Fig. 83.—Demonstration of size of two vesical diverticula by cystography.

Targett). The size of the opening bears no relation to that of the diverticulum. An opening which will barely admit a crow quill may

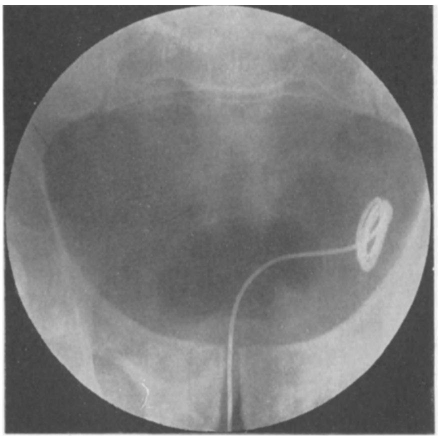


Fig. 84.—Shadow-casting bougie paid into cavity of diverticulum, where it has curled itself up. (*Gilbert Thomas.*)

yet open into a sac capable of containing a pint or more of fluid. The demonstration of a diverticulum may be accomplished by cystography when cystoscopy is impossible owing to a small, irritable, or displaced bladder.

Complications.—Complications are frequent and may be considered under the following headings :—

Urethral or Prostatic Obstruction.—These occur in a large proportion of cases. Their back-pressure is probably an accessory etiological factor and has given support to the view that a diverticulum is an acquired condition and not congenital. The truth is probably that obstruction to urination causes an increase in size of a previously existing diverticulum of congenital origin. Stricture may require treatment before a cystoscopic diagnosis can be made. As above remarked, patients presenting these complications show a mixture of true and false diverticula.

Vesical Complications.—These are infection, stone, and new growth. Thomas in examining the records of 19 cases showed that cystitis existed in 16 (84 per cent), stone in 4 (21 per cent), urethral stricture in 3 (15 per cent), and prostatic hypertrophy in 8 (42 per cent).

Cystitis.—Bladders containing diverticula are very prone to sepsis. It has two predisposing factors, the residuum in the pouch and that

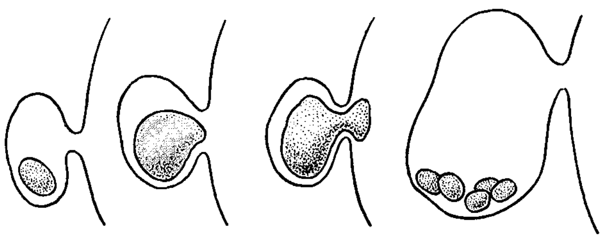


Fig. 85.—Stones in diverticula (various types).

in the bladder. It is sometimes extremely severe, and as the stagnant urine of the diverticulum cannot be evacuated, it is difficult to treat. It may be impossible to clarify the vesical contents sufficiently for cystoscopy, and when they are clear the medium may again become opaque through pus emerging from the sac. Sometimes the bladder itself is small and irritable. Seeing that diverticula are so susceptible to sepsis and that this is so frequently followed by ascending infection of the kidney, the cystoscopist will exercise special precautions to ensure that his own instrumentation does not infect the bladder.

Perivesical inflammation and adhesion are often present and may precede the diverticulum, when they have been regarded as etiological factors, but more generally they result from the spread of inflammation originating in the sac.

Stones.—Stones may form in the sac (*Fig.* 85), in the bladder, or in both. They may be primary, but are generally of the secondary variety. In the sac they may be single or multiple, visible or hidden (*see* page 196). A stone may completely fill the space available in the diverticulum and then enlarge into the bladder, a neck or waist forming at the situation of the diverticular orifice (*Fig.* 86), and the stone assuming a dumb-bell-like shape. This shape can be seen on a skiagram taken at a suitable angle (*Figs.* 87, 88). In the absence of radiological evidence, two cystoscopic features may betray an underlying cause for stone formation, the absolute fixity of the calculus and the fact that it does not rest at the lowest point of the bladder cavity.

Crenshaw and Crompton examined the records of 222 diverticula; stones were present in 28 (1–8 approximately); in 13 the stone was found in the bladder cavity without stone in the diverticulum; in 9 the stone was present in both; whilst in 6 it was in the diverticulum alone.

When diverticula occur in children they are very liable to be associated with stone. Englisch in 1904 collected 171 cases of vesical diverticula in which calculi were found associated. Of these, 22 occurred in children under 10 years of age, the youngest being an infant 8 days old.

Calculi impacted in the sac have been liberated by incising the wall with diathermy cystoscopically (Walther). This method of treatment will only be feasible when both the stone and orifice are small. The technique is similar to that employed in freeing a stone from the lower end of a ureter (page 319, *see also* page 196).

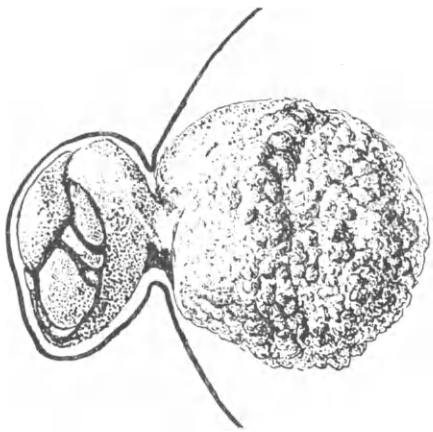


Fig. 86.—Schema showing that the diverticular part of the stone shown in *Figs.* 87 and 88 was made up of several faceted stones. Two previous operations had been undertaken elsewhere for removal of vesical portion, but the condition was not cured till the diverticulum itself was removed.

As a rule the diverticulum, as well as the stone, requires removal or there will be recurrence. The approach is made by the extraperitoneal mobilization of the bladder, followed by the isolation and excision of the sac (*Fig.* 89D). The intravesical prominence of the stone shown in *Figs.* 86–88 had on two occasions been removed and twice recurred before excision of the sac led to a cure.

Growths.—Tumours quite frequently occupy the interior of a sac or its edge, or occur in the bladder associated with a diverticulum. They may be papilloma, carcinoma, or more rarely other growths. In a series of 133 cases treated at the Mayo Clinic, Judd and Scholl

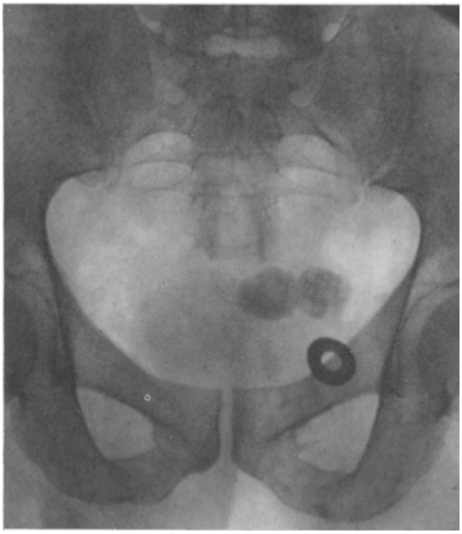


Fig. 87.—'Dumb-bell' stone of diverticulum.

Fig. 88.—Cystogram of stone shown in *Fig.* 87.

Fig. 89.—Diverticulum of the bladder. Operation specimen with orifice facing. Ragged area surrounding orifice is the section glued to the bladder. Remainder is smooth-walled. (*Natural size.*)

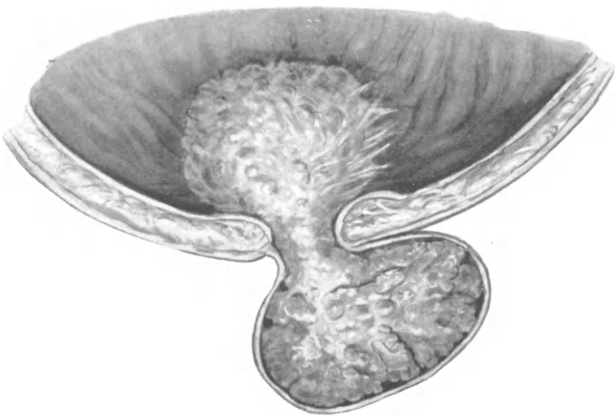


Fig. 90.—Papilloma growing from a diverticulum. Its intravesical component hides its site of origin.

found carcinoma in the diverticulum in 4, and in the bladder associated with the diverticulum in 6. Thomson-Walker reported 3 carcinomata in 1910. Buerger has illustrated one in which a diverticulum containing a papilloma had an orifice which was observed to close. Satellite splashes were present in the bladder itself. In two cases in the author's practice papillomata have arisen within a diverticulum, one of which is illustrated in *Plate VII* C, page 150. *Fig.* 90 shows how it fungated into the bladder, completely precluding all possibility of recognizing its site of origin till the superficies had been cleared away by diathermy. In a third patient a papilloma grew from the margin of the orifice. Amongst rarer growths the following may be noted: Targett found a sarcoma, Hofmoke reported a case in which a large single diverticulum was filled with polypi, whilst von Blum described an angioma in a diverticulum.

Complications arising in the upper urinary tract have been referred to above (page 135).

CHAPTER X.

TUMOURS OF THE BLADDER.

THE SIGNIFICANCE OF SYMPTOMLESS HÆMATURIA AND THE NECESSITY FOR ITS EARLY CYSTOSCOPIC INVESTIGATION.*

'SYMPTOMLESS HÆMATURIA' is a term used to cover all cases in which hæmorrhage occurs from the urinary tract unassociated with any other symptom or sign, such, for instance, as pain, urgent or frequent micturition, or a lump. Such unaccompanied bleeding is quite common, and may be the result of a considerable number of pathological processes. Indeed, there are few of the many diseases of the urinary tract which do not sometimes give rise to hæmorrhage, though with some of them bleeding is characteristic, whilst with others it is exceptional. If the vascularity of the organs concerned is considered, it will not seem surprising that this should be. The kidney in particular is an organ of exceptional vascularity, and that portion of the bladder which is most susceptible to disease—namely, the base—is also rich in blood-vessels. Yet though so many lesions may be the cause of hæmaturia, in practice it will be found that unaccompanied bleeding is very suggestive of a urinary neoplasm. Indeed, there is a well-known dictum which states that "symptomless hæmaturia indicates a growth of the urinary tract". I quote this phrase with diffidence, realizing that medicine abounds with instances of similar dogmata, the majority of which are fertile sources of error and frequently denote a lack of scientific erudition. Yet it is with this probability in his mind that the surgeon will approach the investigation in any given case. That he will frequently find himself mistaken may be shown by reference to four cases of symptomless bleeding which occurred in my own practice recently, and which on further investigation proved to be respectively: (1) A case of scurvy rickets; (2) A case of early renal tuberculosis; (3) One of that group of cases classified under the title of 'essential renal hæmaturia'; (4) Stone impacted in the pelvic outlet, in which, though the patient denied any history of

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pain, the parenchyma had been markedly encroached upon by back-pressure. Many other causes might also be recalled ; but in a large proportion of patients with symptomless hæmaturia a neoplasm of the urinary tract will be found. Walther, in a study of 74 cases of hæmaturia, both accompanied and unaccompanied by other symptoms, demonstrated that over 50 per cent were the result of urinary growths, and that of these, 72 per cent were malignant. If his article had referred only to cases of symptomless hæmaturia, the percentage of growths would have been much higher.

Two matters require investigation in all cases: (1) The anatomical point from which hæmorrhage originates; (2) The nature of the pathological processes giving rise to it.

Of these the former is a matter of urgency. The latter can be dealt with at leisure, but it must be ascertained at the earliest possible moment whether the bleeding is from the upper or from the lower urinary tract, and in the first alternative from which side it is coming. This last is the important thing. A growth in the bladder may be seen when the hæmorrhage has disappeared, but bleeding from the upper tract must be located during an attack, for then the bloody efflux from one ureteral orifice can be seen (*Plate XIV* A, page 328; *see also* page 326) and the corresponding kidney or ureter held culpable. Further, in all cases which are 'symptomless' there is only one real guide, and that is the cystoscope. There is no pain ; there is no lump. Some doubtful information may be obtained from the presence of blood well mixed with the urine, which is generally held to come from the kidney ; or from the presence of worm-like clots which have received their shape from the ureter ; but these are uncertain guides, and even they will not determine which side is bleeding. If he waits until there are other symptoms to guide him, the surgeon runs the risk that the case will become inoperable; yet such procrastination happens very frequently. Hinman, on an analysis of the published work of eight different surgeons, found that in 709 cases of renal growths hæmaturia was the onset symptom in 42 per cent, but that when the cases came to operation only 6·6 per cent showed hæmaturia unaccompanied either by pain or tumour, and he justly remarks that this "indicates the lost opportunity in making an early diagnosis".

Any one of the tumours of the urinary tract is capable of causing symptomless hæmaturia, and more commonly than not they announce themselves in this manner. In order to keep the argument clear I will limit myself to two of the commonest tumours of the tract—namely, papilloma of the bladder and hypernephroma of the kidney. These happen also to be two varieties which very consistently give rise to symptomless bleeding ; the former, according to Hurry Fenwick, showing this as its first symptom in 84 per cent of cases, whilst Israel states that the latter heralds itself thus in 70 per cent.

There is considerable variation in the period of their life-history at which they give rise to hæmorrhage; in some cases we find that the first bleeding comes from a growth, papilloma or hypernephroma, which from its size must have been growing unsuspected for a long time; but in many cases it is quite early, when the growth is small. Such a hæmorrhage coming from a small growth, whether of the bladder or kidney, may not be repeated before months, or occasionally even years, have elapsed, the growth in the meantime having become well-nigh untreatable. Surely this gives an uncanny importance to that single manifestation, and throws a grave responsibility on the medical practitioner to see that it is not allowed to subside without having been traced to its source. Generally the duration of that preliminary hæmorrhage is short; it is often only a few days or even hours, so that the diagnosis of its anatomical origin is a matter of urgency. Denaclara states that in 146 cases of renal neoplasm only once did the primary hæmaturia last as long as fourteen days.

Each of these two types of tumour runs a peculiar and almost invariable course, in that each at first is benign, but eventually undergoes malignant transformation. The papilloma in the early stage is single, has a long slender pedicle, and does not invade submucous planes. Later it becomes multiple, subsessile, or sessile, tends to invade and disseminate, and eventually destroys life by anæmia and cachexia. Singularly enough, the hypernephroma also is at first a benign growth. It is encapsuled and grows slowly. It may exist in this condition for many years—cases have been reported up to twenty years—behaving in the same way as do parotid tumours. Later it also takes on malignant changes, growing more rapidly, invading its capsule and the renal vein, and disseminating. It is remarkable that two growths in the same tract should share this somewhat rare characteristic, but it only emphasizes the importance of prompt diagnosis, for in the early stage the treatment of each is that of a non-malignant neoplasm, is easy and satisfactory, whilst ultimately the growth becomes malignant and the prognosis unfavourable. Nature, as it were, holds out to us the option of successful treatment, if we are but discerning enough to recognize her signals, but she will just as capriciously snatch away the proffered chance if we do not seize and secure it, and the sole intimation of impending disaster which she vouchsafes is that preliminary hæmorrhage which is often so transitory. *Figs.* 91 and 92 show large neglected vesical papillomata, each of which proved fatal,.

To recapitulate, it has been shown that hæmaturia is frequently the only symptom of a growth of the urinary tract; that following this expression of its presence it may retire into absolute quiescence for a long period, during which it is probably increasing in size and advancing towards malignancy; that when it reasserts itself, whether

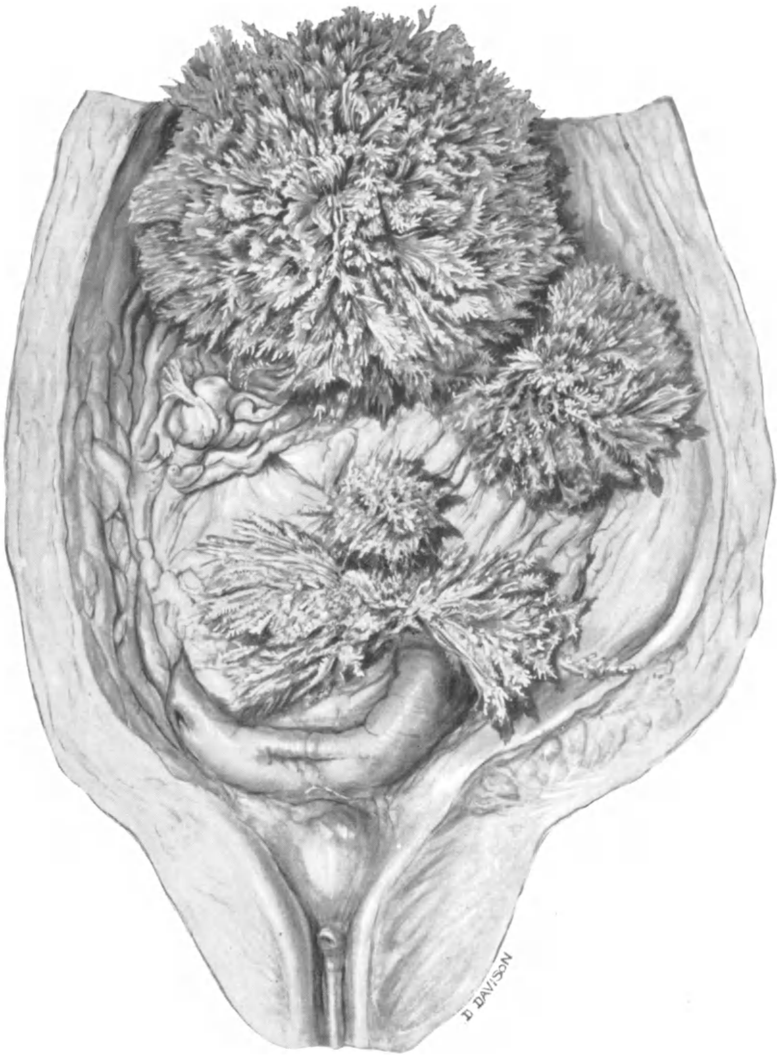


Fig. 91.—Multiple papillomata. Villi beautifully developed. Patient exsanguinated on admission and died immediately.

by a second hæmorrhage, pain, dysuria, or the presence of a lump, it may have passed beyond the operable stage; and that, if the growth should prove to be of the upper urinary tract, the only time at which a diagnosis of the anatomical site can be made is during the period of actual bleeding.*

Hæmaturia is, therefore, not a symptom to be treated *per se.* It is a red danger sign, urgently demanding an accurate diagnosis—(1) As regards its anatomical point of origin ; and (2) As regards its

Fig. 92.—Extensive papillomatosis of the bladder. Patient was admitted with retention and died of uræmia. Stagnation and infection on each side of the upper tract.

pathological cause. It is an easy thing to put a patient suffering from acute abdominal pain to bed and give a hypodermic injection of morphine. Such a course will be followed by relief of the pain ; but the profession has long ago learnt the hazard of this procedure

* Renal function tests and a pyelogram may, however, be suggestive of change in one or other kidney (*see* Chapters XXIII, XXIV and XXVI).

so long as any doubt remains in regard to the diagnosis. Similarly, it is an easy matter to put a man suffering from hæmaturia to bed, apply cold, and administer certain reputed hæmostatics. Such a course may be rewarded by a cessation of the hæmaturia, and the medical attendant will have the gratitude of his patient, but surely, on contemplation, must have the mortification of realizing that he has done him a great disservice. It is much better to keep the patient in active life, and to perpetuate the hæmorrhage rather than to allay it, until such time as a cystoscopic examination can be arranged and the source of the bleeding accurately located. Once the hæmorrhage is stopped the opportunity has passed, possibly for a long period, and unless some gross swelling of one kidney can be palpated or the patient is persuaded to submit to cystoscopy, which may reveal some cause in the bladder, the golden opportunity has gone by and may not recur until much valuable time has been lost.

Instances of such misguided treatment are unfortunately only too frequent in practice. I will cite a single case. A man had had a short sharp hæmorrhage from the bladder three years previously for which he had been treated by his medical attendant, with cessation of the bleeding. From this point onwards symptoms were absent until he began to suffer from vesical discomfort and the sensation of incomplete emptying of the bladder. Cystoscopy revealed a growth of such large dimensions that examination was difficult owing to the instrument plunging amongst the fronds of a papilloma, which, on account of its size, had to be removed by suprapubic cystotomy, and when this was done a pair of smaller 'kiss-cancers' was revealed on the opposite bladder wall. If this patient had undergone cystoscopy three years previously, his condition would have been treated rapidly and easily by diathermy, and the open operation would have been avoided.

As the growth gets older the attacks of hæmaturia tend to become more prolonged, severe, and frequent. On certain occasions I have had to undertake the examination of patients who have had continuous hæmaturia for weeks, a few of these suffering from a severe grade of anæmia. In one instance a medical attendant informed me that he had attempted to knock off portions of a growth by introducing a metal instrument and twisting it about in the bladder—a practice which is condoned in text-books belonging to a past generation, but obviously must be condemned in view of the possibility of ocular demonstration by modern methods.

These are the grosser errors, but I have nevertheless been much impressed by the frequency with which hæmaturia is palliated with resultant danger to the patient. If the best results are to be obtained, the cases must come up at the first onset of symptoms. Other urologists experience the same trouble. Braasch, in an analysis of a series of 83 cases of hypernephroma of the kidney, found that on an average hæmaturia had existed for more than a year in 77 per cent before other symptoms precipitated treatment.

As a matter of fact, the profession is frequently not responsible for the delay, for patients often cannot be brought to realize the importance of the condition so long as it is unaccompanied by pain or discomfort. I have been astonished at the complacency with which patients, particularly amongst the uneducated classes, regard such hæmaturia, and on occasion have had to use considerable pressure to secure a full examination of the urinary tract because they could not understand the importance of the condition. Bransford Lewis records the case of a man suffering from a hypernephroma of the kidney who carried about with him for six years a letter from his medical man to a consultant, in spite of the fact that blood was present in the urine all the time. Similar instances could be multiplied, though the duration in this case was extreme.

I have laid emphasis on the responsibility of the medical attendant because I consider the importance of an early cystoscopic examination has not been adequately brought home in the past. Had symptomless hæmaturia been as common as the acute appendix, it would have gone through the same phase as that condition experienced many years ago, and would now be invariably submitted to immediate cystoscopy, just as the acute abdomen is promptly submitted to laparotomy.

THE EXAMINATION OF VESICAL NEOPLASMS.

INDICATIONS FOR CYSTOSCOPY.

The discovery of a vesical neoplasm is invariably made with the cystoscope. It cannot be made otherwise, apart from open exploratory operation. Cystoscopy is undertaken to explain hæmaturia or pain, and a growth is discovered. In 84 per cent of villous growths (Fenwick) *hæmaturia* is the first indication of disease. The importance of immediate investigation in symptomless hæmaturia has already been explained. The remaining tumours (16 per cent) give rise to *pain*, which may be renal, vesical, penile, perineal, or the pain of obstruction, and in all cases, save perhaps a few neglected ones, the cystoscope is essential to its elucidation.

Having discovered a neoplasm the endoscopic investigation must further ascertain: (1) Its type; (2) Evidences of malignancy; (3) Its size; (4) Its position; (5) The number of growths; (6) Concomitant bladder lesions; (7) Whether primarily of intra- or extravesical origin; (8) Indications for treatment.

Everything, therefore, that can be ascertained about tumours of the bladder it is the office of the cystoscope to disclose. In large part also modern treatment devolves upon it, as will be shown later. Nowhere is cystoscopy more serviceable.

CONDITIONS COMPLICATING TECHNIQUE.

The preparation of an uninfected viscus containing a small growth presents no particular difficulty, but much resourcefulness on the part of the surgeon may be necessitated by : (1) *Tumours of large size* ; (2) *Hæmorrhage* ; (3) *Sepsis*.

1. **Tumours of Large Size.**—The way in which large growths interfere with cystoscopy is discussed later (pages 161–164.)

2. **Hæmorrhage.**—Cystoscopy should, if possible, be undertaken whilst the bleeding is still active in order that, should it prove to originate in the upper tract, its source may be located. Whilst it is, as a rule, possible to clear the bladder sufficiently to permit at

PLATE VII.

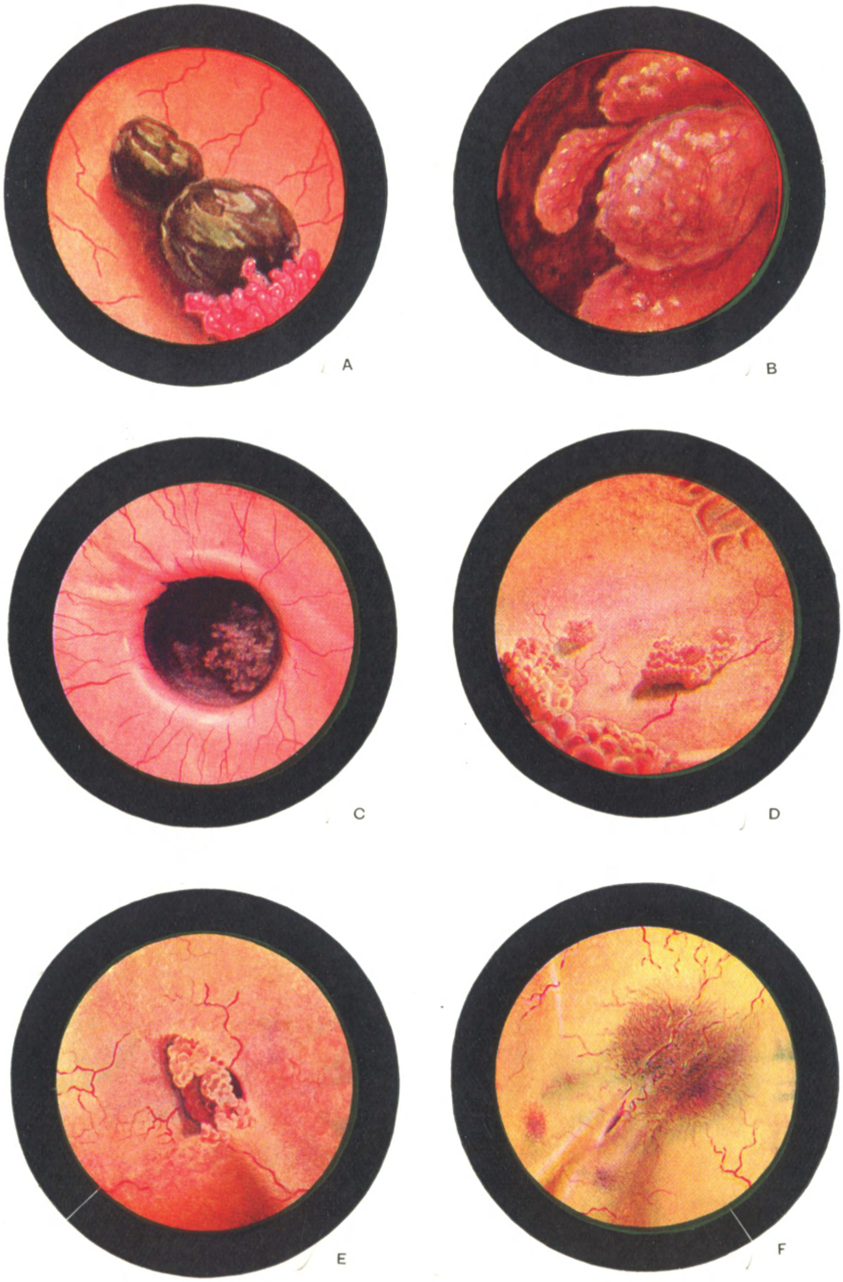
A, Two blood stones resulting from profuse hæmorrhage from the vesical papilloma of which a portion is seen. B, Close view of a portion of a papilloma occurring in an infected bladder; the villi are swollen and there is some phosphatic deposit on their surfaces. C, Papilloma originating in a diverticulum as seen after one treatment with diathermy; prior to the first treatment the diverticulum was hidden by that portion of the papilloma which bulged into the bladder (*see Fig.* 90, page 141). D, Multiple papillomata. The primary growth is in the foreground. E, Papilloma originating in a ureter and fungating into bladder. F, Angioma originating near left ureter.

least a provisional diagnosis, active hæmorrhage is occasionally so persistent, or the organ is so filled with clots which cover its base and discolour its contents, that no progress is achieved. In spite of these occasional failures the rule still holds that cystoscopy should be attempted during the hæmorrhage. In one case in the author's experience where clots arising from a papilloma filled the bladder, cystoscopy had to be postponed for a fortnight. At the end of this time the clots had formed into the two rounded blood stones shown in *Plate VII* A. They eventually acquired a phosphatic crust and were crushed by the cystoscopic rongeur and evacuated.

The hæmorrhage for which one is consulted is often excessive, and I have known many instances in which the patient was so exsanguinated that it became necessary to transfuse before proceeding. When severe, intravesical coagulation is liable to happen, and the attempts of the bladder to evacuate its clots precipitate hæmorrhage afresh. In these circumstances the method of using paraffin for the

PLATE VII.

BENIGN TUMOURS OF THE BLADDER



vesical medium may be given a trial (*see* page 53); otherwise relief should be obtained by suprapubic operation. A Bigelow's evacuator to remove clots, and the perurethral cautery to seal the bleeding point, have been recommended, but are risky, as the growth may be damaged, and they frequently fail.

Hæmorrhage is sometimes initiated by trauma during vesical lavage. This results from :—

a. Bruising of the papilloma by the beak of the instrument. The usual position of the growth is the area facing the vesical outlet, and in this position it is exposed to damage by movements of the catheter during lavage. Where a bladder growth is suspected the instrument should be introduced so far that its eye lies just within the internal meatus, and should be maintained there steadily. Movement, particularly that of propulsion, may bruise the growth and cause hæmorrhage. Note therefore the point occupied by the cystoscope when fluid first escapes from the bladder, and retain the instrument in this position (*see Fig.* 45, page 48). It is easier to do this in the male than in the female, for the instrument is more firmly supported by the urethra of the former.

b. Avulsion.—Occasionally a piece of the growth gets drawn into the eye of the catheter during evacuation of the bladder and the return flow suddenly ceases. When the instrument is withdrawn to discover the cause, a piece of the growth is forcibly detached. The resulting hæmorrhage may be free and uncontrollable. The possibility of such an accident should be remembered if the stream suddenly stops, and instead of withdrawing the catheter, the injection of more lotion should first be tried in the hope that it may disengage the growth. Naturally, large papillomata are more prone to be trapped than small ones. As the growth is usually implanted on the inferior segment of the bladder, the fenestra should always face the pubes during evacuation.

Hæmorrhage may be combated by the methods enumerated in Chapter III, but if a view of the growth can be obtained in spite of continued hæmorrhage, the application of an electrode to the bleeding point may be effective in controlling it.

3. **Cystitis.**—This condition is a frequent attendant on bladder growths. It is more often associated with malignant than with simple ones and is especially partial to the nodular type. It is a serious complication, for such a bladder shares with that of vesical tuberculosis when secondarily infected the unhappy distinction of hampering cystoscopy more than any other combination of lesions. It is small, intensely irritable, and easily bleeds, and the difficulties it imposes may prove insuperable. Gentleness, patience, and the ability to use the cystoscope in a small space may be required. As a rule it is

useless to ward these patients in the hope of gaining amelioration in the cystitis by internal and local medication, for the condition is very intractable and usually shows little improvement.

Cystitis of mild degree is also found with benign growths, and may be a sequel to diathermy, as will be shown later, but it is generally less severe and more amenable to treatment. Severe cystitis must be regarded as suggestive of malignancy; and the susceptibility of a bladder thereto, and also its reaction to treatment, are to be taken into account when estimating a growth's malignancy. The liability to infection must be recognized and every endeavour put forth to maintain asepsis during cystoscopy.

Tumours of the bladder may be of *connective-tissue or epithelial origin.*

TUMOURS OF CONNECTIVE-TISSUE ORIGIN.

Tumours of connective-tissue origin are very rare. Fibroma, myoma, fibromyoma, myxoma, chondroma, angioma, and sarcoma have been recorded. *Plate VII* F shows a capillary nævus which arose in the neighbourhood of the left ureter. In 1930 (*Brit. Jour. Surg.*, xviii, page 205) I reported this case and one other, and I collected from the literature 20 additional cases. The growths are therefore rare. They give rise to profuse and recurrent hæmaturia which led four times in the 20 collected cases to death from exsanguination. They may be small, capillary in type, and obviously superficial, as is the one illustrated, when they are suitable for perurethral diathermy, but they may also take the form of cavernous nævi involving the muscular coats, and must then be submitted to partial excision. Diathermy would merely precipitate hæmorrhage, and in one instance actually proved fatal (Katz). Nævi in other parts of the body have been observed in a large proportion of cases.

TUMOURS OF EPITHELIAL ORIGIN.

Tumours of epithelial origin fall into three main categories: (I) *Villous papilloma*—(*a*) *Benign*, (*b*) *Malignant*; (II) *Nodular* (*malignant*) *growth*; and (III) *Endometrioma* (*see* page 189).

I. VILLOUS PAPILLOMA.

All simple villous growths eventually undergo malignant transformation, and it may therefore be argued that there is no such thing as a benign papilloma. The classification and nomenclature are, however, convenient and will be retained here. The two groups of papillomata will be described together, as it is thought best to regard them as different manifestations of the same process, bearing in mind, however, the fact that the degree of malignancy is more marked in some instances than in others, and that at corresponding ages two growths of similar appearance may behave differently, both clinically and in their reaction to treatment. Many villous tumours are definitely malignant from their commencement.

Life-history of a Papilloma.—The earliest stage of the primary growth is never seen cystoscopically, as it causes no symptoms. However, its appearance can be surmised from that of the minute secondaries to which the parent growth gives origin and which are often observed. It is that of a tiny red elevated spot the size, say, of a pin-head, and when slightly older it shows a tufted crown foretelling its subsequent villiform appearance. On reaching the dimensions of a small pea it will be discovered to have developed a pedicle, which, relatively to the size of the papilloma, is of considerable length. From the main trunk numerous subsidiary offshoots emerge, clothed with an exuberance of crinkled epithelium. After a certain stage growth affects mainly the superstructure, so that the pedicle becomes relatively shorter. Still later it becomes stouter and stockier, until eventually it approximates in girth to that of the main tumour mass. The tumour has therefore passed through three phases in which it has been successively pedunculated, subsessile, and sessile, and with each stage it approaches more closely to malignancy.

The mobility of the pedicle on its site of implantation cannot be tested cystoscopically, but it is known that at first the mucosa from which it springs is freely movable over its subjacent coats, that in the second stage more resistance and stiffness are encountered, whilst in the third, invasion by epithelial elements is present or at any rate imminent. The growth is now frankly malignant, and though glandular involvement is a late feature with all bladder tumours, the prognosis is altered. A similar change affects the villi, whose previously long, slender processes lose their fragility, and to some extent their mobility, and eventually assume a coarser and more swollen appearance.

Papillomata are frequently multiple (*see Plate VII* D, and *Figs.* 91 and 92). Cells detached by trauma or by contact with other parts of the bladder wall engraft themselves and produce secondary splashes. This may occur early in the course of the disease, but is more usual when the parent tumour has reached the size, say, of a marble, or rather more, and the bladder, as it contracts down, is becoming capable of compressing the growth and dislodging tumour cells. Satellite growths may occur close to the site of the original tumour or at a more distant spot. They may be single or there may be several, and in rare instances I have seen a bladder so profusely splashed with small sessile buds as to resemble the rash of measles. This condition has been styled a 'diffuse papillomatosis'. The secondary tumours undergo an evolution similar to that of the original growth, with this exception, that pedicle formation is not so marked in the early period and malignancy must therefore be regarded as less remote.

It may be seen, therefore, that it is rational to regard a benign and a malignant villus-covered tumour as one and the same, at different points in its life-history, and that the simple tumour, though in the early stages an easy victim to destruction, is nevertheless potentially an infiltrating cancer. The age at which these growths become actually malignant varies considerably, a few taking a decade or more, whilst some require but a few months. On the average, however, they need about two to four years. I have seen several in

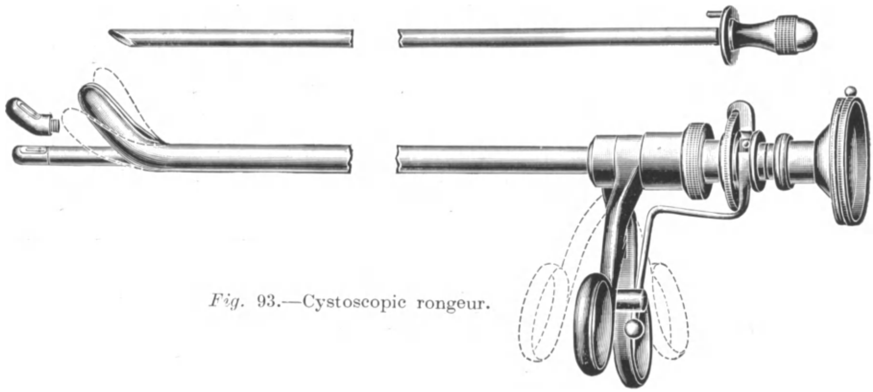


Fig. 93.—Cystoscopic rongeur.

which hæmaturia had occurred for a period of more than ten years and the growth was still suitable for diathermy. In all these the position of implantation was higher than usual on the bladder wall. Such a slow evolution is uncommon.

The *nature* of a growth may be judged by its cystoscopic appearance or by the pathological investigation of a piece of tumour removed by the cystoscopic rongeur (*Fig.* 93). The appearance of a villous growth will be described first and the question of acquiring pathological material will then be discussed.

Benign Villous Papilloma.—Of all the objects observed in the bladder there is none which can compare in elegance with a papilloma. This is particularly true of the smaller growths, which consist of beautiful irregular masses of delicate tendrils clustered together, eddying to and fro with every movement of the vesical contents, and recalling the appearance of a sea anemone. When of larger development they lose in a measure their delicacy and comeliness.

From what has been said above regarding the evolution of a papilloma, it will be gathered that the same growth, seen at different stages in its development, will present varying characters. When still small the villi will be luxuriant, fine in texture, and comparatively long. Various growths, however, show this quality in varying degrees. In some the villi are of unusual length and have then been likened to sea-wrack grass. In others they are club-shaped, squat, and regular, and the general appearance recalls somewhat the surface of a raspberry. The above varieties, however, and especially the former, are rare, and the usual condition, accounting probably for 90 per cent of all cases, is the intermediate one represented in *Plate X* A, page 178. As the tumour grows its villi are actually or relatively reduced in length, and though even in old and extensive growths they are usually evident, in a few they are so much reduced that the surface may be likened to that of a fine marine sponge.

The colour of the papilloma, owing to its vascularity, is slightly more ruddy than that of the bladder wall. Occasionally it has a purplish tinge. When the light catches the edge of a villus it imparts lustre thereto, whilst if a villus intervenes between the lamp and prism it appears translucent. This happens frequently when a large growth that occupies much bladder space is being examined. Occasionally a silvery-looking growth is met with, the appearance resulting from necrosis or from phosphatic deposit in sepsis.

A single blood-vessel occupies each villus, and may be seen by direct inspection or, still better, under transmitted illumination. Several hypertrophied vessels may also be observed coursing in the vesical mucosa towards the base of the papilloma to supply it with blood. When infiltration has occurred at the base a certain amount of thickening, and occasionally some bullous œdema (*Plate VIII*, E, page 160), may be noted in the surrounding mucosa. A very similar appearance occurs after diathermy, and the two must not be confounded, as their significance is entirely different (*see* page 182).

Malignant Papilloma.—In tracing the life-history of a papilloma to the point where malignancy has supervened, we have indicated the ways in which the two differ. The table on page 156 will serve to refresh the memory.

No single character taken by itself is adequate testimony of the nature of the growth (infiltration excepted), and the entire evidence must be reviewed before any conclusion is formed. It is easy to place the obviously innocent and the obviously malignant in their correct categories, but the middle transition stage is more difficult. These growths are frequently bulky and their pedicles and bases are hidden. The reaction to diathermy should be tried in doubtful cases, and will often give a strikingly accurate indication of the growth's proclivities. I have, on the one hand, seen rapid and permanent disappearance, and, on the other hand, I have seen the tumour appear to flourish on diathermy. Many authorities put such reliance on the neoplasm's reaction to diathermy in estimating its nature that it has been called the 'therapeutic test'. But this method likewise is not without its drawbacks, for there will be delay before it delivers its verdict. Moreover, we are risking the displeasure of our patient, who, having undergone treatment which held promise and has miscarried, is now advised that more radical measures are necessary. This is a real danger, as further treatment may be refused, to the patient's detriment and with much loss of prestige to his adviser. If therefore a neoplasm remains under suspicion after one or two energetic sessions of diathermy, it is wise to resort to open operation.

TABLE SETTING OUT THE PRINCIPAL DIFFERENCES BETWEEN INNOCENT AND MALIGNANT PAPILLOMATA.

	INNOCENT	MALIGNANT
Pedicle	Long, thin → subsessile → sessile, →infiltrating	
Villi	Long, fine, sharp, luxuriant	Stunted, swollen, closely packed
Surface	Irregular, like chorionic villi, bright ; no necrosis	Smoother, like marine sponge or cauliflower ; necrosis ; phosphatic deposit
Size	The smaller more likely to be still innocent	The larger more likely to have reached malignancy
Number	Single	Multiple
Base	No thickening, no œdema	Thickened, bullous œdema
Concomitant lesions	Cystitis absent, or slight and amenable	Cystitis more marked, generally obstinate
Reaction to diathermy	Good	Poor, may thrive on it

The task of placing these borderland growths in their correct categories when first seen is a difficult one. It is not to be expected that surgeons will interpret identically the individual members of these intermediate types. This presumably explains the wide discrepancies to be found in the proportions of innocent and malignant villus-covered tumours which make up the lists of various authors. In the table appended are given the figures of two surgeons. They have been selected to illustrate this contrast :—

	PAPILLOMA	CARCINOMA	TOTAL
Egger	38 (47 per cent)	42 (52·5 per cent)	80
Barringer	7 (14·9 per cent)	40 (85 per cent)	47

It is a fair assumption that these surgeons draw their patients from comparable sources, and if so the great dissimilarity in their figures can be explained only by their different individual standards.

Pathological Investigation of a Papilliferous Tumour.—As previously observed, it is possible with the cystoscopic rongeur to remove a portion of the growth for microscopical examination. There is much divergence of opinion in the ample literature about vesical papillomata as to whether more weight should be given to their clinical or to their pathological features. The problem of differentiating a benign from a malignant papilloma or of determining at what point a simple growth has taken on malignancy has baffled pathologists equally with clinicians.

The unreliability of the pathological opinion respecting these tumours is almost a byword, different pathologists having not infrequently given dissimilar reports on the same section. It has happened to many surgeons that a tumour has been reported as malignant and its recurrence as simple, or that a growth regarded by the pathologist as benign has destroyed life by metastasis, or, again, that of one reported as malignant a clinical cure has been effected. Further, a tumour looked on by the pathologist as simple has returned in the suprapubic scar with malignant characteristics and has destroyed life.

Not uncommonly two papillomata are met with in the same bladder, of which one is apparently simple and the other malignant. It is stated, moreover, that malignancy may be discovered in one part of a tumour of which the remainder is apparently innocent. The present writer has seen a case in which a large area of the bladder base was infiltrated by a hard scirrhous mass, whilst close to the outlet sat a small villus-covered tumour of quite different naked eye appearance. Such mixed tumours are not uncommon, and Fenwick thinks that " certain epitheliomata of the bladder are able so to irritate the surrounding healthy vesical surface that . . . benign papillomata spring up ". An alternative explanation would be that a portion of the neoplasm had undergone malignant change which was not shared by the remainder of the growth. These phenomena afford a convenient explanation when pathological reports and clinical course run counter to each other, but show that serial sections of these tumours are required for their satisfactory appraisement.

Further, there is no agreement as to whether the pathological material shall come from the tumour's superficies or from its base, each position having its advocates. Thus Beer, Buerger, Young and Davis and others recommend the prominence, whilst Geraghty says that " the base of a papilloma may show no signs of infiltration and yet the tumour may be distinctly malignant in its body and periphery ". Later he admits that " probably in no other tumour have so many mistakes been made by pathologists ". In another paper, however, this writer makes the significant statement that " in the vast majority of cases there was not sufficient evidence to indicate whether a tumour would respond to fulguration ". Ziegler, Orth, and other writers also favour pathological investigation, but they recommend that the base be examined, and indeed many writers assert that no opinion can be formed from an examination of the superficial portions.

Quite apart from the question of the value of microscopical examination, it must be frankly recognized that there are practical objections which concern the methods of acquiring such pathological material. If it is intended to examine the *superficies* of the growth, this will be obtained by the cystoscopic rongeur. But gentleness is fundamental in handling vesical papillomata because of their great liability to disseminate, and though the danger may in some measure be mitigated by lavage with lotions meant to destroy grafts, it must be insisted that the use of the rongeur violates first principles. Probably microscopy of the superficies of a papilloma is valuable, but the wisdom of practising it is questionable. If, on the other hand, the *base* is selected for examination, it can be obtained only by open operation, and this is unfortunate, for the excision of the growth must then be completed at the time of this operation, and thus doubt regarding the diagnosis may lead to timidity in removal.

These practical difficulties and the acknowledged uncertainty of the pathological opinion have led me to rely exclusively on clinical, which actually means cystoscopic, data for my diagnosis.

Amongst those who hold a view contrary to that expressed above is the staff of the Mayo Clinic, where a preliminary biopsy has been the practice for seventeen years (Bumpus). It is denied that any ill comes from avulsion of the superficial part of the growth with a specimen-taker. The neoplastic material thus acquired is then classified according to Broders' system of grading, it being denied that different portions of a growth exhibit variations in their characters.

II. NODULAR CARCINOMA.

To the diverse appearances presented by a nodular carcinoma parallels can be found in malignant growths of other regions of the body, so that even the novice will have something to guide him. These appearances vary to some extent in proportion as the neoplasm is elevated above the surrounding mucosa or has undergone ulceration, etc. Five characteristic types may be illustrated, and ***Figs.*** 94*a*–94*e* will assist the student in understanding the following description.

The tumour shown in ***Fig.*** 94*a* projects into the bladder as a fleshy mass of reddish or yellowish-red colour, not dissimilar to that of the bladder, but generally somewhat deeper in shade. Often, however, it is of a deep-red hue. The surface is more or less rounded. It may be smooth, but is generally irregular and may be much lobulated. It bleeds slightly when touched, and ulceration is absent. The growth shown in *Fig.* 94*b* is not very dissimilar to that of *Fig.* 94*a*, but forms a flattened plaque, projecting little or not at all into the bladder and, resembling a hard chancre in appearance. Its margin

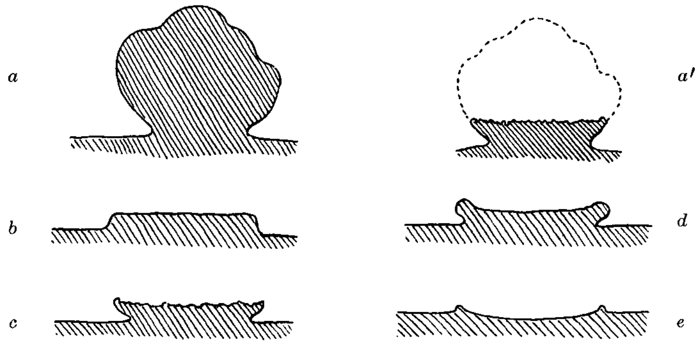


Fig. 94.—Types of nodular carcinoma. For description, *see* text.

is rounded, regular, or sinuous, and its central portion may be flat or slightly retracted. Generally it is of a distinctly deeper red than the surrounding bladder wall. It bleeds on being touched, and superficial necrosis is slight or absent.

Fig. 95.—Infiltrating carcinoma with crateriform ulceration. Note rod in ureter. Operation specimen (cf. *Fig.* 94*d*.)

The growth in *Fig.* 94*c* probably arises from that in *Fig.* 94*a* as the result of necrosis of the upper part of the prominence. It conveys the impression that the upper two-thirds of the fleshy mass have been roughly sliced off (*Fig.* 94*a'*), leaving a flat but ragged fibrous surface of necrotic tissue (*Plate VIII* C). This surface varies in shape, according to that of the original tumour, but is often roughly circular in outline. Its edges are sharp but jagged. The lateral aspect of the tumour retains the appearances described above for *Fig.* 94*a* and recedes as it approaches its base of attachment to the bladder.

Fig. 94*d* presents the appearance typical of an ulcerated epithelioma (*Plate VIII* F and *Fig.* 95). The surface is irregular, ulcerated, red, and often covered with flakes of sphacelus. The margins are rounded, irregular, and everted. Its appearance can scarcely be mistaken. *Fig.* 94*e* shows the same condition as *Fig.* 94*d* save that ulceration is more rapid and advances *pari passu* with tumour formation. There is therefore little or no rampart of neoplasm, and excavation is so active that a saucer-shaped depression occurs.

The growth shown in *Fig.* 94*a* is probably the least and that in *Fig.* 94*e* the most rapid, whilst the others show an intermediate malignancy. The vesical mucosa surrounding the neoplasm may be healthy and normal, or may be puckered and infiltrated. Frequently there is surrounding œdema apart from infection. Cystitis is very common.

PLATE VIII.

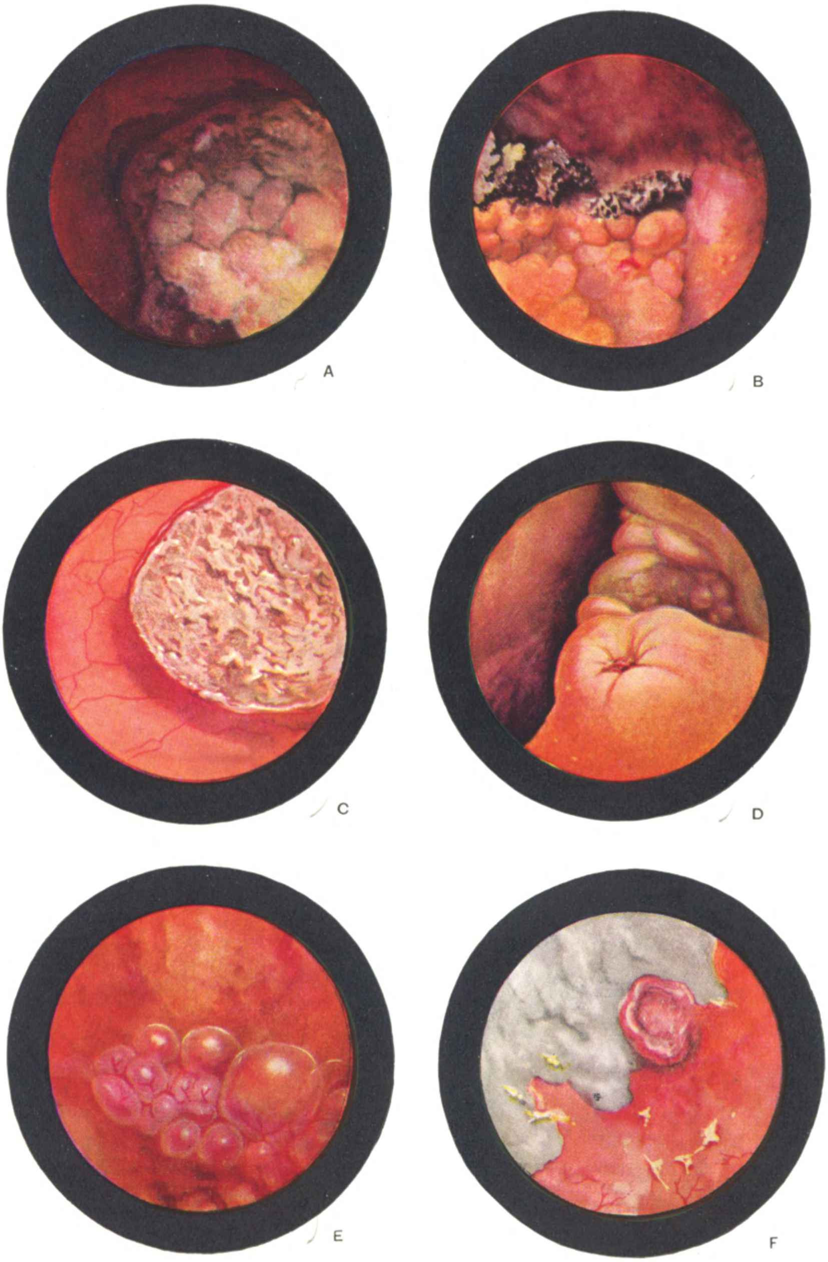
A, Cauliflower carcinoma with some superficial phosphatic deposit. B, Irregular nodular carcinoma; the dark objects seen centrally and to the left are changed blood-clots. C, Nodular carcinoma with flat, ragged, ulcerated surface. D, Carcinoma of the uterus invading the bladder. Note the elevation of the growth and the central puckering. The nodules are multiple. E, Enormous transparent bullæ occurring near the base of a malignant growth. F, A nodule of epithelioma implanted at the edge of a patch of vesical leucoplakia. Note the rolled everted margin of the growth. The silvery blue appearance of the leucoplakia, its sharp irregular edge, and undulating surface are well shown. The remaining mucosa is inflamed and several patches of purulent débris may be observed.

I have on occasion removed for biopsy part of a nodular growth, the appearance of which was not distinctive. The objections raised above (page 158) to this form of examination concern papilliferous tumours only and are inapplicable to nodular growths, for which it is a satisfactory procedure and devoid of risk. It should terminate the cystoscopic examination, as thereafter the field will probably be blood-stained. For the same reason the surgeon should make sure that the pathological material is acquired with the first bite of the rongeur.

Number of the Growths.—The number of the papillomata varies widely. They are multiple in one-third of the cases. It is rare for them to exceed three or four save in advanced and inoperable instances, but up to a hundred or more have been found. A painstaking hunt for satellites must always be instituted. The proper time for this is the initial cystoscopy so that loss of time may be avoided

PLATE VIII.

MALIGNANT GROWTHS OF THE BLADDER



during treatment. The search must be deliberate, every crypt and depression being explored for insignificant red spots which may prove to be incipient neoplasms. These spots in their early development are closely simulated by certain small rounded thickenings seen in cystitis, and if the latter occurs following diathermy, it may be difficult to determine the nature of the lesion. Satellites often spring up close to the parent mass and may then be hidden behind or underneath it, escaping notice until it is destroyed. The position of secondary splashes must be charted (*see Fig.* 117, page 187) and their size indicated. Their destruction will precede that of the main tumour at the first session of diathermy.

Multiplicity has not the same significance for all writers. Young and Davis hold that multiple tumours are "almost surely malignant", and Fenwick says that "the prognosis of cure after operation will never be so good or so hopeful in multiple as in single papillomata". On the other hand, Swan and others see in it no additional reason to suspect malignancy. Wherever the truth lies, plurality unquestionably portends a strong tendency to engrafting, and succeeding grafts show a progressive increase in their malignancy.

Size of the Growth.—With tumours of small and medium size it is easy to form an approximate estimate of their dimensions. With those that are large it is much more difficult. The size has an important bearing on the cystoscopy, as will now be shown.

Effect of Size on the Examination.—The series of diagrams presented in *Figs.* 96 to 99 will assist in demonstrating the ways in which the size of the papilloma affects the cystoscopic examination.

Fig. 96 shows a small single growth. Even with the prism closely approximated it is easily circumscribed in a single cystoscopic field. By means of lateral inspection the pedicle may perhaps be brought into view, though this is by no means always possible. No secondary buds are yet seen. Such a neoplasm would be rapidly demolished at the first sitting with the high-frequency current.

Fig. 97 represents the same growth at a later period. In order to encompass it in a single cystoscopic field, the instrument must now withdraw to a greater distance. Thereby, of course, illumination and magnification are sacrificed. However, it is easy to approximate the prism and examine in detail each component portion of the growth. Much greater difficulty will be experienced now in obtaining a view of the pedicle owing to the extensive arborescence which overlaps and shrouds it. This overlapping of the base is important. The appearance of the pedicle should witness for or against malignancy. In actual practice one has, as a rule, to rely on the shape of the tumour itself, on its elevation above the bladder, on the relation of the tumour to its shadow, and on the height attained by its lowest branches, to form an impression of the degree of its pedunculation. Papin has suggested an ingenious method of estimating the breadth of the pedicle. A ureteric catheter is made to underrun the growth in three different directions and palpate the periphery of the pedicle. This, however, is not a procedure which finds favour with the writer, for, unless absolutely necessary, instrumentation of all sorts should be avoided in order to obviate the risk of tumour dissemination. A more satisfactory expedient is, when commencing diathermy, to

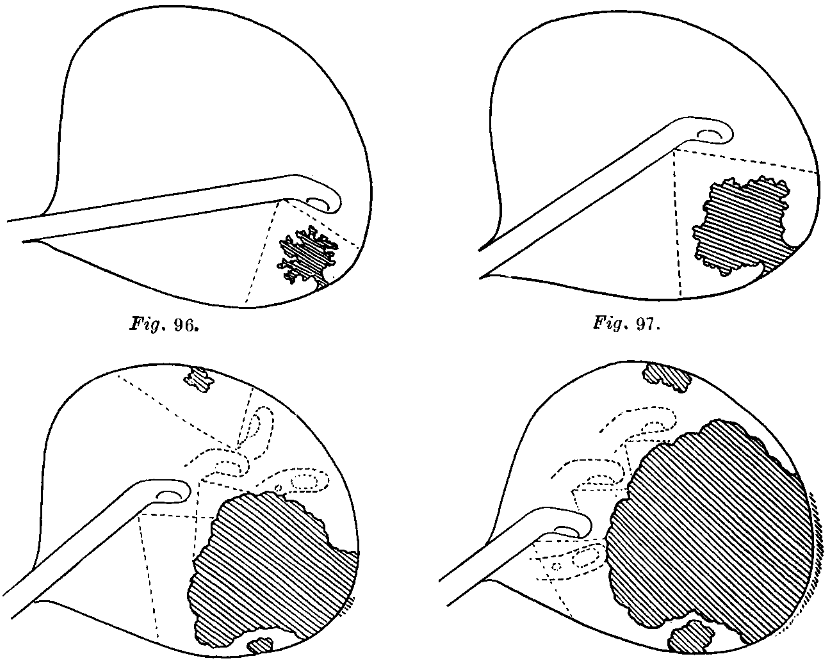


Fig. 96. *Fig.* 97.

Fig. 98. *Fig.* 99.

Figs. 96–99.—To illustrate the effect of the size of a papilloma on cystoscopy. For description, *see* text.

sink the electrode into the body of the growth so that when the current is running it adheres. Traction on the electrode may then indicate the mobility of the pedicle (Jocelyn Swan). In this figure no secondary buds are pictured. A papilloma of such size would be destroyed with ease in about two sessions of diathermy.

In *Fig.* 98 the growth is much larger. The difficulties of examination have increased materially. It is now impossible to obtain an idea of the tumour's dimensions by examination of any single field. A number of areas must be viewed successively and an attempt made to estimate its size by comparing it with the extent of unaffected and visible bladder wall.

It will be appreciated that increase in dimensions of the papilloma inflicts a double disadvantage on the surgeon, in that the tumour has increased and the bladder cavity has decreased. Owing to the former there is greater need for cystoscopic manœuvring, and on account of the latter there is less space for its accomplishment. In this connection the question arises whether it is wise to augment the quantity of vesical fluid. There is some risk in so doing of stretching or rupturing the base of the growth and starting hæmorrhage, but the advantages of increased space are so marked that the risk, which is not a very serious one, may be accepted. When found necessary, therefore, gently increase the bladder contents to a maximum of about 16 oz. This, of course, must not be done if cystitis is present.

In the case of a growth originating on the lateral wall of the viscus, especially if close to the urethral meatus, it is easy to understand that once it has overstepped the median sagittal plane of the bladder a direct view is impossible, and recourse must be had to observation obliquely along its surface.

In *Figs.* 98 and 99, and especially in the latter, this difficulty of orientation is well exemplified, and an attempt to show the positions of the cystoscope in an examination of such cases has been made. Two secondary nodules have been inserted in the drawings. In *Fig.* 98 one of these nodules would be discovered by careful cystoscopy. The second and lower one would probably be missed owing to its being overlapped by the main tumour. In *Fig.* 99 the growth of the bladder roof also might well be overlooked now that the bladder space is so much encroached upon. Note that in *Figs.* 96 and 97 there is no invasion of the submucous coat. This has occurred in *Figs.* 98 and 99. The question of treatment in growths of this size will be discussed later (page 180).

Large papillomata, especially when growing from the lateral recesses, tend to gravitate towards the bladder outlet. Multiple growths in this situation are frequently seen. At an open operation they are found packed down into this, the lowest portion of the bladder. The separate tumours fall together, their villi coalesce, and their bases are hidden. It is impossible to say how many tumours are present until the superstructure is removed. It is always surprising that they do not have a more pronounced effect on micturition. When a bladder affected in this way is cystoscoped the beak of the instrument passes through a thick collar of papillomatous material (*Fig.* 100) before it emerges into the open, but it is almost impossible to judge the depth of this collar so as to assess the size of the tumour. Any attempt to see the vesical meatus fails because this is completely covered, as is also the trigone. There is therefore no landmark from which to get one's bearings. These growths are amongst the most unsatisfactory from the point of view of perurethral diathermy. They usually prove to be quite big and are best treated through a suprapubic cystotomy.

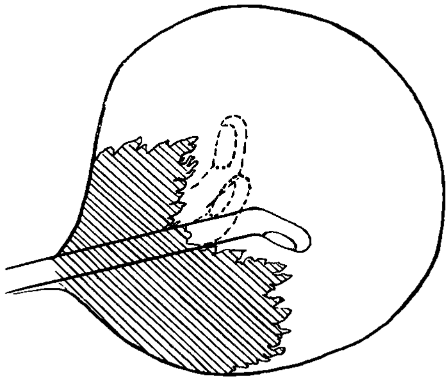


Fig. 100.—On entering the bladder the cystoscope plunges through a deep collar of growth. To show the difficulty of judging the size of papillomata in this position and especially their depth.

Position of the Growths.—

Primary Papillomata.—These have a strong predilection for the regions immediately behind and external to the ureter and inter-ureteric bar. In my experience the trigone escapes, though other writers have described growths arising therefrom. As we pass from the base to the fundus and roof their frequency diminishes rapidly. They are quite rare in the upper half of the bladder. Malignancy is greater in the lowest segment of the bladder, growths of the roof being very benign.

Another well-recognized though much less common site for implantation is the internal meatus. In this position the neoplasm covers that orifice as though a coin were placed upon it. It may bleed on the introduction of the cystoscope, and its extent is difficult to determine owing to its relationship to the prism. In the examination and treatment of growths in this situation the retrograde cystoscope is helpful (*Fig.* 101). It was for this purpose that Swift Joly introduced his retrograde instrument (*see Fig.* 178, page 282). Apart from it treatment would have to be by open operation.*

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*The chief value of this instrument is for growths situated half an inch to one inch away from the meatus. I personally find it difficult to approximate the electrode to the actual urethral margin, but this can be satisfactorily dealt with through a posterior urethroscope of the Geringer or Joly pattern after the main tumour has been destroyed through the retrograde cystoscope.

The position occupied by the papilloma, and an approximate indication of its size, should be entered upon a chart, and the drawing kept for reference during treatment. Further allusion to this chart will be made on page 186.

With tumours of large size it will be impossible to state with precision where the pedicle is implanted until its bulk has been reduced. The site of origin of an apical growth is also difficult to assign (Fenwick).

Secondary Papillomata.—Satellite buds do not confine themselves so exclusively to the peri-ureteric region. They are more widely and more evenly distributed over the bladder surface, though they are more common near the parent growth than away from it.

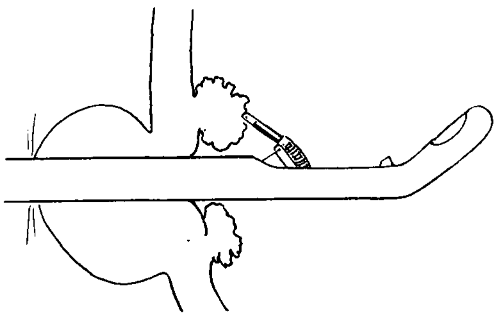


Fig. 101.—Treatment of papilloma covering the meatus by means of the retrograde cystoscope.

Nodular Growths.—These are, as a rule, easily located, but where cystitis is troublesome an incorrect impression may be obtained, both of their position and size.

The Relationship of the Ureters to the Growth.—This is important, as one of the ureters is frequently involved at its orifice, or in its intramural course, owing to the site of election of these tumours. It must be carefully located, and the possibility of damaging it by diathermy and causing stenosis must be kept in mind. Often it is concealed by a papilloma until a considerable portion of that growth is destroyed, when it emerges again. This reappearance becomes evident, however, not at the time of the treatment, but at the subsequent inspection (*see* page 183). When in close proximity to a carcinoma the ureter's relationship, which might at first sight appear to be of much importance, loses some of its significance, seeing that, whether adjacent or actually involved, it will need to be divided and re-implanted.

The implication of a ureter by a neoplasm is occasionally suggested by a complaint of renal pain resulting from back-pressure. Hurry

Fenwick believes that a kidney so involved is very susceptible to ascending infection. *Fig.* 102 illustrates the production of a dendritic stone following such infection with a urea-splitting organism.

Neoplasms invading the Bladder Secondarily.—Growths not originating in the bladder itself may be: (1) Extensions from elsewhere in the urinary tract, or (2) From parts not belonging to these organs.

1. Tumours not Originating in the Bladder Mucosa, but Extending to it from Other Parts of the Tract.—These may be papillomatous implantations from the renal pelvis or ureter or may arise in vesical diverticula, or the remnants of the urachus.

Implantations from Renal or Ureteric Papillomata.—Tumour cells may be implanted in the bladder from a papilloma of the renal pelvis or ureter, and occasionally one originating in the ureter may project into the bladder, as shown in *Plate VII* E, page 150. Papillomata arising in the renal pelvis seed themselves all the way down the ureter and, as a rule, most prolifically at the ureteric orifice (*Plate IX*). A growth projecting into the bladder from the ureter is much more likely to have a primary in the kidney pelvis than actually to originate at the end of the ureter. It is difficult or impossible to decide by

PLATE IX.

A carpet of papillomata covers the lower two-thirds of the ureteric mucosa, increasing in thickness towards the bladder end. Growths are sparse or absent at the upper end. The ureter is dilated to accommodate the tumours.

urography or otherwise with any certainty where the primary lies, but wherever it lies the correct treatment is a complete nephro-ureterectomy, the cavities remaining unopened except at the point of section, and the cautery being used here in order to avoid implantation of tumour cells in the wound.

The case history of the patient from whom the ureter shown in *Plate IX* was removed is sufficiently interesting to justify the inclusion of a summary :—

History.—The patient was a male, aged 49.

Summer, 1926.—Slight hæmaturia.

May, 1927.—Nephrectomy (right) by another surgeon.

June, 1928.—Occasional hæmaturia.

July, 1928.—Suprapubic operation for vesical papillomata.

February, 1929.—Fresh hæmaturia treated by another suprapubic operation—diathermy.

During the termination of his convalescence in the nursing home there was a 'lighting up' in the neighbourhood of the renal scar. Aspirated twice, and blood-stained fluid evacuated. Also "the swelling voluntarily burst and a fair quantity of blood was emitted".

June, 1929.—Severe but markedly intermittent hæmaturia.

On Sept. 15, 1929, the patient was first seen by me. The bladder was found to be slightly infected but free from papillomata. Sept. 21, 1929,

PLATE IX.

URETERIC PAPILLOMATA

To face page 166]

Fig. 102.—Papillo-carcinoma over the lower end of the right ureter. Dilatation of the ureter and pelvis. Coralliform stone in pelvis. Glass rod (passed from above) marks site of ureter.

total ureterectomy and closure of a small suprapubic orifice, slight leakage from which had been a cause of annoyance. Subsequent cystoscopies have shown no further papillomatous disease of the bladder.

In the spring of 1932 a lump re-formed at the site of the renal scar. Hæmorrhagic fluid was evacuated and tissue from the wall showed papillomatous material. Under irradiation the swelling disappeared, but again showed itself in the summer of 1934 and proved resistant to treatment. Secondaries in the spine became evident in December, 1934.

This case illustrates several interesting features :—

1. The tendency for ureteric grafts to occur in cases of papilloma of the renal pelvis. These gravitate to the lower end of the ureter, which is more seriously involved than the upper.

2. The extreme importance of complete removal of the ureter with the kidney.

3. The tendency for papillomata to affect the bladder also. If the bladder is infected from a pelvic growth, the chances are that the ureter too is involved.

Apart from those cases in which papillomata are discovered in the bladder, from which the pathology of the renal growth can be surmised, the difficulty is to recognize the type of growth before operation, for other growths of the kidney and also clots in the renal pelvis may cause filling defects. It is highly important to remove all the structures *unopened*, as if they are opened infection of the surrounding tissues with papillomatous material inevitably takes place. Whenever papillomatous material is shed into the connective tissues surrounding the urinary tract it reacts to its new environment by assuming the characters of a malignant growth, even though whilst confined within the tract the tumour had behaved as a benign one. Any sections of the urinary channels should, therefore, be made with the thermocautery or other destructive agent and the surrounding area should be packed off.

Diverticula.—Not infrequently diverticula are the seats of neoplasms (*see* page 139) both villous and nodular. A beautiful example is portrayed in *Plate VII* c, page 150. This growth, when first seen, fungated through the opening of the diverticulum into the bladder and hid the orifice. It was only when it had been reduced in size that its site of origin was appreciated (*see Fig.* 90, page 141). Allusion to the method of treatment adopted for this growth is made on page 185.

Urachal Growths.—Tumours presenting primarily at the apex of the bladder and cystoscopically indistinguishable from papillomata or epitheliomata may arise in those remnants of the urachus which persist so commonly within the bladder wall or in its immediate vicinity. Begg indeed states that this is the commonest type of tumour arising in the vault. *Fig.* 103 shows such a neoplasm and it can be clearly seen to occupy a channel within the vesical musculature. The intravesical portion is marked A and its cystoscopic appearance is shown

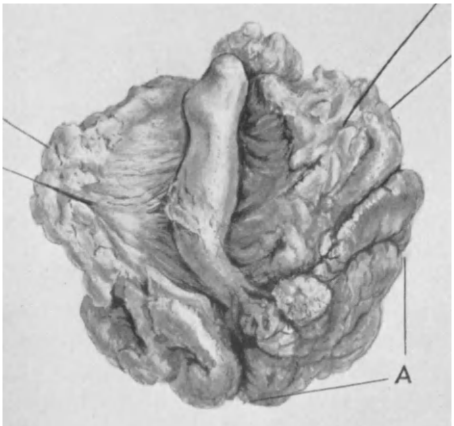


Fig. 103.—Operation specimen of a urachal growth laid open to expose the neoplasm as it lies in the canal of the urachus. The intravesical projection corresponding to *Fig.* 104 is marked A. The rounded upper pole of the growth was, at operation, just visible outside the bladder wall.

in *Fig.* 104. Most of these tumours are adenomata or adenocarcinomata, and many show colloid degeneration. They originate in the primitive cells of the urachus, and their histological type, which

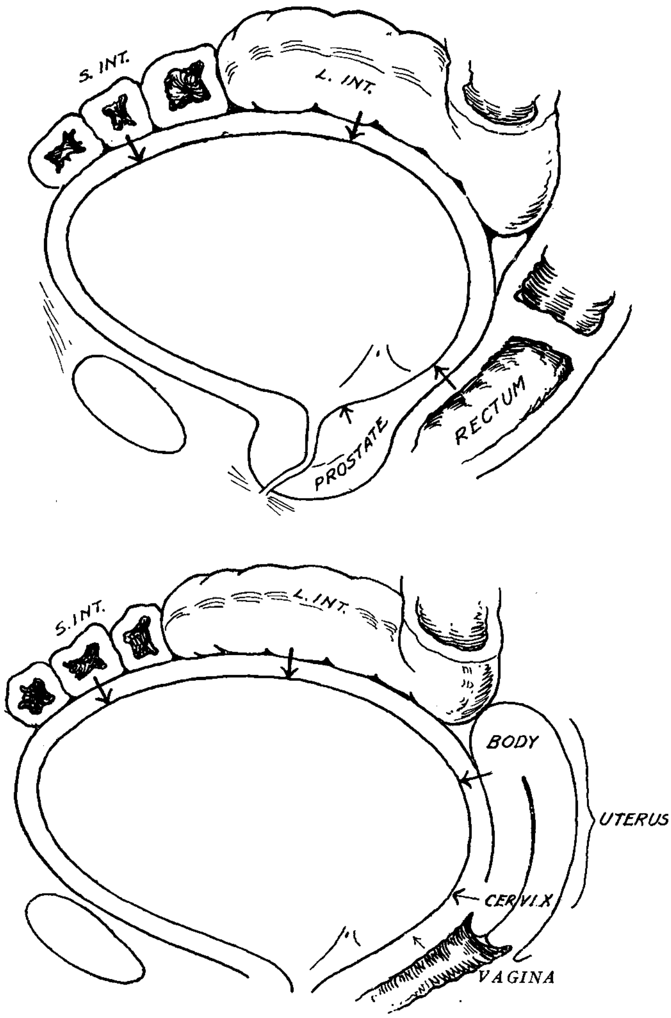
Fig. 104.—Cystocopic appearance of a tumour spreading from the urachus, of which the operation specimen is shown in *Fig.* 103.

closely simulates that of a rectal cancer, betrays an embryological descent from the hind-gut of the embryo. A consideration of their site of origin shows the futility of treating them by perurethral surgery. They must be freely excised, a procedure for which their situation renders them eminently suitable. When a primary tumour is discovered in the bladder vault the possibility that it is of urachal origin must be kept prominently in mind.

2. Tumours arising in Organs not belonging to the Urinary Tract.—Such growths encroach on the viscus at its nearest point (*Fig.* 105); thus tumours of the rectum or uterus will involve it posteriorly, those of the sigmoid superiorly, whilst those of the prostate will undermine the trigone. When involvement of the bladder secondary to another viscus is diagnosed, the position of the invasion may help to decide the primary site of the tumour. Tumours originating elsewhere and invading the bladder secondarily are easily distinguished from those primary in that viscus. The first alteration generally takes the form of an elevation of the bladder wall. Subsequently, however, the growth itself fungates into the viscus, or central puckering occurs in the mass as contraction takes place in the underlying neoplasm (*Plate VIII* D, page 160). At a later time fistulæ—the vesico-vaginal variety is the commonest—result from perforation. A cystoscopic drawing taken from a case of sigmoid carcinoma which perforated into the bladder is shown in *Plate VI* D, page 130. The whitish purulent material seen in the centre of the picture flowed into the bladder during cystoscopy and became more abundant on suprapubic pressure.

Differential Diagnosis.—When the conditions are favourable, the diagnosis of a vesical tumour is easy; but when cystitis, hæmorrhage, and a 'thimble bladder'—severally or in conjunction—thwart the operator, mistakes readily occur. A growth covered with fibrin and muco-pus, and especially if encrusted with phosphates, is easily mistaken for a calculus. Conversely, a stone similarly coated in débris may be mistaken for a necrotic tumour. The mobility of the stone when touched by a bougie, and the fixity and tendency to hæmorrhage of a growth under similar circumstances, serve to distinguish them, as will indeed a radiogram. Occasionally a circular blood-clot occupying the bladder base will simulate an infiltrating carcinoma. Subsequent investigation will correct this error.

The difficulty in distinguishing between a small papillomatous bud and some of the manifestations of cystitis has already been discussed (page 84). It arises particularly in infected bladders, which are, or have been, the seat of a villous tumour. A similar difficulty may be experienced with larger growths—say those the size of a pea. Cystitis with proliferation occasionally produces polypoid objects ('cystite végétante'), and it may be very hard to decide whether such a lesion is neoplastic or inflammatory. The latter are usually more irregular in shape than are new growths, are generally devoid of pedunculation, and indeed their base is, as a rule, wider than their apex, whilst their swollen appearance and deep-red colour correspond to that of the surrounding hyperæmic and œdematous mucosa. These



b

Fig. 105.—Points of invasion of the bladder by carcinoma arising in the various contiguous structures. *a*, Male ; *b*, Female.

vegetations are, however, extremely polymorphic and may be almost indistinguishable from papillomata. Probably further examination of the bladder will show other similar manifestations close to or in a remote part of the viscus, whilst treatment directed against the cystitis may clear that organ sufficiently to allow any true neoplasm to be identified.

Concomitant Bladder Lesions.—Concomitant bladder lesions are frequent. Most of them have already been referred to. *Cystitis* is the most important. Its occurrence, especially complicating malignant disease, has been noted, and is so characteristic as to have diagnostic significance. It may precede or follow instrumentation. *Leucoplakia* (*Plate VIII* F, page 160), described on page 221, is an occasional sequel of old-standing cystitis. Malignant degeneration of the thickened epithelium may accompany it, and in this instance the cystitis is, of course, a precursor and cause of, instead of a sequel to, the growth. *Calculus* formation is rare. It is usually of the secondary phosphatic type. Blood stones may occur when hæmorrhage has been severe (*Plate VII* A, page 150). *Fistula* and *diverticulum* have already received adequate notice. In places where the disease is endemic, *bilharziasis* acts as a precursor to various neoplasms (*see* page 128).

CYSTOGRAPHY.

Unhappily not a few patients reach the surgeon when the growth is so advanced that even its cystoscopic recognition is difficult or impossible. The bladder may be almost or quite filled with growth, cystitis or infiltration may render it small or intolerant, whilst hæmorrhage may be severe and intractable. Cystoscopy is hampered and may be of little use. We may then take advantage of cystography. By filling the bladder with some radiographically opaque solution (*see* page 136) a silhouette of its cavity may be obtained on an X-ray film. A vesical tumour projecting into this cavity will appear as an area of diminished opacity within the X-ray shadow. Though incapable of affording us the detailed information attainable by cystoscopy, this examination will ratify the suspicion that a neoplasm is present; it may show its size and position and may also indicate whether it is villus-covered or smooth. It will further demonstrate the shape and size of the bladder itself, and thereby it is often possible to judge the probability of infiltration.

Benign Tumours.—A benign villous papilloma shows an irregular wavy margin with numerous secondary indentations (*Figs.* 106–108). When the axis of the rays is suitably directed the pedicle will be recognizable and breaks the line of the bladder contour. It can generally be located in one or other of plates taken in different axes. When the pedicle lies in the axis of the rays it will not be seen, and the

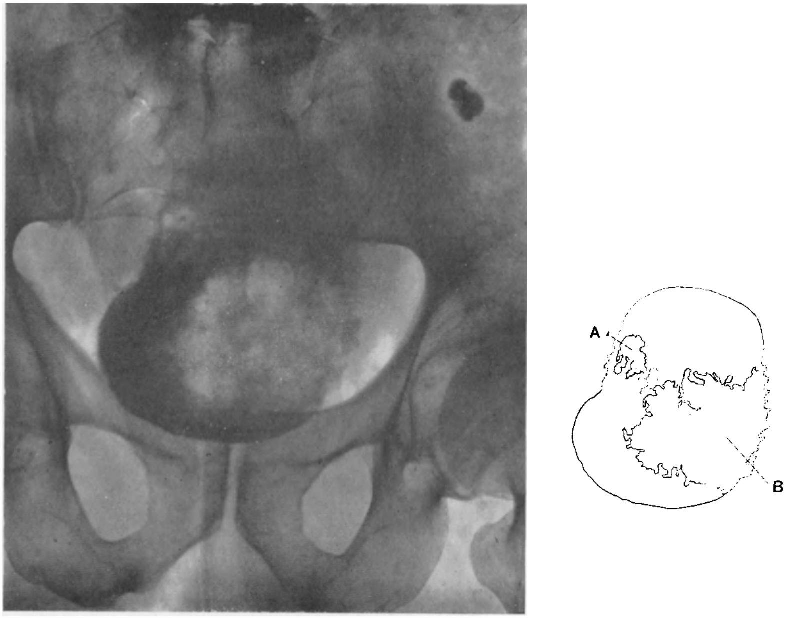


Fig. 106.—Cystogram of large papilloma and secondary growths; A, Outlying growths; B, Main growth.

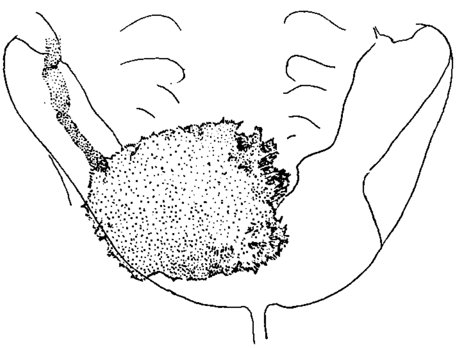


Fig. 107.—Tracing of cystogram in a case of large left-sided vesical papilloma. Note regurgitation up the ureter of the unaffected side.

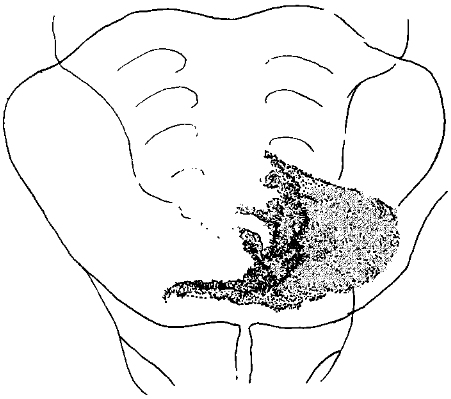


Fig. 108.—Tracing of cystogram in a case of large papilloma of the right side of the bladder.

gap produced in the shadow by the growth will probably be completely surrounded by contrast solution.

The bladder shadow shows an organ of normal size, and its contour is smooth, sharp and regular, except at the points where it is in contact with the papilloma or its pedicle. Hypertrophy of the musculature is often present in papilloma-containing bladders owing to obstruction, and the small irregular indentations to which it gives rise at cystography are quite characteristic and easily recognized once their appearance is known (*see Fig.* 78, page 132). Blanc and Negro state that the fronds engage in the vesical neck at a given moment and stop the stream. If radiograms are taken before and after micturition, a considerable residual will, in many instances, be observed in the second plate. Blanc and Negro appear to have found retention very common in papillomatous bladders. It is favoured by a long pedicle, long villi, and also by large growths.

Infiltrating Tumours.—A reference to *Fig.* 94 will show that an infiltrating tumour may or may not have a noticeable intravesical prominence. When there is such a prominence its outline is smoother than that of a benign growth, the villi, if present, being stunted or swollen and the tumour relatively solid. Owing to the absence of penetration by contrast fluids amongst the villi, the lacuna which the tumour causes within the vesical shadow is more pronounced and has better-defined edges. When there is no protrusion but merely infiltration no lacuna will appear on the radiogram. But in this case, as also frequently in the case of projecting malignant growths, the bladder itself is modified. It is irritable and small. Its outline shows considerable change, and much variety of shape may be seen in any series of bladders, largely dependent on infiltration and infection.

The following table modified from Blanc and Negro summarizes the principal cystographic features of simple and malignant neoplasms.

	Papilloma	Epithelioma
Vesical capacity -	Good	Reduced
Bladder outline -	Regular	Irregular but sharp
‘ Image lacunaire ’ -	Density not uniform	More uniform and intense
	Margins broken, delicate, shade off	Sharper
Bladder evacuation -	May be incomplete	Generally complete

Similar information may be obtained by intravenous urography, the exposure being made after the bladder has had time to fill with contrast solution. This procedure has the additional value of indicating renal function and of showing whether there is back pressure on either kidney.

INDICATIONS FOR TREATMENT.

At the cystoscopy the surgeon must make up his mind regarding his line of action. Growths may be judged to be suitable for: (1) Perurethral treatment; (2) Open operation: (*a*) Intravesical fulguration, (*b*) Partial cystectomy. Or they may be (3) Unsuitable for radical treatment, possibly suitable for suprapubic drainage or radium.

The factors controlling the decision are the size, position, and nature of the neoplasm, and the age and condition of the patient. Simple villous tumours will invariably nowadays be submitted to diathermy unless they are deemed too extensive. The effect of size on treatment is reviewed on page 179. When definite malignant change is observed, partial cystectomy will be required. Nodular growths, when not too extensive and not involving too much of the trigone, can be excised. Implication of one ureter does not preclude excision, but when both are involved operation is contra-indicated. The further away a growth is from the neck and trigone, the more suitable is it for removal. Hard-and-fast rules cannot be laid down to govern the choice of cases. Considerable judgement and experience are required, whilst individual surgeons vary in their selection of a method of attack.

THE PERURETHRAL TREATMENT OF SIMPLE PAPILLOMA OF THE BLADDER.

History.—Modern perurethral treatment of bladder papillomata dates back to the year 1910, when Beer introduced the electrode of the monopolar or Oudin current into the bladder through the cystoscope, and thus opened the way for the destruction of vesical tumours under observation. His first report included two cases, which, however, were rapidly followed by others from Keyes, Buerger, Wolbarst, etc., so that, in 1911, 38 cases could be collected by Beer. The procedure rapidly gained adherents. At first the monopolar current was employed, but it soon gave way to the bipolar, d'Arsonval current. With the former the electrode was held at a distance from the tumour, and destruction was obtained by firing sparks of varying lengths thereat.* In the bipolar method, which I believe holds the field exclusively to-day, the active electrode is introduced amongst the villi of

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*Beer in America has recently drawn attention to some advantages of the Oudin monopolar current. The difficulties of insulation are greater with the Oudin than with the d'Arsonval current, which presumably accounts for the preference shown for the latter on this side, as with the small-calibre cystoscopes in favour here these difficulties cannot be overcome.

the papilloma and the current passes through the whole tissue of the growth to the inactive electrode, which is situated under the sacrum. This form of treatment had previously been applied to lesions of the surface of the body, growths, nævi, tuberculomata, etc., the only difference between it and the intravesical application being that the latter was carried out under water and through the cystoscope.

Technique.—The bladder is prepared in the way described for the examination of the growth. For routine work a distension of 8 oz. should be employed. Lesser quantities are inconvenient, giving too little space, whilst over-distension may be provocative of bleeding. The inflamed bladder may, of course, decline to take this quantity,

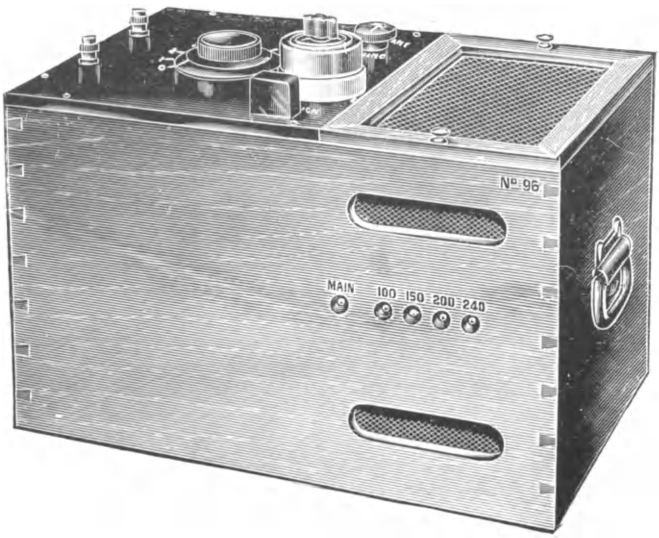


Fig. 109.—Diathermy machine.

and on the other hand large bladders may be induced to take considerably more, but such an amount should be employed only after failure to manipulate the cystoscope with less fluid, as over-distension may excite hæmorrhage. Where much difficulty is encountered from the size of the growth, however, the surgeon should not hesitate to employ as much as 16 oz.

The patient occupies the usual cystoscopic position, and under his sacrum lies a large flat electrode (7 by 5 in.) which is connected to one pole of the diathermy machine (*Fig.* 109). The other pole is attached to the active or vesical electrode, which is an insulated and supple wire of the size of a ureteric catheter, tipped with platinum

(*Fig.* 110). Ogier Ward prefers the multiple electrical contacts given by a brush electrode (*Fig.* 111). The pad of the inactive electrode is soaked in saline solution. The active electrode is sterilized by immersion in antiseptic lotion. A single catheterizing cystoscope is employed, and after the bladder has been prepared the telescope is introduced and the barrel loaded with the electrode.

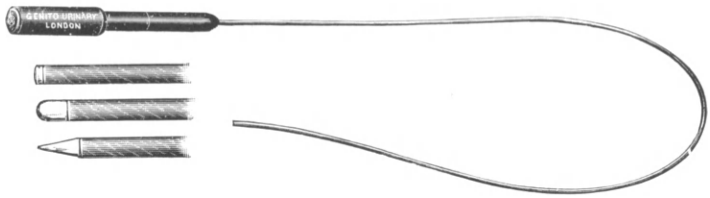


Fig. 110.—Intravesical electrode for perurethral diathermy.

In Chapter II the practice of connecting the cystoscope direct to the town's mains, as is sometimes done, was disapproved. When that supply of electricity is employed for the diathermy machine a separate source of current to light the cystoscope lamp is essential to

Fig. 111.—Ogier Ward's brush electrode for treatment of vesical papillomata.

safety. A Universal machine which is 'earth-free' may, however, be employed, as the low-tension circuit, containing the cystoscopic lamp, has then no direct connection with the main.

A fresh survey of the field of operation is now made and the line of action determined. Satellite buds are attacked first when they

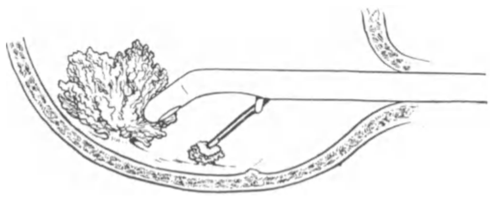


Fig. 112.—Treatment of vesical papilloma begins with secondary growths if any are present.

are accessible (*Fig.* 112). Their situation is known, for it was charted at the examination cystoscopy, and they are quickly located. They are generally rapidly and completely destroyed. If left until after the main tumour has been burnt, they may be hidden by débris derived from the destruction of the latter.

After the electrode has been projected the current is turned on. A swirl will be seen in the medium and the villi of the papilloma will sway slightly. Let the current be weak at the start and increase it gradually. The writer estimates the strength required by the effect on the growth rather than by the ammeter. As the electrode comes into contact with a villus, more marked movement occurs and a stream of bubbles rises to the bladder summit. If the cystoscope is held vertically over this stream, the bubbles will encounter the fenestra, and lodging there will obstruct vision ; but if the instrument is held obliquely, they pass by on their way upwards. When bubbles do so obstruct the view they are easily dislodged by rotating the whole instrument so that the fenestra points upwards and then tapping the barrel, when the bubbles will rise to the bladder apex, or sometimes they may be more simply removed by withdrawing the telescope momentarily into the catheter. Blanching and coagulation occur in the area of the papilloma which is in contact with the electrode. The longer the two remain in contact, the wider and deeper becomes the extent of the charring, and the central portion eventually turns

PLATE X.

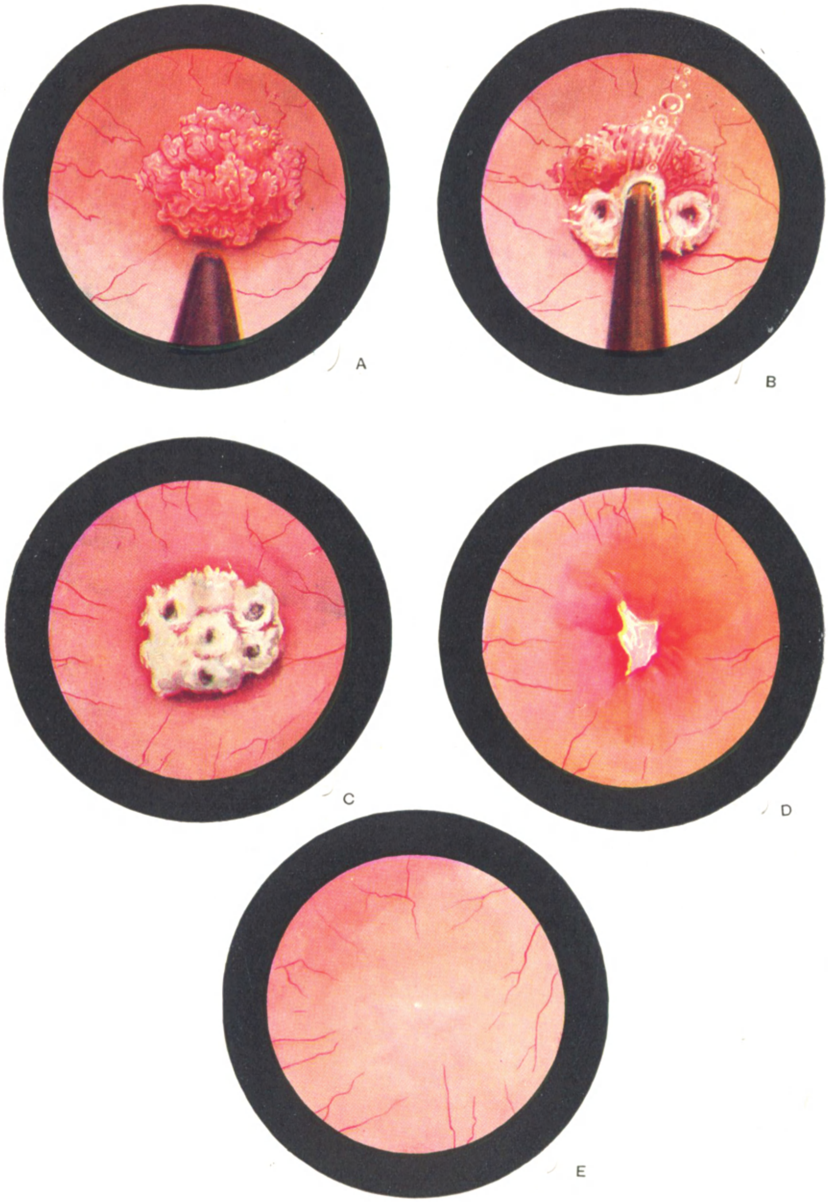
A, A small papilloma prior to treatment. Note its delicate villi each containing a vessel. The intravesical electrode (foreshortened) is seen in the foreground ready for application. B, Electrode in contact. Note the white eschar with a dark centre and the gaseous bubbles rising to the vesical vault. C, Treatment completed. D, Seen twelve days later. A central unhealed ulcer with surrounding hyperæmia and slight œdema. E, The area of implantation at end of two months, now avascular.

black. This eschar is non-conducting to the electrical current, and the consequence is that sparking takes place to adjacent portions of the growth, and not infrequently a miniature explosion occurs as bubbles imprisoned in the growth force their way to the surface. When the current is working at good pressure a hissing noise is produced in the bladder, and is conducted to the surface by the shaft of the instrument.

The current is switched off before any attempt is made to withdraw the terminal, and then it will be observed that the tip has adhered to the neoplasm and must be forcibly detached. Often it retains its hold stubbornly and ultimately carries away with it a portion of charred tissue. This does not occur until the process of cauterization has been pressed home deeply at a given spot. Charred débris acts as an insulator and must be removed. Sometimes this can be done by withdrawing the electrode into the barrel of the cystoscope, the diathermic current being, of course, turned off. Contact with the walls of the catheter may detach it. Usually, however, it becomes necessary to withdraw the electrode completely for more effective mechanical cleansing, as by scraping.

PLATE X.

PERURETHRAL TREATMENT OF VESICAL PAPILLOMA



Size of the Growth.—The size of the neoplasm has an important bearing on the treatment.

Small Papillomata.—Growths the size of a large pea or a small marble may be quickly destroyed by the application of the electrode at three or four points (*Plate X* C). Complete blanching of the growth is obtained, and at the finish the electrode is sunk into the mass centrally and held there in order to obtain destruction of the pedicle. Examination after a period of three weeks will demonstrate the disappearance of the growth.

Larger Tumours.—These will probably require many points of contact and more than one sitting. With a growth about the size of a small walnut high frequency may be applied to the whole of the surface at a first sitting, and material decrease in its size be obtained. It is well, as a rule, to start with the part farthest from the operator, placing the electrode behind the growth and burning its distal or upper surface. If the reverse process is adopted, this area will later be hidden from view by charred débris lying in front of it. The nearer portions are then systematically attacked. When a new spot is being selected for application of the current it should not lie too close to the previous zone, for the surrounding area is already doomed, whether it appears so or not (*see* page 183). A second application in three weeks' time will probably complete the work on a tumour of this size and render the bladder free from growth, though the speed of reaction to diathermy varies with the degree of malignancy.

Should one ignore the surface of the tumour and direct one's energies to the pedicle, thus, as it were, undermining it ? This suggestion is frequently put forward and is unusually attractive. In practice, however, it proves disappointing. Most tumours have a rounded, squat formation, and though they may have fairly long pedicles, yet the branches swoop down and conceal the main trunk with a spacious arborescence which precludes direct application of the electrode. Occasionally, however, one does come across a particularly long pedicle which invites division.

The same principle may be applied to secondary branches of the growth by turning the cystoscope on to its side and cutting into the mass laterally. A whole frond may thus be cut off low down and fall away—a manœuvre which is economical of time. It is doubtful, however, whether the procedure is wholly wise. Cells from the surface of the papilloma are capable of being detached and re-implanting themselves with the production of grafts. Is not such implantation specially likely to occur if masses of unnourished growth are recklessly thrown down on the healthy bladder wall ? It is probably safer to adopt the more tedious and laborious process of killing the tumour from surface to base with the assurance that each portion of detached growth is previously devitalized.

Large Growths.—With each increase in the size of the tumour the surgeon's difficulties multiply, until at length it becomes questionable whether the case is suitable for perurethral treatment at all.

To deal with large papillomata Kidd introduced a special diathermy cystoscope (***Fig.*** **113**), in which a large electrode forms the beak of the instrument. This electrode is capable of carrying much heavier currents than the usual pattern, but it demands the greatest care and much experience to use it safely. Heritage and Young have also designed instruments to deal with large growths.

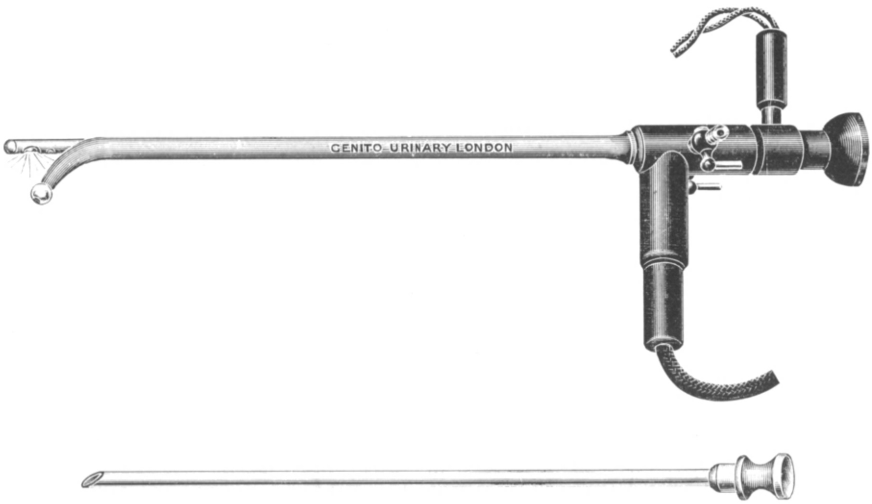


Fig. 113.—Kidd's cystoscope for fulguration of large papillomata.

When a large neoplasm is benign, one must decide whether to set out on a protracted course of diathermy or to open the bladder and, by employing a combination of cutting current and diathermy, to destroy the tumour (*see Lancet*, 1931, Dec., p. 1403). There are disadvantages with each method, for prolonged and repeated endovesical treatment is trying alike to patient and surgeon, whilst with the open operation comes the danger of wound implantation, the prolonged convalescence, and the fact that the patient does not entirely escape subsequent cystoscopies and perhaps diathermies. Most surgeons, however, at a given stage elect open operative methods, though the point at which the transition is made will differ with different workers and with the features of the individual growth. Amongst other things the position occupied by the neoplasm has its influence. Thus a tumour the size of a golf ball lying well back in the bladder opposite the surgeon might be easily dealt with per urethram, whereas if a growth of similar size lay over the vesical outlet (*see* page 164 and *Fig.* 100), open operation should be preferred. In borderland cases it is well to give a first or probationary sitting, as thereby the size of the tumour may be reduced so that treatment will be easier at a subsequent date. Where it is difficult to manœuvre the cystoscope so as to get a reasonably good view of the growth, points are selected remote from the bladder wall in order to ensure the latter against damage. Considerable reduction in the size of the tumour may thus be obtained, especially if the treatment is carried on persistently, and at a subsequent date one may be able to work under better conditions. Thus certain tumours which at first sight appear to be unsuitable for perurethral treatment may ultimately be destroyed.

Clarity of Medium.—As the surgeon works, the bladder medium becomes cloudy. This results from the charred débris of the treated surface floating out into the vesical fluid and rendering it opaque. Turbidity is much more troublesome with large and luxuriant growths than with smaller ones, whilst with the smallest it scarcely interferes at all. In the last mentioned such débris as there is remains adherent to the papilloma or falls quietly on to the bladder base. In middle-sized tumours re-washing becomes imperative after five or ten minutes' treatment. Gradually the medium becomes so cloudy that only a vague impression of the bladder contents is possible. At this stage the cystoscopist, who has watched the papilloma and its surroundings during the transition from clear to opaque, can still effectively and safely apply his treatment, even though it would now be difficult to demonstrate the growth to another observer, and it is advisable to continue well into this phase lest irrigation be too frequently resorted to and time be lost. Safety is guaranteed by keeping to portions of the villous tumour which are known to be remote from the bladder wall, and by restricting the movements of the electrode.

Re-washing.—Advantage should be taken of the properties of the irrigating cystoscope when re-washing the bladder, for not only does this obviate the passing of a fresh instrument, but its thin walls and consequently large bore allow rapid entry and exit of fluids, with greater disturbance of vesical débris and therefore more rapid cleansing of the field. With this instrument half a minute suffices for the whole procedure. The eye of the instrument during the inflow should face the growth. By this means the débris on the papilloma and the bladder base is disturbed and a more effective clearance is obtained. Before evacuation the fenestra must be rotated so that it points away from the growth, lest the latter should become entangled therein.

On re-examination of the bladder the improvement in visibility is gratifying, but inspection of the tumour generally suggests an unsatisfactory extent of destruction. The burning, however, goes deeper and further than present appearances indicate, as will become evident at a subsequent date (*see* page 183).

Duration of Treatment.—Treatment is carried on in the case of small or medium-sized tumours until total destruction appears to be achieved. In larger growths either of two factors may be responsible for terminating the session. When the tumour has been fulgurated over a large area it becomes covered with semi-adherent powdery débris which detaches itself at every touch of the electrode and so renders the medium turbid. Further, this adherent débris is a non-conductor of electric currents, and it is valueless to apply diathermy through it. For these reasons treatment cannot be carried on beyond a certain point, which is reached as a rule in about half to three-quarters of an hour.

Anæsthesia.—A papilloma is insensitive and can be burnt freely without evoking pain, if the bladder surrounding its base, which is sensitive to thermal stimuli, is safeguarded. The question of anæsthesia really turns on the amount of time that will be occupied by the treatment, and therefore on the tumour's size. Large growths are taken into the hospital wards and given treatment say up to three-quarters of an hour in duration. To these patients a general or a spinal anæsthetic is administered, chiefly because of the discomfort of so long a cystoscopy. Smaller growths are treated in the Out-patients' Department, where also the late sessions of diathermy for large ones are given. For these a local or sacral injection is sufficient.

Period in Hospital.—Cases treated in the Out-patients' Department return home immediately. The stay of a patient admitted to hospital is regulated by his recovery from the anæsthetic rather than by the condition of his bladder. As a rule he leaves his bed the day following operation and is discharged on the subsequent day.

Date of Return for Examination.—The patient is instructed to return on a specific date for re-inspection. Whether he returns to the ward or to the Out-patients' Department depends on the surgeon's impression of the amount of destruction attained, and his idea of what the growth's size will be at the next session.

It is a mistake to inspect the organ before an interval of three weeks has elapsed, as sloughs and débris require this period to separate completely. Moreover, a certain amount of bullous œdema and chronic infiltration may still remain round the cauterized spot, giving an appearance suggesting malignancy. Cabot calls this a 'pseudo-carcinoma', and states that it may last as long as three months. We know that it was not there when treatment began and may therefore assume that it is due to the burn; but if any doubt exists as to its nature, fulguration in its immediate vicinity should be avoided until any inflammatory induration has had time to subside, otherwise the cystoscopist may again and again be misled by the appearance of infiltration which looks to be neoplastic but really results from his own treatment. I have twice had patients referred to me on account of such a ' pseudo-carcinoma '. In each case the surgeons had reburnt the supposed growth to obtain a cure. In each, as should have been foreseen, the lesion was aggravated, but under expectant treatment it subsided completely. If, after a reasonable period of waiting, the cystoscopic appearance remains indeterminate, a bite of the affected wall may be removed by the rongeur and submitted to the microscope ; but there is some danger of obtaining only the inflammatory area around an actual tumour, as in five instances recorded by Frater in which such material was reported upon as inflammatory, in each the disease eventually showing itself to be malignant.

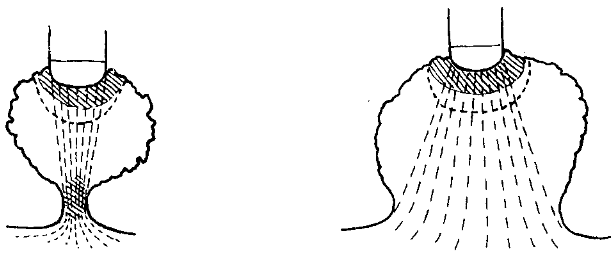
The opposite mistake has also been made, a ' pseudo-carcinoma ' being removed operatively, whereupon its inflammatory nature was discovered by microscopy (Barney). Prolonged cystoscopic vigilance is apparently easier and more satisfactory than any other mode of investigation, as, should the lesion be due to the burn, it will recede, whereas if it represents malignant infiltration it will progress.

Another lesion which may be wrongly construed is a patch of unhealed mucosa, whose velvety granulations, floating under water and seen with the high magnification of close cystoscopic inspection, may simulate a bud of neoplasm. Three or four weeks, therefore, should be allowed to elapse in order to permit the separation of sloughs and the disappearance of such pitfalls to correct diagnosis.

When the diagnosis of vesical papilloma is first made the patient should be advised of the necessity for repeated treatments and inspections. He should be told that the cessation of hæmorrhage must not lull him into thinking that the growth is cured. If the probability of relapse and ultimate malignant transformation is carefully explained, there will be but few delinquents.

Effects of Treatment.—At the examination three or four weeks after the diathermy it is always interesting to discover how much of the papilloma has disappeared. Usually the destruction is greater than was foreseen. It is not uncommon, indeed, when a papilloma has been treated without any expectation of its disappearance, to re-examine at the end of a month and find it gone. Whilst this may be gratifying in one way, it is a matter for apprehension, in that the base has not been adequately cauterized. Generally, however, a search will demonstrate an area of hyperæmia in the position previously occupied by the papilloma, and the application of an electrode at this point will allay anxiety. For this reason it is not good to allow the period between cystoscopies to overrun four weeks lest this indication should vanish.

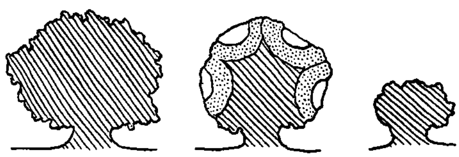
The large extent of devitalization is explained by the way heat is developed in the tissues through which the current passes on its way to the inactive electrode. The whitened tissue seen through the cystoscope only represents the zone of intense heat around the point of the terminal where actual coagulation is taking place. Heat,



a b

Fig. 114.—Diagrammatic representation of the course of the diathermic current in papilloma with: *a*, A small pedicle; and *b*, A broad pedicle.

however, is developed in greater or less degree at every point between the two electrodes, its intensity diminishing as the cone of tissue through which it is passing broadens out (*Fig.* 114*b*), so that the visible area of white charring overlies one in which the current density is insufficient to cause coagulation, but is nevertheless sufficient to



a b c

Fig. 115.—Illustrating effects of diathermy on a papilloma: *a*, Original growth; *b*, The apparent destruction at end of session; and *c*, The appearance presented at a subsequent sitting.

devitalize the cells. This tissue, which appeared unchanged at the time of the treatment, has died and disappeared at the end of three weeks (*Fig.* 115).

Concentration of Heat on the Pedicle.—The amount of heat, therefore, developed in any tissue is proportional to the current density. If a papilloma has a thin pedicle, the current is highly concentrated on this structure (*Fig.* 114*a*) and its devitalization is always a possibility. Presumably the unexpected total disappearance of tumours is thus explained. *Fig.* 116 represents a piece of papilloma passed per urethram by a patient about a fortnight after treatment, the pedicle having been destroyed by such concentration of the current. Another interesting example was seen in a man who developed a papilloma in a diverticulum (*Plate VII* C, page 150), and the growth attached to a spot far out of sight could not be directly cauterized under inspection. The diverticulum and growth should have been submitted to open operation, but on other grounds the case was unsuitable for so serious a procedure. Diathermy was therefore applied to the protruding surface of the growth and was continued very persistently. No recurrence of the neoplasm showed itself during a period of two years in which the case was under observation, and I take this as fair evidence that the destruction was complete in spite of the impossibility of reaching the base of the growth.

Fig. 116.—Piece of papilloma passed per urethram fifteen days after diathermy. (*Natural size.*)

Figs. 114 *a* and *b* also demonstrate the safety of the bladder wall from burning, as the current on reaching it is immediately dissipated in all directions, and the amount of heat generated is very small. Burning of the viscus can, therefore, only take place when an electrode is in actual contact.

The site previously occupied by a papilloma seen at the end of a three weeks' interval may be difficult to identify, so closely does it approximate to the normal bladder mucosa. However, at this period an area of hyperæmia may generally be detected, and occasionally well-marked bullous œdema which disappears within a week or two, or even a thermal ulcer may be seen. At the end of an eight weeks' interval the site is marked by a few leashes of blood-vessels converging on an avascular spot (*Plate X* E, page 178). When the growth has been incompletely destroyed its appearance will vary with the degree of destruction obtained. The areas over which the cautery has been effective lie lower than previously and may be fringed by longer and sometimes straggling portions which have escaped destruction. The former are generally smoother and more granular in appearance, and perhaps a deeper red than is the ordinary papilloma tissue.

Recurrence.—Recurrences after apparent cure may show themselves early or late, at the site of the original growth or away from it, or as a general papillomatosis. *At the site* of the original tumour recurrences are due to inadequate destruction of the papilloma base. It is interesting to note that after the first three months they are very rare. Gardner sent round a questionnaire on this point, and found that only a single case—and that one of his own—could be traced. It showed itself at the end of three years. Another writer, whose patients had been unfortunate in the number of recurrences from which they had suffered, states that these had almost invariably taken place at a site remote from the primary growth.

Recurrence *elsewhere* may be due to secondaries present at the time of the operation, but so small as to be invisible, which have now grown into evidence. Suspicion may be aroused that they result from the implantation of cells knocked off during cystoscopy. As a prophylactic measure against this complication, the irrigation of the bladder with weak silver nitrate solution (1–1000) after treatment should become routine, as thereby possible implantations are destroyed. In addition, I leave a couple of ounces in the bladder for the patient to pass later.

Whenever a bladder is found to contain more than three or four tumours, we may prophesy a continual tendency to relapse. Recurrences caught early are rapidly and easily controlled by diathermy; they should never be allowed to get out of hand if the follow-up system is efficient.

Follow-up Record.—The following-up of these cases is one of the most important parts of their handling. If all cases were persistently and systematically watched at appropriate intervals, fatalities from recurrence would be rare. I personally have great belief in the efficiency of perurethral treatment if carried out as described and properly followed up. When I hear, as occasionally happens, of some growth which has recurred and now appears inoperable I believe it is more frequently than not the follow-up that is at fault. My own system is as follows:—

After the papilloma is considered to have been destroyed the bladder is inspected once at the end of a month. Thereafter two examinations are made at three-monthly intervals, and three more at six-monthly intervals. That carries us over a period of two years. In isolated cases where the growth was very large or presented doubtfully malignant characteristics further inspections may be recommended. At each of these cystoscopies the whole of the vesical mucosa is carefully scrutinized, whilst the site occupied by the original tumour and by any secondary splashes receives special attention. Any recurrence is caught when very small and easily destroyed. I keep a record book (*Fig.* 117) of bladder tumours in which the original condition, position, and number of growths are charted, and the history is entered, together with my original impression of the prognosis. On the back of each sheet are noted the way in which the tumour is reacting to treatment, the time when it is proposed to treat it again, and whether the patient must come into the ward or to the Out-patients' Department, etc. In this way patients are not overlooked, as is liable to happen when numbers of similar cases are under treatment at one time.

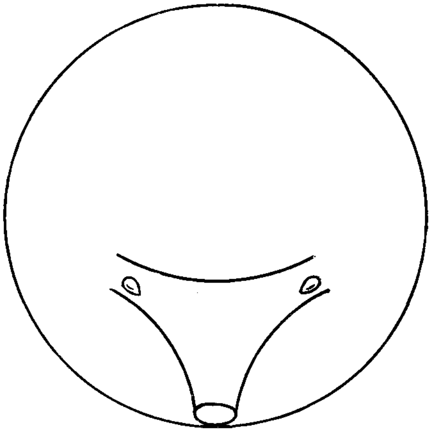
VESICAL PAPILLOMA. FOLLOW-UP RECORD.

Name	*Sex* ....
Address	*Age* ....

SIZE

NUMBER

PROGNOSIS



HISTORY

REMARKS

(*Heading of the back of Record.*)

Instructed to return	Returned	Treatment and Remarks

Fig. 117.—Record book for bladder tumours.

Post-operative Complications.—A little discomfort on micturition, especially on the first occasion, is usually all that is observed, though occasionally a patient complains of abdominal pain, groin pain, or pain in the back, which is attributable to the cauterization of the bladder wall itself. Three complications, however, claim our attention; they are hæmorrhage, sepsis, and burning of the internal meatus.

Hæmorrhage.—This is a complication which, according to Beer, occurred in 3 out of 200 cases (1½ per cent). It is therefore rare. It may happen shortly after the treatment or at the period when the sloughs separate. It is generally not severe, and can usually be controlled by rest and cold. Occasionally, when copious, the bladder has to be opened in order to stop it, but it is often possible to wash the viscus clear and once more seal the bleeding point with the cautery through the cystoscope. The possibility of its occurrence should be kept in mind, and during the period in which his sloughs are separating the patient should not go too far from where he can obtain skilled surgical aid. In actual practice the complication rarely arises.

Sepsis.—After diathermy a necrotic mass is left behind which offers itself as pabulum to any micro-organisms present, so that sepsis must be meticulously guarded against. The responsibility of keeping a bladder clean through a long series of cystoscopies requires emphasis. These patients must be flooded with hexamine for twenty-four hours before, and for a week after, operation. Further, I irrigate the bladder, as before stated, with silver nitrate after the fulguration, and leave a couple of ounces in the viscus for several hours.

The presence of *severe* cystitis prior to diathermy should be regarded as a contra-indication to that operation, and a determined effort should be put forth to get it under control before such treatment is adopted. If this proves to be impossible, open operation should be considered. The choice will, however, depend on the degree of the sepsis. Even if it were advisable to treat a papilloma in a considerably inflamed bladder, the treatment would be difficult because the surrounding redness and œdema hide small buds and indeed may simulate them, and also because the inflamed viscus resents manipulation. Malignant cases are more susceptible to sepsis than are simple ones, and much more difficult to cure. In the presence of infection, tumours, especially carcinomata, may take on fresh activity and grow more rapidly.

Burns of the Internal Meatus.—If the cystoscope or electrode is unwittingly withdrawn against the urethral orifice whilst the diathermic current is still running, a linear burn of the internal meatus will result. I know of two cases in which this has occurred, one of these being in my own practice. I had subsequently to open the bladder because the tumour was very large, and observed the mark of the electrode on the meatus. It is liable to cause acute retention of urine, the precise reason for which may not be guessed. No permanent damage should remain, as the burn is narrow, linear, superficial, and radiates from the meatus. Once the possibility of such an accident is pointed out, a little care should prevent its occurrence.

CHEMICAL COAGULATION OF BLADDER TUMOURS.

Joseph introduced the method of coagulation of bladder tumours with trichloracetic acid. Crystals of this substance dissolve in their own water of crystallization when heated, and form a concentrated, strongly corrosive solution, which, however, has the disadvantage that on cooling it rapidly re-crystallizes. To prevent this 5 drops of glycerin are added to 4 or 5 c.c. of the concentrated solution, and this, together with the syringe which is to be employed, is kept warm on a water bath. The tumour itself is very sensitive to the action of the acid. The cystoscopist identifies it and lays the end of a ureteric catheter against it. A small quantity (not more than 5 c.c.) of the acid is then very slowly syringed by an assistant through the catheter on to the surface of the growth, which blanches and, in due course, dies and disappears. The acid is heavier than the bladder solution and should therefore be poured from above on to the tumour. The pedicle of the growth is best treated by thermo-coagulation. The bladder wall appears to be relatively insensitive to the action of trichloracetic acid and rapidly recovers if some is accidentally spilt on to it. This method can be used for large tumours which are difficult to treat by electro-coagulation.

III. ENDOMETRIOMA.

Only during the last few years has the occasional appearance of endometrial tissue in the female bladder been recognized, and already about 20 cases have been collected. Prior to this period other examples have probably been reported as adenomata (Morson) or angiomata (Mueller). The tumour occupies that portion of the posterior bladder wall which is invested with peritoneum. Its structure is similar to that of endometrial tumours found in the inguinal canal, in operation scars, and at the umbilicus, and consists of acini arranged in a vascular stroma and lined with columnar epithelium similar to that of the uterus. In some cases the growth appears to have grown from the peritoneal aspect and invaded the viscus (Plaut, Whitehouse). In others it is entirely intravesical (Morson, Weitjlandt). The most striking symptom is hæmaturia, but there may also be vesical discomfort, tenderness, and even pain. All the symptoms are much increased by menstruation, though hæmaturia and pain occurring at this time may for long be disregarded because thought to be uterine in origin.

Cystoscopy shows an irregular submucous swelling situated in the retrotrigonal area which is usually engorged with blood. The blood cysts on its surface are somewhat characteristic. During the menstrual flow the tumour becomes much increased in size and congested.

CHAPTER XI.

VESICAL CALCULUS.

INDICATIONS FOR CYSTOSCOPY.

In the system of investigation outlined in Chapter III the radiological examination precedes the cystoscopy. The surgeon therefore knows in most instances that there is a pelvic shadow. It is well known, however, that radiography sometimes fails to detect a stone, especially one of the uric acid variety. The patient's symptoms will then be unexplained until cystoscopy reveals their cause. The comparative accuracy of these two methods was investigated by Crenshaw in 621 patients, and the following table shows his results :—

Method Used	Patients Examined		Positive		Negative		Indeterminate	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
X ray ..	449	74·09	345	76·83	91	20·26	13	2·89
Cystoscope ..	459	75·74	445	96·94	10	2·17	4	0·87

Crenshaw says : " The high percentage of positive diagnoses with the cystoscope (96·94 per cent) must be explained by the fact that the cystoscopist usually had the benefit of seeing the plates before cystoscopy ; also in some instances when poor plates were reported 'negative' and a request made for a re-ray, the stone was discovered by cystoscopy and the re-ray was not made."

Cystoscopy and X rays are the only two methods of diagnosis permissible nowadays. 'Sounding for stone' should be abandoned. In the event of a calculus being present it will, of course, probably detect it, but when the symptoms are indeterminate and other diseases have yet to be excluded, especially tuberculosis and neoplasm, it is undesirable and dangerous and should be discarded.

The surgeon's attitude to cystoscopy will depend on the route by which he proposes to remove the stone. If the conditions are suitable, he will crush and evacuate it. He must, therefore, assure himself that there are no contra-indications to that operation, and for this purpose cystoscopy must be employed. It should demonstrate that the stone is not too large, not lying in a retroprostatic pouch, that cystitis is not too marked, that the stone is free from diverticulum, ureter, etc., and that the bladder is sufficiently large to allow of the operation. The composition of the stone must also be noted, as oxalic acid calculi may prove too hard for crushing. The existence of a moderate degree of cystitis should not deter the operator. The bladder wall is but little damaged by lithotrity and will quickly recover when freed from its incubus. Further, phosphatic stones arise in septic bladders, and they are soft, and as a rule very suitable for crushing. After lithotrity cystoscopy is again needed to ascertain that the bladder is completely evacuated.

If, on the other hand, the surgeon proposes to open the bladder, cystoscopy will only be a supplementary procedure, and will often not be undertaken. Where, however, the shadow is excentric or fixed it is well to seek the explanation by cystoscopy.

The examination cannot be carried out in the presence of a stricture. It may fail in prostatic hypertrophy, owing either to the calculus being covered by the median lobe or to inability to introduce the cystoscope. These two conditions may, of course, be etiologically related to the presence of the stone.

TECHNIQUE.

If the urine is clear and the stone not very large, the examination is easy and the calculus can scarcely escape detection. Frequently, indeed, on introducing the metal shaft for the purpose of irrigation, one feels the click of the instrument as it impinges on the stone, and the diagnosis is made or confirmed. Yet it is remarkable how long one can sometimes look into a bladder containing a calculus without seeing it. The reasons are threefold :—

1. The instrument drives the stone before it to the fundus of the bladder and holds it there so that movements of rotation can be carried out without bringing it into view.

2. The shaft of the cystoscope is introduced into the bladder above the stone with its beak upwards, and as it is turned over to investigate the base of the organ, it rolls the calculus away from that area.

3. The stone lies in too close apposition with the window, so that the light does not illuminate the segment to which the prism is applied. This difficulty is more evident in the case of large calculi.

Large calculi occupy so much of the bladder cavity that only a lateral crescent of the viscus is available for the cystoscopy (*Figs.* 118, 119). The stone rests on the bladder bottom and is probably in contact with the urinary meatus. It towers up above the cystoscope when that instrument occupies the primary position. It is obvious that it cannot be seen by turning the fenestra downwards. Therefore let the window face the pubes, and, manœuvring it towards one side of the bladder, look along the edge of the calculus. It is very easy to get the window so applied to the surface that nothing can be

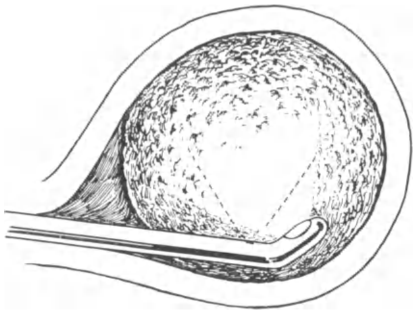


Fig. 118.—Cystoscopy in a case of large vesical calculus.

seen (as described above). Large stones are often infected and covered with a coat of fibrin, pus, muco-pus, etc. The inevitable friction of the instrument dislodges some of the latter and clouds the bladder medium, thus impairing visibility.

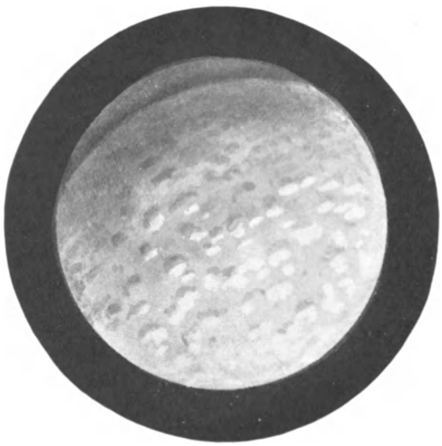


Fig. 119.—Margin of stone shown in *Fig.* 118.

EXAMINATION OF THE BLADDER.

The examination will investigate the: (1) *Composition of the calculi*; (2) *Number*; (3) *Size*; (4) *Position and mobility*; and (5) *Presence of concomitant lesions* such as cystitis, ulceration, prostatic hypertrophy, diverticula, etc.

1. **The Composition of the Stones.**—The composition of the stone is judged by its appearance. Seen through the cystoscope this differs but little from that of the stone when removed from the body. Most stones are composite, but, having one component in excess, they assume the characteristics of that type. They may be primary or secondary. Of these the former exist in an uninfected bladder, the latter in a septic one. A bladder containing a primary calculus may

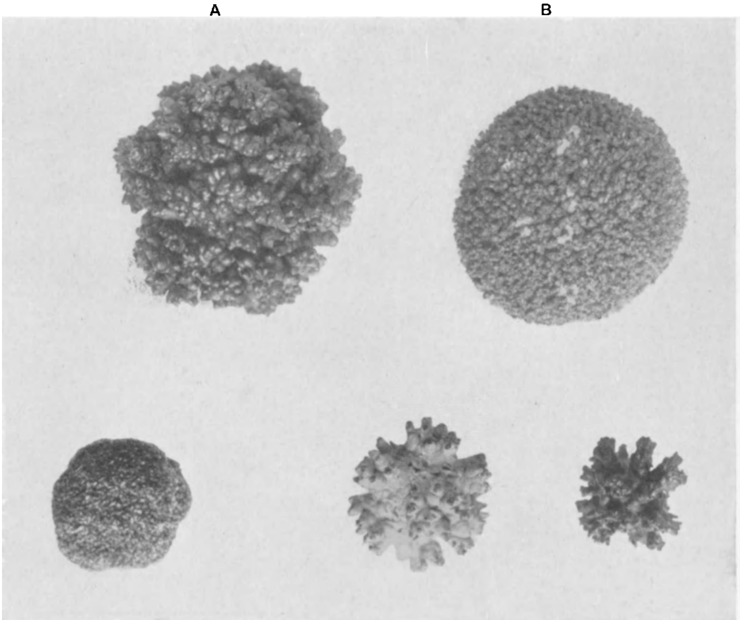


Fig. 120.—A group of oxalate (mulberry) calculi. The two upper stones (A and B) are of unusual size, being $2\frac{1}{5}$ in. by 2 in. and 2 in. by $1\frac{1}{3}$ in. respectively. The pale colour of D is due to a superficial deposit of phosphates (sepsis), and a very early stage of the same process is seen on B. C is a 'white oxalate' stone; the photograph, however, makes it appear darker than the original.

become infected and the stone become covered with a layer of phosphates. It will then assume the external characteristics of a secondary calculus.

Uric Acid and Urate Stones.—These are generally rounded, oval, or flat, fairly smooth or slightly nodular, and vary in colour from a fawn or pale yellow to a light brown (*Plate XI* A). They may be small or of medium size, but are occasionally very large.

Oxalate Calculi.—Such stones are very easily distinguished (*Plate XI* B and *Fig.* 120). They are usually single, and rounded or flattened. They are less likely to grow to large size than any of the other varieties.

though I have removed one that was $2\frac{1}{5}$ by 2 in. Crystals of pure calcium oxalate are colourless, as may be seen in some brightly glistening examples (*Fig.* 120, C), and of old these were known as 'white oxalate' stones (Swift Joly) to distinguish them from the commoner 'black oxalate', whose deep colour is due to pigment adsorbed from urine and blood. Stones of intermediate colour, fawn, yellow, or a rich dark brown, are also quite frequently seen. Their surface is uneven. Sometimes this irregularity takes the form of flattened bosses (mulberry calculus, *Fig.* 120), at others the exterior bristles with spikes (star calculi—jack stones, *Fig.* 121). The oxalate calculus, by

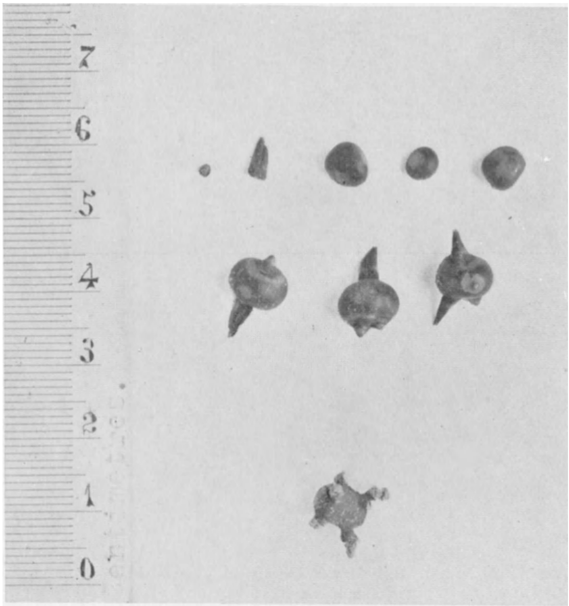


Fig. 121.—'Jack stones', or star-shaped calculi—eight from one patient, one from another. Note the process of budding.

reason of its hardness and irregularity, gives rise to more prominent symptoms— pain, hæmorrhage, etc.—than do the others.

Phosphatic Calculi.—Calculi composed of triple phosphates occur in bladders infected by the urea-splitting group of organisms, and evidence of cystitis will be seen (*Plate XI* C). The stones are white in colour, somewhat glistening, smooth or granular, frequently multiple, and often attain a very large size. They may fill the whole bladder. They are rounded or flat when single, but when multiple they become faceted. To them are often attached shreds of inflammatory deposit, and they may be completely encased in a thick membranous caul which hides the stone proper. Such stones are generally soft and are suitable for crushing if free and not complicated by severe cystitis or urinary obstruction. Phosphatic calculi occasionally become stained by various extrinsic agencies; thus a deposit of blood pigments gives them a brown colour; when silver nitrate has been in use for vesical irrigation they acquire a deep-brown or metallic appearance, whilst I have seen a greenish-blue stone whose colour resulted from the taking of proprietary pills containing methylene blue.

If the various types of stone are gently tapped with the end of the cystoscope, it will be noticed that an oxalate calculus, being very hard, gives a bright ringing note; a phosphatic stone, being soft, produces a dull note; and the uric acid variety an intermediate one.

Other Varieties of Calculi.—Cystin, xanthin, indigo, and other rare stones are occasionally seen. *Plate VII* A, page 150, illustrates two blood stones following severe hæmorrhage from a papilloma.

2. **The Number of the Stones.**—This is very variable. Usually not more than three or four are found. As many as four or five hundred may be present (Thomson-Walker). *Plate XI* E shows a prostatic recess filled with a large number of calculi which are partly visible over the edge of the median lobe. In this instance 67 calculi were counted. It is not always possible to judge the number of stones present by the cystoscope, as will be evident from looking at the above-mentioned illustration, where some of the calculi are hidden behind, or buried underneath, others. This is true also when stones are of larger size than those shown in the illustration. One must often be contented with saying that several calculi are present.

The shape of multiple stones varies with their consistency. When soft and phosphatic they are faceted, when hard they are generally round. Several small phosphatic stones may fuse into a single large one, the latter soon assuming a rounded shape, as in a case watched by the writer.

3. **The Size of the Stones.**—It requires considerable experience to judge the size of objects through the cystoscope. In the case of a stone it is easier to rely on the radiogram than on the cystoscope, though the former generally exaggerates the size to some extent. The dimension of the cystoscopic image varies, of course, with the approximation of the fenestra to the stone, as will be readily understood from *Figs.* 11 and 12, page 13, and *Fig.* 15, page 15. The small stone in *Plate XIII* D, page 302, came out of the ureter shown in *Plate XIII* C. Its actual size when withdrawn from the bladder by Bigelow's evacuator is represented in *Fig.* 122. Size may be estimated by comparing the dimensions of the stone with other bladder

structures, as, for instance, the trigone, or by noting the definition of the bladder wall when the cystoscope is held above the stone. If the object can easily be encircled in the cystoscopic field, it is quite small. When only a small segment of an obviously large sphere is seen, or when there is great difficulty in manipulating the cystoscope, the stone is undoubtedly large.

Kneise adopted the following ingenious ruse. Using a catheterizing cystoscope he paid out into the bladder an amount of catheter equal to the focal length of the objective. At this distance (canonical distance) objects should appear twice their natural size (Chapter II). He brought his catheter tip into contact with the stone and accepted the measurements then presented to his eye as double the actual size of the stone. This method, however, gives results which are only approximately accurate, as will be understood from a consideration of *Fig.* 16 and its related text (page 17).

Fig. 122.—Actual size stone seen in *Plate XIII* D, page 302.

4. **Position and Mobility of the Stones.**—A calculus may be free in the bladder, or fixed.

PLATE XI.

A, Uric acid calculus. B, Oxalic stone. C, Small phosphatic stone. D, Fragments of calculus after litholapaxy. Slight bruising of mucosa. E, Numerous calculi behind prostate. F, Two large calculi in retroprostatic pouch. Slight trabeculation of vesical wall.

Free Stones.—The position of a movable calculus alters with that of the patient. It gravitates to the lowest point of the bladder, which is near the outlet in the upright attitude, but in the recumbent is retrotrigonal. As the patient is recumbent at the cystoscopy, the stone will be found behind the interureteric bar. Much of the bladder irritation will, on the other hand, be found anterior to this, in the situation which is occupied by the stone in the ordinary sitting or standing position.

Fixed Stones.—These are anchored in some one situation, generally in a diverticulum, in the lower end of a ureter, or behind the prostate. Very large calculi occupy so much bladder space that they may be considered as relatively fixed. In some cases they are actually firmly wedged, and a conical prolongation may extend into the urethra (*Fig.* 123). Such stones are, of course, unsuitable for cystoscopy. Alternatively they may be primary in the urethra and fungate into the bladder.

Stones in Diverticula (*see also* page 138 and *Figs.* 85–88).—These may be single or multiple. They may be small and occupy

PLATE XI.

VESICAL CALCULI

the deep portions of the recess, where they cannot be seen cystoscopically, or they may fill the whole cavity, and present at the orifice through which their nose is visible. Occasionally they protrude through the aperture into the bladder. Being constricted by the edges of the opening they then assume the shape of a dumb bell. Only the vesical portion will be visible cystoscopically. Its intradiverticular component will be demonstrable by a skiagram taken at a suitable angle. Generally the vesical projection does not occupy the lowest point of the bladder, and it is fixed. It cannot even be moved with the point of a ureteric bougie, and so arouses suspicion. Similarly a radiographic shadow occurring in an eccentric position demands cystoscopic inquiry. A stone has been observed fixed in the lower end of a patent urachus (Dykes).

Fig. 123.—Vesical and urethral stones which articulate.

Prostate.—Fixed stones also occur behind the prostate. Here they are often multiple (*Plate XI*, E and F). Urinary stagnation and decomposition are the predisposing causes. *Fig.* 124 shows eleven stones which rested on the upper surface of a very large gland, the shadows therefore occupying an unusual position.

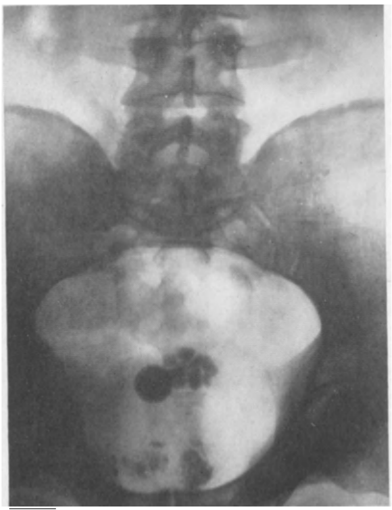


Fig. 124.—One rounded and 11 faceted bladder stones. The diffuse shadows lying just behind the symphysis pubis are due to multiple small stones in an enlarged prostate.

Ureter.—Stones in the lower end of the ureter are recognized by their position, the history of ureteric colic, and the œdematous orifice which surrounds them like a collar (*Plate XIII* C, page 302). Their treatment will be discussed in Chapter XX.

5. **Concomitant Vesical Lesions.**—These include cystitis, prostatic hypertrophy, and diverticula. Of these the two latter are sufficiently dealt with already. In addition new growths are observed on rare occasions. In countries where bilharzial disease is prevalent,

vesical stones are very common, being formed around masses of bilharzial tissue.

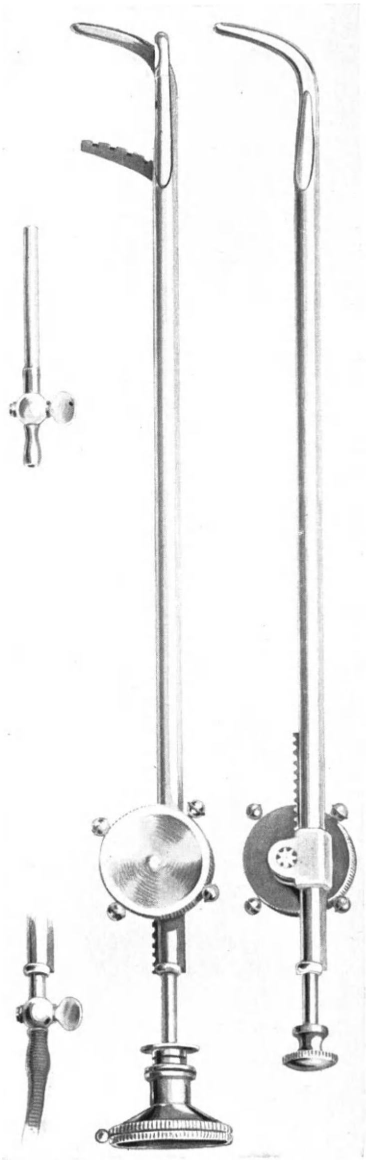


Fig. 125.—Canny Ryall's cystoscopic lithotrite.

Cystitis.—Cystitis is an invariable accompaniment of vesical stone. It may be an aseptic process dependent upon the irritation of the foreign body, or it may be a septic one. With *primary* stones there is generally no sepsis in the first instance. The inflammatory reaction which results from the irritation and pressure of the calculus is confined to the base (basal cystitis), where in the upright position the stone rests. It may go on to ulceration, though this is seen with difficulty through the cystoscope. There is no formation of purulent membranes and the urine is sweet. At any time organisms may be introduced and determine the deposit of phosphates on a part or the whole of the calculus. When infection occurs it may be spontaneous or instrumental. The cystitis spreads to the whole surface of the viscus (universal cystitis), but is still most acute at the seat of the stone. When it is severe, thick, felted, purulent membranes form in the bladder, cover the calculi, and mask their outline. The urine becomes putrid and ammoniacal, and examination may be rendered difficult on account of the vesical irritability. In this way a stone which at first belonged to the primary category may take on a coating of white or yellowish phosphates and look like a *secondary* one.

Frequently, however, the cystitis precedes, and is the determining factor in, the formation of the calculus, either singly or in combination with urinary stagnation. The stone is then always of the phosphatic type.

At the close of a *lithotrity* it is customary to wash and refill the bladder and to examine it for débris and uncrushed portions of stone. In this way we ascertain whether the organ is clear or not, and therefore whether the operation is complete. *Plate XI* D, taken during a lithotrity, shows some partially crushed fragments on the bladder floor. As seen here, there are invariably some small blood-clots visible and the mucosa is often somewhat bruised. Occasionally it is necessary to postpone the cystoscopy to some subsequent date owing to the amount of clot on the bladder base. The examination is important, and even though it occupy some time it should, if possible, be accomplished, as otherwise fragments and occasionally whole calculi may be left behind.

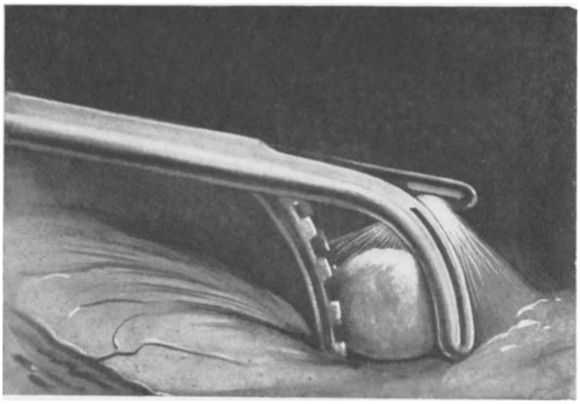


Fig. 126.—Canny Ryall's cystoscopic lithotrite grasping a bladder stone under inspection.

Some septic bladders are regular stone factories, and when cleared re-form calculi again and again. Periodic inspection may be useful in such cases by finding a stone whilst still small enough for evacuation. Many recurrent calculi are formed around nuclei of débris following lithotrity, and this would not occur if the cystoscope were routinely employed. The instrument is therefore used before lithotrity to ensure that the conditions are favourable, and subsequent to that operation to guarantee that the bladder is free.

Certain instruments may be employed for the seizing and crushing of calculi under inspection. Canny Ryall's cystoscopic lithotrite (*Figs*. 125, 126) was designed for this purpose. It should be remarked that it is less powerful than the ordinary lithotrite, as its shaft is hollow for the accommodation of the telescope. It must, therefore, be used with discretion and a recognition of its limitations. The cystoscopic rongeur (*see* ***Fig.*** 93, page 154) is less suitable than the above-mentioned instrument, but may be used to break up stones which are very soft and friable, particularly phosphatic ones (***Fig.*** 127). It should not be employed for harder ones, as the jaws might bend and be difficult to extract from the bladder. Those who

Fig. 127.—Jaws of cystoscopic rongeur approaching a small friable calculus.

are experienced in the use of the ordinary lithotrite will prefer that instrument to these more complicated ones, as it is more generally serviceable and less fragile. Lithotrity is an operation in which the rigidity of the instrument is the first consideration.

CHAPTER XII.

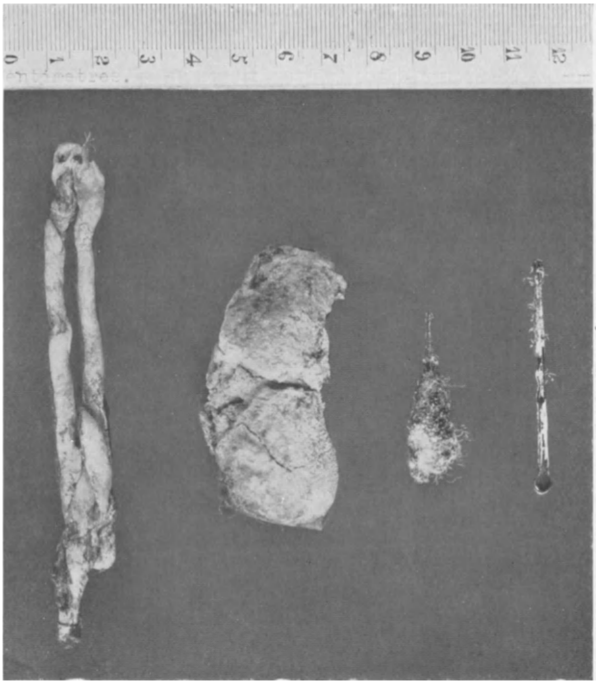
FOREIGN BODIES IN THE BLADDER.

THE diagnosis of a foreign body in the bladder may be made by X rays, the cystoscope, or by the history of its introduction—surgically or otherwise. When a foreign body is opaque to the rays it ought to be discovered before the patient is submitted to cystoscopy. In other instances that examination will be undertaken in the investigation of urgent and painful micturition, pyuria, and, in general, symptoms suggestive of cystitis. The foreign body will be found unexpectedly.

Modes of Entry of Foreign Bodies.—Foreign bodies may reach the bladder in four ways: the urethra, the ureter, by perforation of the walls of the viscus, and by surgical interference. Packard investigated 222 reported cases, and found that in 108 the object was part of a *surgical instrument*. Such may have been introduced via the urethra—for instance, the broken end of a catheter (*Plate XIII* E, page 302), bougie, or de Pezzer's tube, or the flexible guide of a urethrotome. When the instruments have been employed in the treatment of a stricture it may be found impossible to pass the cystoscope for their investigation. Again, the foreign body may have gained access by a suprapubic wound—a compress or a piece of rubber drainage tubing, for example. Before their danger was recognized, silk sutures were often found acting as nuclei for the deposit of salts. A row of small calculi thus formed might be seen along the line of a bladder incision. Nowadays the use of absorbable suture material has obviated this risk, though they are still sometimes seen when silk used in gynæcological operations has perforated the bladder.

Foreign bodies *introduced by the patient* reach the bladder via the urethra. They are much more commonly found in the female owing to the greater ease of introduction, though they are far from being unknown in the male. They are employed either in an effort to provoke erotic sensations or in a misdirected attempt to produce abortion. The usual article is a hairpin, though ordinary pins and needles, wires, straws, thermometers, glass rods, a tooth-brush handle, matches, pencils, a bit of wheat, pieces of wax and tallow, and many other objects have been recorded. Nitch recently exhibited a piece of 'slippery elm' which he had removed from the female bladder, and a piece removed by the author is illustrated in *Fig.* 128, B.

Foreign bodies *passing through the walls of the viscus* are not uncommon. Bullets, shrapnel, etc., were frequently observed during the war, arriving there either by direct hit or by subsequent abscess formation and rupture into the organ. Portions of clothing not infrequently accompanied the missile. When the track of a foreign body passed through the bladder and the bony pelvis it occasionally left a sinus between the two, through which sequestra were frequently shed into the bladder to form the nuclei for stones (Legueu).



A B C D

Fig. 128.—Foreign bodies from bladders. A, Taper from male bladder. Introduced by patient when intoxicated and pushed in by a second taper. Floated in vault of bladder. Recovered by cystoscopic rongeur, bite of which may be seen at upper end. Its lower end is knotted. B, Slippery elm buried in phosphates. Introduced about fifth week of pregnancy as an abortifacient. Removed by suprapubic route late in pregnancy. C, Phosphate-covered needle. D, Hair-slide from the bladder of a girl aged 7½ years. Removed by operating cystoscope. Slight incrustation.

Pointed articles—for instance, needles, surgical and otherwise—occasionally perforate the bladder. *Plate XIII* F, page 302, shows the tip of a hatpin which is just visible through the vesical wall. The patient had been stabbed near the umbilicus by a hatpin, which, breaking off, had been lost. Bladder symptoms developed some considerable time later, and when investigated cystoscopically were attributed to the presence of the tip of the pin, which was found to have perforated the bladder near its apex. Judd has reported a similar case, the foreign body in his patient being the end of a 'jack-knife'. Objects which had presumably been swallowed have been removed from the urinary bladder, reaching the viscus by ulceration (Freeman, Harrison, Ballenger and Elder, Young, Roberts), and sequestra from a tuberculous hip have been removed from that organ (Judd). Fragments of bone from a fractured pelvis also occasionally penetrate the bladder.

Cystoscopic Examination.—On cystoscopy the article is easily recognized, but the appearance which it presents supplies an interesting lesson in the optical properties of the cystoscope. Magnification and distortion are more readily appreciated when everyday objects are viewed. In many instances the surgeon will know the size of the object because he is familiar with its appearance outside the body. He will realize the more clearly how difficult it may be to estimate the size of a growth or stone through the cystoscope. More important, however, is it for him to form an opinion of the extent of phosphatic incrustation with a view to deciding whether extraction via the urethra is feasible. The size of the foreign body itself offers an obvious scale against which the deposit can be measured. Lengthy foreign bodies must be examined bit by bit. They cannot be seen in their entirety.

The position occupied by the object varies with its size and length. When small it lies in the retrotrigonal area, but when long it is accommodated transversely or obliquely. Flexible bodies, such as catheters or urethrotome guides, may become tied in knots (Thomson-Walker, *see also Fig.* 128 A). Paraffin, chewing-gum, and other foreign bodies lighter than water will be found in the region of the air-bubble until they become coated with urinary salts and sink to the bottom. It is apically that they must be sought with any instrument which may be chosen for their removal, as was the case with the taper shown in *Fig.* 128 A.

Infection is usually introduced with the foreign body, but occasionally it may be absent for a long time. Eventually it is inevitable. It leads to urinary decomposition and the deposit of phosphates on the article, a part or the whole of which is covered thereby. As a rule, however, sufficient remains exposed to allow the diagnosis to be made, those portions which are submitted to friction being especially liable to escape. When completely covered the curious shape of the object may arouse suspicion. If the cystoscopist and radiologist both fail to recognize the nature of the nucleus, the foreign body may be regarded as an ordinary stone, and the attempt made to crush it. The mistake will be discovered, either by the unaccustomed sensation imparted to the touch by the foreign body, or by the cystoscope when that instrument is used towards the end of the litholapaxy (page 199).

The extent of phosphatic deposit will vary with the degree of the cystitis, the length of time the foreign body has lain in the bladder, and also with the material of which it is made. In some authentic instances foreign bodies are known to have remained in the bladder at least fifteen years. The longer they have been present the more marked will probably be their incrustation. Phosphates, however, adhere to some substances more readily than to others. Zuckerkandl states that wax does not become coated at all, silver is slow, whilst iron, rubber, and vegetable substances are quickly covered. The absence of incrustation on wax has also been noted by Sherman and others, but that it is not always immune is shown by H. Turner, who found a nucleus consisting of a cylinder of wax in the interior of a huge stone which he had removed from a man's bladder. The wax had been introduced three years previously. Baldwin has reported a similar case, the patient being a woman and the nucleus consisting of tallow. It was known that the tallow had been in the bladder for only a few months.

The urine may become ammoniacal and fœtid, and the bladder too irritable to tolerate cystoscopy. Ulceration is common, especially near the ends of lengthy articles, but it is usually hidden by the interposition of the foreign body. Perforation occurs occasionally.

Treatment.—The cystoscopist must decide whether removal shall be by suprapubic operation or per vias naturales. Many foreign bodies which have found an entrance through the urethra may be induced to retrace their steps. Severe cystitis and a contracted bladder indicate open operation. When the object is deeply encrusted with salts it should not be withdrawn through the urethra.

Soft objects, such as catheters or straws lying free in the bladder, may be withdrawn by the lithotrite. The cystoscopist should note beforehand their situation so as to be able to seize them quickly, and also the extent of their incrustation. The cystoscopic lithotrite (*Figs.* 125 and 126, pages 198, 199) or rongeur (*see Fig.* 93, page 154) may also be employed. I have known a broken catheter to be spontaneously evacuated.

Certain *hard* objects, such as hairpins, wires, etc., may be withdrawn by some form of operating cystoscope. The forceps shown in *Fig.* 129 is very serviceable for this purpose, and may be employed through a Swift-Joly or Buerger instrument. Prior to seizing it with the forceps the foreign body should be brought into line with the urethra. To accomplish this the vesical distension should be as great as the circumstances will reasonably permit, and an ordinary ureteric bougie should be employed to manœuvre it into position. If the foreign body has one end more rounded than the other, that end must lead. These manipulations are performed through the Joly or Buerger instrument as the case may be, and the bougie is then gently removed and replaced by the forceps, the cystoscope remaining *in situ*. When the foreign body has been grasped satisfactorily it is withdrawn through the sheath, the whole of the catheterizing and optical parts being removed in order to make room for it. If, owing to its shape, length, or size, the foreign body refuses to enter the sheath, the surgeon must decide whether it is wise to remove the cystoscope, retaining his hold on the foreign body and withdrawing it gently after the instrument, or whether it is better to resort to suprapubic operation. This decision will be made on the knowledge which he has acquired of the size, etc., of the foreign body.

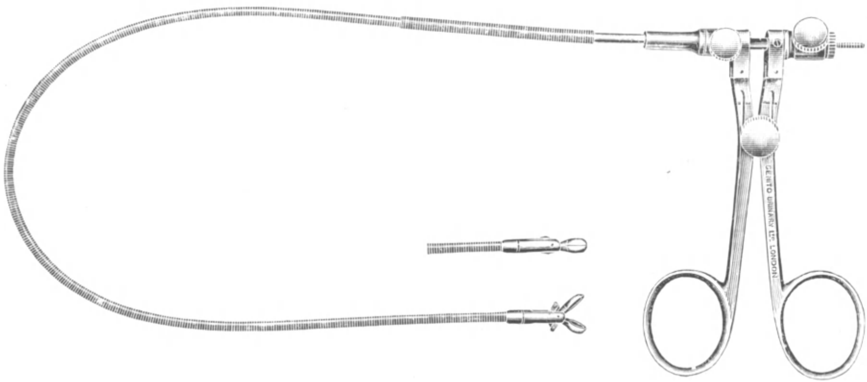


Fig. 129.—Buerger's forceps.

Other instruments capable of grasping and withdrawing objects found in the bladder are the cystoscopic rongeur, and Ryall's cystoscopic lithotrite. They are much more powerful in the jaws than the one just described. By them portions of phosphatic deposit may be chipped away under inspection, so as to reduce the size of the foreign body sufficiently to permit withdrawal.

Kelly, Luys, and other exponents of direct cystoscopy would remove foreign bodies from the female bladder through the straight endoscopic tube. The patient occupies the lithotomy position with the head low. When the tube is introduced the bladder distends with air owing to the gravitation of the abdominal contents in the direction of the diaphragm. A head lamp illuminates the vesical cavity, and a pair of alligator forceps passed through the tube is used to seize the foreign body, which will be found in the vesical fundus. The method requires practice, and most operators will nowadays prefer to achieve their ends through the indirect or prismatic instrument.

CHAPTER XIII.

URETEROCELE. URETERIC PROLAPSE.

URETEROCELE.

THIS condition has been known under several different titles, such as 'ballooning of the ureter', 'cyst of the ureter', etc. The name 'ureterocele' is probably the best. The term 'prolapse of the ureter' has also been applied to it, but should be reserved for the condition described at the end of this chapter. *Plate XII* C and E. page 244, give

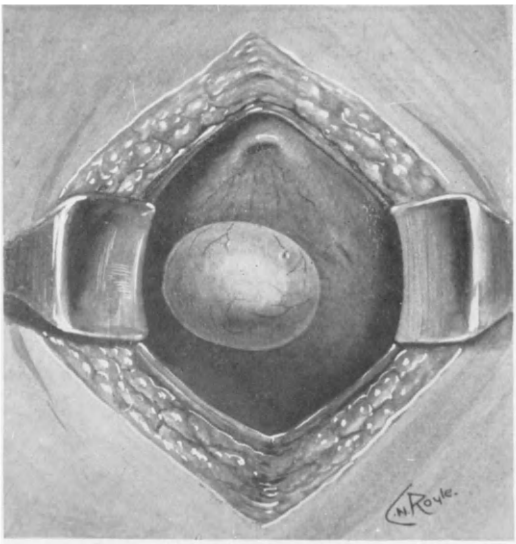


Fig. 130.—View of ureterocele at operation. Note the small orifice of the ureter situated to the inner side of the cyst, and compare it with the size of the right ureteric orifice.

a good impression of the appearances presented cystoscopically, and *Fig.* 130 that seen when the bladder is opened. With the cystoscope a translucent cyst is seen rising from the position of one or both ureters. It may be circular or oblong, is narrow at its origin, and swells out above. It consists of healthy mucous membrane in which vessels are to be seen coursing outwards from its attachment towards its extremity. Occasionally the cyst itself may be covered with smaller translucent cysts (Thomson-Walker). In the case from which *Plate XII* E was taken the orifice of the ureter could not be brought into view as it was situated at the apex of the cyst in a position to which the fenestra could not be approximated ; it is, however, well shown in ***Fig.* 130**, which was drawn at operation on this patient, and there its diminutive orifice contrasts strongly with that of the opposite side, which is normal. In another patient (*Plate XII* C) the minute orifice, which was situated more favourably, can be seen. It is visible as a rule when the cyst is small, but not when it is large.

Fig. 131.—Operation specimen of ureterocele from a female. It prolapsed down the urethra causing retention, and presented externally. It was specially troublesome during pregnancy, a fact which has been observed also in other patients. The dark area at the apex shows the exposed portion. Bristle in orifice.

Ureteroceles have been noted to swell up slowly whilst under observation as the ureteric wave brought down fresh fluid to them, and then to collapse again. In one case I distended the bladder with 12 oz. of lotion, hoping thereby to get a more complete view of the ureterocele. The result was different from what was anticipated. I found that the cyst had collapsed under the extra pressure and lay like a flaccid bag on the bladder base. When a certain amount of fluid was withdrawn and the intravesical pressure was thus reduced, the cyst recovered its distended condition. The distension or flaccidity of the cyst appears therefore to be a resultant between the bladder pressure and the intra-ureteric pressure. Probably the observation that some cysts fill up gradually whilst being watched, and then collapse again, is explained by the fortuitous circumstance of the bladder pressure being approximately equal to that within the ureter. It seemed to me that if I had met with the cyst in a collapsed condition on the first occasion, I might have failed to make a correct diagnosis. Very large cysts may likewise give rise to diagnostic difficulties because they tower above the fenestra as a large surface clothed with healthy vesical mucosa. The unusual shape of the viscus and the absence of a ureteric orifice will help to establish a diagnosis. Cysts so large as this will, however, already have made contact with the vesical orifice and have caused some disorder of micturition. The example illustrated in *Fig.* 131 had passed down

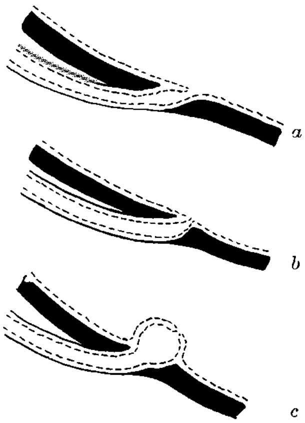


Fig. 132.—Schematic representation of the evolution of a ureterocele *a*, Opening of normal size ; *b*, Pinhole aperture in mucosa, opening through muscular layer is of normal size, theoretical condition in early life before onset of ballooning ; *c*, Early ureterocele.

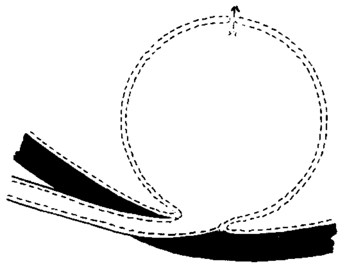


Fig. 133.—Diagrammatic representation of a ureterocele.

the urethra and had presented at the external meatus, causing retention of urine. The whole cyst wall is thickened and that portion which had passed beyond the external meatus is red and velvety. These changes were easily recognized at cystoscopy.

The underlying factor in the production of this condition is the smallness of the orifice of the ureter. This appears to affect the mucous coat only (*Fig.* 132). The cyst is produced by mechanical distension. A quantity of fluid brought down from the kidney by the peristaltic wave of the ureter impinges on the inadequate orifice and balloons a double layer of mucosa into the bladder cavity. The repetition of this process brings about a constantly increasing dilatation of that part of the conduit which has no external muscular support—the intravesical termination—but it acts similarly, if less effectively, on other sections, producing ureteric and pelvic distension.

In most of the reported cases where microscopic examination has been made, the cyst wall has been found to consist of two layers of mucosa, a vesical and a ureteral (*Fig.* 133), back to back, with a small amount of intervening areolar tissue. In very few has muscular tissue also been present. The remaining coats of the ureter and the pelvis of the kidney are dilated, as I have proved by noting cystoscopically the wide-mouthed orifice left after operation, and by pyelography (*see also Fig.* 134). Dilatation has also been seen in post-mortem specimens, and severe hydronephrosis is sometimes encountered.

The cyst is bilateral in about 10 per cent of cases. Other congenital abnormalities are frequently present, both in the bladder and elsewhere. Faulty insertion of the ureter is often observed. Hurry Fenwick reported 15 cases in which the intravesical ending of the ureter had been noted. In 9 it was double on the side of the cyst, and in these cases the cyst was connected with the ureter which received a faulty insertion in the trigone. This ureter drained the upper third of the corresponding kidney, which portion was usually found to be hydronephrotic from back-pressure (cf. pages 357 et seq.). In one case I found a strongly marked remnant of the urachus at operation. In some cases the condition has been associated with such deformities as cleft palate and hare-lip (Caulk). These associations are evidence of a congenital origin, a view which is further supported by the fact that ureteroceles have been seen in the new-born.

Stones complicate these cysts in a large proportion of cases. Goldberg found them 5 times amongst 22 cases, O'Connor in 4 out of 19, and Hellström in 5 out of 7 patients. They may be composed of any of the usual constituents and may be single, but are frequently multiple. Their customary situation is within the sac, but they are not uncommonly found in the ureter or kidney. Their existence has been erroneously adduced as an argument in favour of the acquired origin of ureteroceles, it having been thought that they were an etiological factor in the production of the cyst by causing stenosis which led to dilatation. The origin of stones in a true ureterocele is not difficult to understand, as in addition to stagnation there is a very minute orifice, so that a flake of solid material which would normally escape is held back to become the nucleus for a stone. The stone, therefore, is a secondary phenomenon, whereas in the false ureterocele (*see below*) it is the primary factor, and the dilatation of the terminal ureter is secondary.

Bladder Symptoms.—These are generally absent until the cyst has grown sufficiently to make contact with the vesical outlet. Once this has been established, obstruction to micturition, incontinence, pain, and hæmorrhage are liable to occur. Their cause will be unexplained apart from cystoscopy. Occasionally the cyst has presented itself at the external meatus in the female (*see Fig.* 131, and page 208). Some have been snipped off by gynæcologists, who have not recognized the condition with which they have been dealing. Two instances of this occurrence have come within my own knowledge, and another is reported by Furnival. Prior to the onset of bladder symptoms, there may be symptoms referable to the renal distension, and they become very acute if the cyst gets caught in the urethra.

Urography.—The advent of excretion urography has provided a means of demonstrating a ureterocele radiographically, as the contrast fluid is temporarily detained within the cyst. To get a satisfactory picture the bladder should be empty or nearly empty, and it is therefore a good plan to use an inlying catheter. Several plates may have to be exposed to ensure catching the cyst at a time when it is distended. *Fig.* **134** is a sketch from such a radiogram and exhibits the rounded contour of the cyst and the dilatation of the corresponding ureter and pelvis.

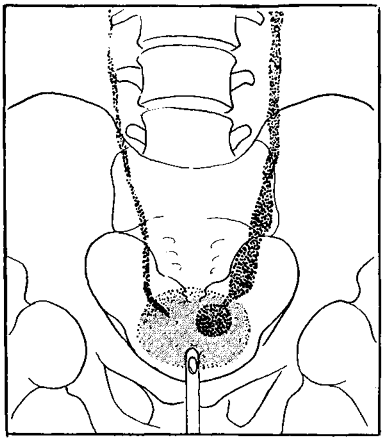


Fig. 134.—Sketch made from a urogram in a case of ureterocele.

Treatment.—This may be undertaken by open or perurethral methods. *Fig.* **130** shows a ureterocele seen through a suprapubic incision. It was snipped off close to its attachment with a pair of curved scissors. Perurethral operation is the method of choice nowadays. The cyst is burned by means similar to those employed in the treatment of a papilloma. *Plate XII* D, page 244, shows the cyst depicted in the preceding picture, after partial destruction. It takes a length of time for the burned tissue to separate, during which the drainage of the ureterocele should occur through its natural orifice. Great care must therefore be exercised that this opening be not sealed by the electrode. It is, as a matter of fact, so tiny that any trifling œdema, even such as is produced by the electrode applied at a distance, is capable of closing it and so producing complete ureteric occlusion. It is unnecessary to diathermize the cyst widely; the objective is adequate drainage, and a small aperture will accomplish this and will not threaten the patency of the existing orifice by rendering it œdematous. *Plate XII* D, page 244, betrays an excess of zeal which should not be imitated. A small dependent puncture is better practice. The cyst subsequently tends to shrivel, and unless it is of unusual size does not impede micturition or otherwise cause trouble. Should the condition be bilateral, the two sides must not be treated at the same sitting. Recognition of this danger is particularly important because it is one which is likely to be overlooked unless pointed out. Probably in the future the modern cutting current will incise in contradistinction to coagulating the cyst and so provide immediate drainage.

A stone in the sac is no contra-indication to the perurethral operation, as has been asserted by some, for it will duly be shed into the bladder, whence, if small, it will be evacuated spontaneously. If large, it can be crushed.

FALSE URETEROCELE.

Another type of cyst having a totally different origin is found at the lower end of the ureter. It consists of a distension of the ureter in its intramural section and always contains one or more calculi. *Fig.* 135 is a sketch made from a radiogram and shows a group of stones collected at this point, the ureteric opening being too small to let them pass. The stones were released by perurethral incision of the anterior wall, using the cutting current. As a preliminary a catheter was placed in the ureter to protect the underlying wall. This condition must be carefully distinguished from the true ureterocele, for the two types are constantly confounded in the literature. It owes its existence to the stones which have collected at the extremity of the ureter and which have formed for themselves a pouch within the ureteral lumen—a false ureterocele (*Fig.* 136). It is distinguishable by its shape, which is that of a broad-based salient, in contrast to the true ureterocele, which might almost be said to be pedunculated. Moreover, it is never possible to introduce a catheter

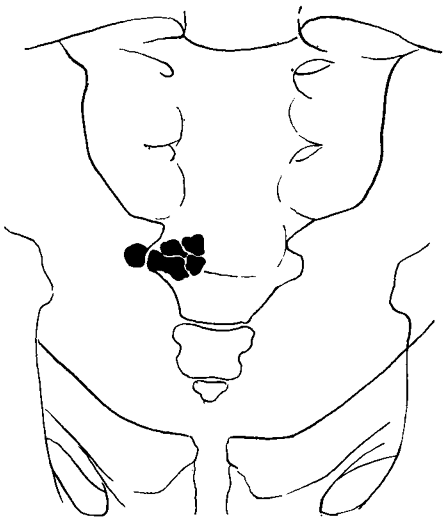


Fig. 135.—Tracing of stones occupying a false ureterocele. (cf. *Fig.* 136.)

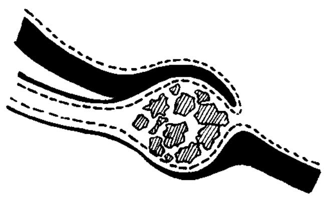


Fig. 136.—Diagrammatic representation of stones in a false ureterocele. (cf. *Fig.* 135.)

into the orifice of a true ureterocele as I did here. I have seen several instances of this variety of dilatation, and comparable cases have been described by Blum, Kretschmer, and others. It is probably this type which has led some authors to assert that a stone retained at the ureter end may give rise to a stricture, this in turn causing a ureterocele. In my opinion the true ureterocelc always results from a congenital inadequacy of the opening in the mucosal coats, the cyst developing secondarily by reason of the distensile or inflationary action of the imprisoned urine (*see* page 208).

PROLAPSE OF THE URETER.

Prolapse or procidentia of the ureter into the bladder cavity is sometimes met with. Its essential feature is an eversion of

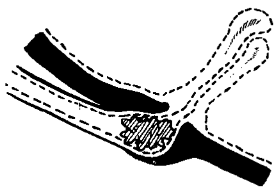


Fig. 137.—Diagrammatic representation of stone impacted near ureteric orifice causing prolapse.

the terminal ureter into the vesical cavity. Almost invariably resulting from a low-lying calculus, it consists, as a rule, of the

Fig. 138.—Prolapse of the ureter. Sepsis absent and œdema slight.

Fig. 139.—Ureteral prolapse. Sepsis severe. A few large bullæ.

mucosal coat only (***Fig.* 137**), though in severe cases all the coats participate. The mucosa is thickened and œdematous in most examples, particularly when sepsis, a frequent complication, is present. These manifestations were little developed in the specimen depicted in *Fig.* 138, but there was severe infection in the case from which *Fig.* 139 was drawn. The projection rarely exceeds three-quarters of an inch in length and it protrudes into the cavity like an everted coat sleeve, the large terminal opening being patulous and visible. A catheter tip will engage in the opening, but is immediately held up by the firmly impacted stone. The condition is quite unmistakable, the non-translucent mucous membrane, the steep, parallel, sausage-shaped sides, and the patulous terminal opening bearing no resemblance whatsoever to the more delicate ureterocele, with its rhythmic ebb and flow. On removal of its cause a prolapsed ureter recovers its natural state. Thus a patient who presented a large and tumid ureteric eversion was re-examined by me three months after the removal of his stone, when the prolapse was found to have receded and the meatus was indistinguishable from the normal.

CHAPTER XIV.

FISTULA OF THE BLADDER.

INDICATIONS FOR CYSTOSCOPY.

Cystoscopy is not indispensable for all fistulæ of the bladder. Those which occur to the skin (e.g., suprapubic fistulæ), the vagina (vesico-vaginal fistulæ), or the uterus (vesico-uterine fistulæ) result in the loss of urine to the surface and are self-evident, so that little fresh information is likely to be required from cystoscopy. The two last

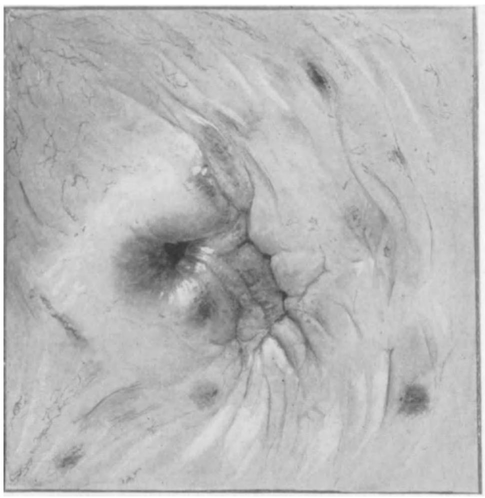


Fig. 140.—Bladder opening of a vesico-sigmoidal fistula.

mentioned, however, need differentiation from such fistulæ as lead to the ureter and not to the bladder (*see below*).

Fistulæ taking place between the bladder and the neighbouring hollow viscera are moderately common and call for cystoscopy. The large intestine is implicated much more often than any other structure, the order of frequency with which its various sections are involved being the sigmoid (***Fig.*** **140**), rectum, appendix (***Fig.*** **141**), cæcum, and

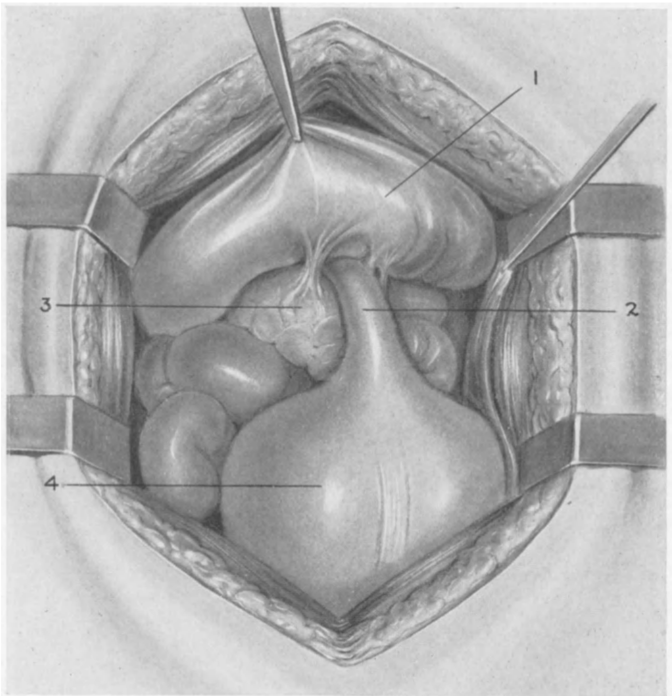


Fig. 141.—Vesico-appendicular fistula, due to rupture of an inflamed appendix into the bladder. 1, Bladder; 2, Appendix; 3, Thickened meso-appendix; 4, Cæcum. *Inset.* View of bladder opening after separation of the appendix.

transverse colon.* Diverticulitis and carcinoma of the colon between them account for almost all fistulæ between the bladder and colon, and of these diverticulitis is definitely the more frequent. Telling and Gruner reported that in more than 12 per cent of 280 cases of diverticulitis the gut showed direct adhesion to the bladder. With many fistulæ, however, there is an intervening abscess cavity, or a track of some length lying surrounded by intestines or omentum. Other organs involved are the Fallopian tubes (simple or tuberculous salpingitis) and the small intestine.

Abscesses draining into the bladder, though not truly fistulæ, are conveniently considered under this heading. Of these may be selected for mention the peritoneal suppurations (appendicular, tubal, etc.) and psoas abscess, whilst prostatic and vesicular suppuration (especially tuberculous) may find an outlet into the bladder, leaving a gaping, fistulous opening in or near the trigone. The lesion responsible for any given fistula may prove to be either inflammatory or neoplastic, but it is rarely primary in the bladder itself, as few of the diseases of that organ show any disposition to perforate to the skin or to an adjacent mucous surface.

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* Harrison Cripps, in his classical monograph (1888), gives the following figures : Rectum 25, colon 15, small intestine 12, colon and small intestine 5, not stated 6 (total 63).

Pascal (1900) collected 190 cases of vesico-intestinal fistula, and showed that the rectum was involved 113 times, the colon (principally the sigmoid) 42 times, the ileum 26, the appendix 7, and the cæcum twice.

Sutton (1921) produced statistics of 59 entero-vesical fistulæ, and gave the following distribution :—

	Cases	*Per Cent*
Vesico-entero-vaginal ..	1	1·69
Vesico-entero-rectal ..	1	1·69
Vesico-appendiceal ..	3	5·08
Vesico-uretero-rectal ..	3	5·08
Vesico-rectal ..	3	5·08
Vesico-ileal ..	13	22·03
Vesico-cæcal ..	1	1·69
Vesico-sigmoidal ..	34	57·62

The fact that the fistula involves a third organ in not a few cases will be realized from Cripps's and Sutton's tables. Of the last-mentioned group of 34 vesico-sigmoidal fistulæ, 21 had a single aperture in the gut, but in 5 there were multiple openings into the sigmoid itself, whilst 8 cases showed the complication of an opening into a third viscus, the third organ being the ileum in 4 instances, the ileo-cæcal angle twice, and the rectum twice.

The difference in the incidence of rectal perforations is striking. The last series probably reflects the value of cystoscopy in the diagnosis of fistulæ of the lowest sections of the gut, and also our modern knowledge of sigmoid diverticulitis. Cripps, indeed, remarks the frequency with which inflammatory lesions were responsible for fistulæ and the correspondingly good prognosis, pointing out also the remarkable fact that a rectal carcinoma but rarely perforates into the bladder (7 times in 63 collected fistulæ). Probably some of his and Pascal's rectal fistulæ were really sigmoidal.

FISTULÆ TO INTRAPERITONEAL ORGANS.

When an adjoining inflammatory process involves the vesical wall there is a prodromal period of vesical irritation which is unexplained. Should an abscess burst into the bladder, a quantity of pus is discharged with the urine, following which a generalized cystitis develops and leads to an aggravation of the bladder symptoms. When the fistula is of the vesico-intestinal variety, flatus and fæces may be passed with the urine. The passage of flatus per urethram (pneumaturia) is an arresting phenomenon which the patient rarely overlooks in giving his history. It is almost pathognomonic, quite rarely having any explanation other than that of a fistula communicating with the bowel. The flatus escapes at the end of micturition because the gas occupies the bladder vault and is thus the last of the bladder contents to be expelled. It makes a gurgling or spluttering noise, and bubbles sometimes form momentarily at the external meatus. The gas expelled may smell fæcal. If the patient reports pneumaturia, the surgeon should seek the opportunity of witnessing it, but the chance may not offer as the symptom is intermittent, and in many cases occurs only occasionally, depending on the state of the bowel.

Fæcal material in the urine can be recognized by the naked eye or by the microscope, and the urine has a characteristic odour. Grape seeds and other foreign particles are sometimes recognizable in the urine. When the fistula is very low down the large gut the fæces are solid and so may be passed through the urethra with difficulty or even block it completely. Strangury and obstruction may result, though the urine itself generally passes back into the intestine and so escapes. The passage of urine per anum is a recognized sign of an entero-vesical fistula, but is absent or inconspicuous when the fistula is small. If urine is present in quantity it may be taken to signify a free communication.

The fistulous opening is usually quite small, but it may reach the size of a two-franc piece (Adams). By the cystoscope the fistula itself is generally difficult to identify because of its minute size, though its position may be suspected on account of the severe hyperæmia, bullous œdema, and the plicæ which surround it (*Plate VI* D, page 130). This area of swelling, however, is of small extent—usually about the size of a sixpence or a shilling—the remainder of the bladder merely showing cystitis of greater or less degree, though in a few instances it is completely free from inflammation. Centrally placed in the suspected area may sometimes be seen a tag of slough, pus, or fæces, which betrays the actual situation of the opening, and in many instances pressure applied at an appropriate spot in the hypogastrium will cause the escape of pus or other foreign material into the bladder through this central spot, which escape may be seen through the cystoscope and clinches the diagnosis.

The situation of the fistula depends on the bladder's relationship

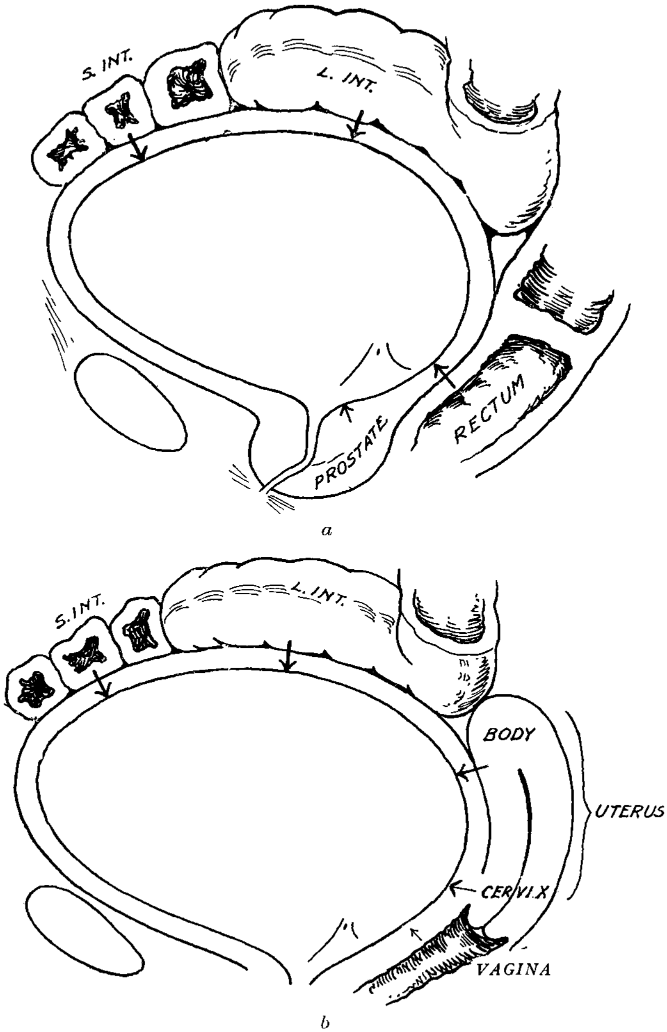


Fig. 142.—Relationship of the bladder to various neighbouring organs, illustrating some sites at which fistulous communication may take place. *a*, Male; *b*, Female.

to extravesical organs (*Fig.* 142). The important group of fistulæ which lead to the intraperitoneal viscera are necessarily limited to the peritoneum-covered part of the bladder, and are, therefore, to be observed in the retrotrigonal area and on the posterior and lateral walls. My personal experience is that, with great regularity, they give the impression of being high up on the posterior wall near where it meets the roof of the bladder, though other writers have seen them frequently in the ureteric region. The left side of the bladder contains the fistulous opening three times as often as the right because of its relationship to the sigmoid.

A ureteric catheter can sometimes be passed through the fistulous opening, and opaque solution, such as a 10 per cent solution of sodium iodide, may be syringed through the catheter into the bowel. In this way a good radiogram of the bowel may be obtained and the section which is involved may on occasion be identified. Sometimes one may even be fortunate enough to recognize the features of the responsible pathological condition—diverticulitis, carcinoma, etc. In a few instances the fistulous track between the bowel and the bladder is long and tortuous, and this fact may be diagnosed pre-operatively by injecting the sinus. Fistulous tracks of this type generally result from an abscess developing between the two organs and rupturing into both.

The nature of the responsible lesion, whether inflammatory or neoplastic, is not likely to be discovered by the cystoscope. Intestinal carcinomata are very advanced before they present within the bladder and even then their appearance is not characteristic. The nature of the primary lesion may be disclosed by a barium enema but otherwise it remains obscure until operation and even then it may, at first sight, be uncertain. This is unfortunate, for the etiology determines not only the prognosis, but also, in many cases, the desirability of interfering at all.

SUPRAPUBIC AND VESICO-VAGINAL FISTULÆ.

Fistulæ to the skin of the suprapubic region are in a different category from those leading to internal organs, as they are easily discovered cystoscopically. Old fistulæ, in particular, are epitheliated, pale, and smooth, and show little or none of the œdema which characterizes so many vesico-intestinal and other internal fistulæ.

With *vaginal fistulæ* of any size the bladder contents escape into the vagina during lavage. A large fistula is discoverable by vaginal palpation or by a speculum and may be occluded for the purposes of cystoscopy by a finger or a tampon. These openings are placed in the bladder base and appear like irregular crypts showing epithelialization when old and varying grades of bullous œdema. Occasionally a stone fills the fistulous opening and may show channels for the escape of urine (*Fig.* 143).

Vesico-vaginal fistulæ require to be differentiated from uretero-vaginal fistulæ. The former may in favourable cases be identified by cystoscopy, but when small are found with difficulty. A useful ruse is to fill the bladder with some easily recognizable fluid such as indigo-carmine, and any escape of the bladder contents will stain

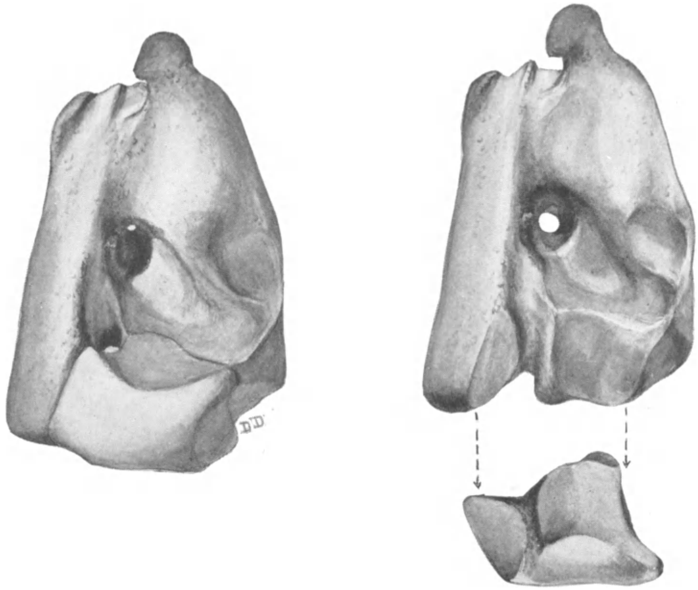


Fig. 143.—Stone occupying a large vesico-vaginal fistula. Note grooves into which fitted the edges of the fistulous opening, and holes by which urine escaped.

a tampon placed in the vagina to receive it. This examination is open to the fallacy that there may be ureteric regurgitation and a return of the fluids through the fistulous ureter.

CHAPTER XV.

A MISCELLANY OF BLADDER CONDITIONS.

LEUCOPLAKIA.

Leucoplakia of the bladder is a rare disease. Its cystoscopic features were first described by Brik in 1896. Comparatively few cases have been reported, and some of those found in the literature are not very convincing. It is, however, a well-recognized condition, and is probably commoner than the meagreness of the records would indicate. The writer has seen two definite cases, one of which had undergone malignant degeneration (*Plate VIII* F, page 160). In the other the lesion was recognized at operation, having been overlooked at cystoscopy. It seemed to him that, just as ichthyosis linguæ is best demonstrated when the tongue has been dried, so the corresponding condition of the bladder may escape observation because it is seen through fluid, and especially when, as often happens, there are other manifestations of cystitis present.

Leucoplakia is generally regarded as a sequel of long-standing irritation (Nitze, etc.). In most cases this is so, and cystitis or stone is present to account for it. However, Marchand has reported a case of extensive leucoplakia of the urinary tract at the age of 7 years, and Leber one in which the renal calices showed a similar lesion at 4 months, so that some other etiological factors must exist. Kretschmer showed that the fourth decade of life is the one in which the incidence is heaviest (27 per cent).

Cystoscopic Manifestations.—The leucoplakic patch resembles the corresponding lesion of the tongue. It is grey or silvery in colour, and is generally smooth in surface, but is occasionally corrugated. In no reported case have cracks or fissures, as seen in the tongue, been recorded. Blood-vessels are not seen, being completely hidden by the proliferated epithelium. The edges of the patch are sharply defined and demarcated from the surrounding hyperæmic bladder wall. It is little or not at all raised, though the central portion may be elevated to some extent. The outline is extremely irregular, and its margin may be scalloped or dentate.

Position.—All parts of the bladder seem to be affected indiscriminately, the trigone (Lichtenstein), neck (Halle), upper anterior surface (Krebs), etc., having been involved. Once leucoplakia was found in a diverticulum (Czerny). In each of my own cases the base was the only region affected.

The *number* of patches varies, but is usually inconsiderable, though Lohenstein reported a case in which there were numerous plaques near the trigone. The *size* also varies. The patch may be quite small, but in several instances the entire bladder has been involved (Ravasini, etc.).

Other Lesions.—

Cystitis.—This is generally present and is looked upon as a predisposing cause ; it is usually of the chronic variety. Healthy mucosa or an area of hyperæmia may surround the patch of leucoplakia, and the latter may contrast strongly with its pearly-white appearance. Papin, however, denies this, and says that the absence of an areola serves to distinguish the plaque from an ulcer of the bladder covered by a false membrane. When there is much mucopurulent deposit on the bladder base it may hide the thickened epithelium, or the latter may remain unrecognized because of its similarity in colour and general appearance to the muco-pus.

Calculi and Trabeculation.—These are frequent concomitants (Albarran).

Malignant Degeneration.—In one of my patients a red elevated nodule which appeared to resemble an epithelioma was found. A portion of it was removed with the operating cystoscope and was found microscopically to be epitheliomatous. Malignant degeneration has also been reported by Marion.

The leucoplakia is not always limited to the bladder. In some instances one or both ureters and renal pelves have been involved and the kidney dilated and infected. The ureter may be strictured (Verrière, Kretschmer). Sometimes the process originates in the upper tract and spreads to the lower. It may arise in a tuberculous kidney (Beer).

Diagnosis.—The diagnosis is made cystoscopically, the patient suffering from symptoms of cystitis in which pain is unusually prominent (cystitis dolorosa). As before pointed out, leucoplakia may be overlooked when there are false membranes on the vesical wall, or again, the cystoscopist may be in doubt as to whether the lesion is leucoplakic or is such a false membrane. If it is touched with the tip of a ureteric bougie, its solidity and intimate association with the bladder will be demonstrated.

An ulcer covered by a slough may also give rise to difficulty. The slough is creamy or pale yellow in colour, granular in texture, in contrast to the epithelial thickening, which is silvery or white and glabrous. The slough can be dislodged with a bougie, when a red, hæmorrhagic base will be exposed. The wall surrounding an ulcer is more intensely injected than that round a patch of leucoplakia.

There is only one characteristic feature which might suggest the nature of the disease before cystoscopy, and that is the presence in large quantities of stratified epithelium in the urine. Every case report which I have seen draws attention to this, and in my own it was specially remarked upon in the pathologist's reports. Frequently to the naked eye there is an obvious flocculent deposit, and in some instances patients have drawn attention to it themselves, or have reported the passage of 'gravel', etc., which may have been noticed for years. In a few cases, when flakes have been passed from the kidney in large quantities, colic has occurred.

Prognosis.—Marion and Heitz-Boyer state that if periodic cystoscopic examinations are made, it is found that the plaques never recede, they usually tend to increase. The supervention of malignancy has already been mentioned.

PURPURA OF THE URINARY TRACT.

The fact that the urinary tract may share in a generalized purpura is so well known that if blood is discovered in the urine in the course of such disease, it is invariably and rightly attributed to the purpura. Hæmaturia may be found in association with most of the various types of purpura, such as purpura rheumatica, erythema multiforme, etc., and, as with those conditions, its incidence is heaviest in spring and autumn.

More recently a variety of purpura limiting itself to the urinary tract has been described. Kidd, in this country, paid special attention to it, and Stevens and Peters described in detail a series of 26 cases observed by them on the western battle front during the Great War. It has also been recognized by writers on the Continent, especially Paschkis and Praetorius. Whether this localized type of purpura is the same disease as the generalized variety and has merely shown special selectivity for the urinary apparatus, is not known. A few reported cases in which the localized variety of purpura has been followed within a few weeks by subcutaneous hæmorrhages (Villemin, Boeckel, Praetorius) may be held to support the view that they are one and the same. On the other hand, Stevens and Peters saw so long a series of cases in which urinary purpura occurred without any manifestations beyond the tract that they were led to the belief that this is a special entity. Purpura appears capable of affecting the bladder alone, one or both kidneys alone, or of involving the whole urinary system.

When the kidneys are affected without the bladder, and especially when one alone is affected, the condition presents great diagnostic difficulties. It becomes necessary to differentiate it from other causes of renal hæmorrhage, especially an early renal tumour, and the 'essential' hæmaturias. The only cystoscopic finding is that of fluid blood, generally in large quantity, flowing from one or both ureters. The pyelogram is unchanged, and there is, in many cases, nothing in the symptom complex to guide one. The danger of leaving an early growth or of removing a kidney which is capable of recovery must be faced. To hold one's hand carries with it the danger of leaving an early growth untreated, but an over-precipitate operation may remove a purpuric kidney which was quite capable of complete recovery. Probably many of the renal purpuras have, up to the present, been grouped with the 'essential' hæmaturias. If a kidney of this type is removed it presents submucous hæmorrhages in the pelvis and effusions in the tubules. But it must be confessed that some examples which I have seen are not really convincing, because most nephrectomized kidneys show similar lesions, the result of operative handling, and in the absence of bladder petechiæ the question to me is an open one whether all such specimens are true examples of renal purpura.

Cystoscopic Appearances.—Purpura seen in the bladder is distinctive and bears a strong resemblance to the corresponding cutaneous lesion, eexcpt that it is, in some small degree, modified by the greater transparency of the bladder mucosa. The hæmorrhages vary in size from punctate spots to areas as big as a sixpence. They are very variable in shape—rounded, stellate, linear, etc., and have sharply defined margins. The disposal of the petechiæ around the blood-vessels is evident when the hæmorrhages are not too large. Foci may be widespread over the whole bladder or grouped in one area, and no part of the organ seems to be specially picked out, unless it be the region of the sphincter which is possibly slightly more susceptible than other regions. The ureteral orifices are curiously exempt (Kidd). The lesions appear flat, extravasation rarely, if ever, raising the mucosa noticeably. Their colour depends on the stage at which they are examined. At first a bright blood-red, they become somewhat purplish within a day or two and slightly mottled. Subsequently they pass through the various colours familiar to all as any extravasation fades, till in about two or three weeks all signs of the disease have completely vanished. Sometimes recurrent extravasations occur, and if they follow each other quickly, lesions at different stages may be observed in the bladder. The mucosa covering the petechiæ is intact and healthy. Stevens and Peters excised portions by means of a cystoscopic punch and showed the mucous membrane to be normal and unbroken, with blood-cells in profusion lying in the submucous tissues. There was no leucocytic infiltration or anything else suggesting an inflammatory lesion. Blum claims to have seen ulceration of the overlying mucosa, but this observation is not confirmed by other urologists.

Diagnosis.—In the absence of a generalized purpura, vesical purpura requires to be differentiated from hæmorrhagic cystitis, as the two cystoscopic appearances may easily be confused. Symptomatically also there is some similarity, as each gives a certain amount of 'ardor urinæ', though this is generally more marked with a cystitis of such severity as to be hæmorrhagic than it is in purpura. Many purpuric cases exhibit general malaise, headaches, muscular weakness, and an irregular pyrexia which are liable to be attributed to a pyelocystitis. Cystoscopically the chief distinguishing feature is the appearance of the mucosa between the patches. In purpura it is completely normal and healthy, retaining its sheen and showing no undue vascularization. In this it contrasts with a hæmorrhagic cystitis, where the membrane intervening between the extravasations is dull and inflamed, in most cases intensely so (*see Plate III*B, page 80, also pages 80 and 92). In cystitis there may also be a deposit of mucus or muco-pus, which is not seen in purpura. The bladder capacity, which in cystitis is reduced, may likewise be diminished in purpura, but as a rule it is unaltered. The presence of pus and organisms in the urine in cystitis is a further feature serving to distinguish these two conditions, both being absent from the urine in purpura. It should be remembered, however, that the purpuric bladder is unduly susceptible to infection, and that this may arise either spontaneously or as a result of cystoscopic instrumentation. Once it has put in an appearance, both the cystoscopic and the clinical pictures are dominated by it, and the purpuric origin of the illness may be overlooked.

VARIX.

Small tortuous veins in the submucosa which are unworthy of the dignity of this title are not uncommon. They occur in the region of the trigone and bladder neck, but are also to be seen in the body of the viscus. A true varix is rare; in fact, its existence has even been denied. Varices were first observed by Viertel and have been described by Péan, Bazy, Albarran, and many others. An example is shown in *Plate VI* C, page 130. The site of election is the neighbourhood of the neck, trigone, and retrotrigonal area; they are never seen in the upper part of the organ. They may occur either in the male or female, but are much more frequent in the latter, especially during pregnancy. When varices occur in the bladder they are generally also seen elsewhere, especially on the vulva, legs, and anus. Hæmaturia from this source sometimes occurs (Guyon, Baraduc, etc.), but is rare. It may be very profuse and necessitate suprapubic cystotomy

(Casper). It is often assumed that a urinary hæmorrhage during pregnancy has its origin in a varicose vein, but this is an unsafe assumption, and the possibility of overlooking a neoplasm should invariably lead to the recommendation of early cystoscopy, though if the patient is already near term, it should be postponed till the termination of the pregnancy. In men varices are seen most commonly as a complication of prostatic hypertrophy. In either sex they may be observed in the neighbourhood of large vesical or extravesical tumours. In cancer of the uterine cervix they are not uncommon, and according to Barringer result from venous engorgement caused by adherence between the growth and the bladder wall.

The appearance of the blue tortuous vessel is scarcely mistakable. It is never extreme in its development, and usually not more than three varices are found. They never gives rise to symptoms, with the exception of hæmorrhage, and their discovery is merely a cystoscopic incident.

MALAKOPLAKIA.

Ever since Hansemann in 1903 first discovered this condition at a post-mortem, sporadic cases have been observed. Thomson-Walker and Barrington in 1924 collected 38 cases. The following is taken from their description :—

" On cystoscopy . . . there was no difficulty in getting a clear medium. The whole of the mucous membrane of the bladder, with the exception of the trigone, and a small area behind this, was strewn with yellow plaques, which varied in size from a very small point to an area the size of a threepenny piece. Viewed from a distance the colour was yellowish-pink, but on closer inspection it was pale yellow. . . . A plaque was flat, or nearly so, on the surface, it had a rolled-over edge and stood up sharply from the mucous membrane. The central part was frequently a little depressed, somewhat like the nodules of molluscum contagiosum. They were rounded or oval. Closely examined, they had the appearance of a caseous nodule covered with a thin layer of epithelium. Occasionally the base was a little contracted, so that the edge rolled over. Around the edge of the plaque there was a halo of moderate inflammation in a few plaques, but in most of the plaques there was no sign of reaction in the mucous membrane around, and there was no ulceration. The mucous membrane, apart from the plaques, was healthy. The ureteric orifices were normal with a slight reddening of the lips."

Occasionally cystitis is observed as an accompaniment of the disease, and in a few cases leucoplakia has been noted. The disease affects principally middle-aged and elderly women and gives rise to symptoms which are indistinguishable from those of cystitis.

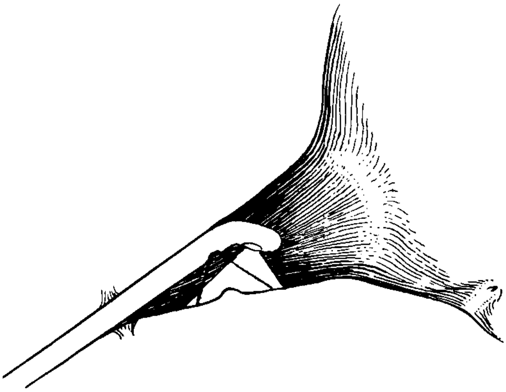
Histologically the plaque occupies the submucous coat of the bladder and consists of a stroma in which lie numerous cells. Some of these are leucocytes and lymphocytes. But the most striking and characteristic cells are polygonal, vacuolated, faintly staining, bodies of very large size, having for the most part a single central nucleus, though occasionally multiple or eccentric nuclei are observed. Within these large cells are invariably found rounded refractile inclusions known as Michaelis-Gutmann bodies, which are variable in size and may reach twice the dimensions of the nucleus. The origin of these inclusions has been the subject of much fruitless conjecture. The epithelium covering the plaque has generally been shed.

The nature of malakoplakia is unknown. Some writers have regarded it as a form of tuberculosis, others have thought it to be comparable to leucoplakia. Both views are probably incorrect. Tubercle bacilli have been looked for without success. The *Bacillus coli* is frequently present and may occur in large numbers and even in clumps within the masses. The ureter and renal pelvis may be involved in a similar process. The diagnosis is made by the cystoscopic appearance, which is generally distinctive. Blum and Kidd have removed, by means of a cystoscopic rongeur, bits of affected tissue for examination. The same two writers have treated the condition by perurethral fulguration, the individual plaques being severally attacked.

CHAPTER XVI.

FUNNEL-NECK DEFORMITY OF THE BLADDER.

If, in a normal man the cystoscope is withdrawn from the bladder so that it lies within the posterior urethra, the field is dark because, in so narrow a tube, the lamp is in contact with the mucosa and its light is shaded. Moreover, the cystoscope window lies too close to the urethral mucosa to allow definition. In certain circumstances, however, the upper and lower walls of the urethra are more widely separated, so that if the ocular is depressed and the prism is turned downwards, the postero-inferior wall of the tube and the colliculus seminalis come into view (*Fig.* 144). The anatomical basis of the



* *Fig.* 144.—Well-developed funnel-neck deformity. Cystoscope held over colliculus seminalis.

condition is a dilatation of the proximal urethra due to relaxation of the internal sphincter, the whole posterior urethra assuming a conical shape with the base of the cone directed towards the bladder and the apex at the triangular ligament.

Apart from a case report by Alexejeff (1914) which concerned a patient suffering from enuresis, this phenomenon was unknown clinically till 1917, when Burns, of Baltimore, published 21 cases

* The blocks for figures used in this Chapter are kindly lent by *The Royal Society of Medicine*. They formed a part of the material for the author's presidential address to the Section of Urology of that Society.

of spinal syphilis (mostly tabetics) in which he had seen the condition. Previously Barrington had observed similar changes caused by transsection of the cord in the cat. From the time of Burns' article onwards there is practically no further English or American literature on the subject. On the European Continent six examples of funnel-neck bladder, all occurring in subjects suffering from various diseases of the central nervous system, were reported by Schramm (1920), and the Germans, disregarding preceding publications, have christened the condition 'Schramm's phenomenon'.

ANATOMY OF BLADDER CLOSURE.

Fresh ideas have been advanced recently regarding the trigonal muscle, and if they prove to be acceptable our views on the physiology of micturition must be modified. Till recently it has been taught

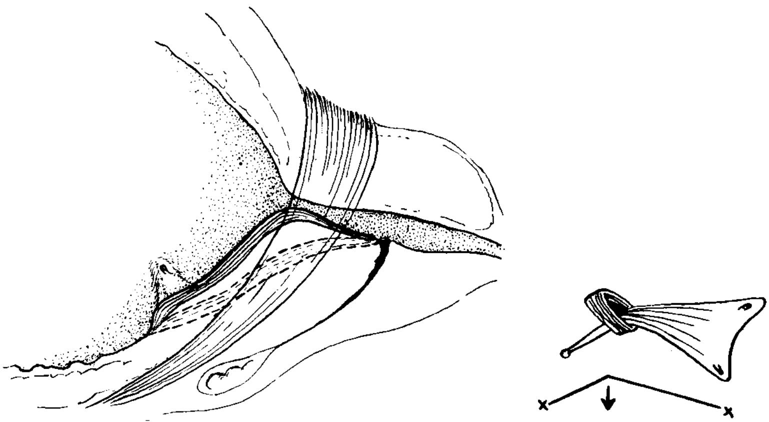


Fig. 145.—Sagittal section of bladder neck to show the trigonal muscle at rest and in contraction (dotted line). (*Modified from Young.*)

that at the onset of urination the internal sphincter undergoes an 'inhibitory dilatation' comparable to that seen at the anus. According to Young and Wesson, however, the trigonal muscle, superficially placed in reference to the other muscles of this region, passes downwards and forwards through the internal sphincter to receive an insertion near the verumontanum (*Fig.* 145). Its course between these two points is not in one plane, the vesical and urethral sections forming an angle, which angle corresponds to the internal meatus of the bladder and lies at the uvula vesicæ. In contracting the trigonal muscle straightens out this angle and drags down the lower lip of the vesical orifice. Those muscular fibres which run circularly round the urethra are dragged open, and urine passes into the posterior urethra.

The trigonal muscle has, however, been shown by my colleague, McCrea, to be but a thin sheet, whilst the internal sphincter is a very definite structure, so that if the trigonal muscle has the function which Young and Wesson ascribe to it, a relaxation of the sphincter must accompany the trigonal contraction. Many elastic fibres situated in the region of the internal sphincter appear to play a part in the closure of the bladder neck. Perhaps the sphincter itself relaxes, but the trigonal muscle is responsible for dragging it open together with these elastic strands.

The writer has drawn attention to the fact that the trigonal muscle, as a result of its triangular shape, acts not only in a backward but also in a transverse direction (*Fig.* 146). The two bars of Bell converge on the internal meatus, and as they start the urethral section of their course they change their direction and run side by side down that tube. In contraction these two muscles straighten out and so exert lateral in addition to downward pull on the meatus, thus opening it transversely as well as vertically, and giving the orifice a triangular shape in cross-section. The appearance presented by the manifestation under discussion would be satisfactorily explained if the sphincteric fibres were paralysed, and this may be provisionally accepted as the anatomical basis for the condition.

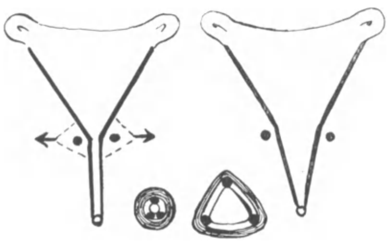


Fig. 146.—In action the divergent limbs of the trigone open the meatus in a transverse direction.

The funnel-neck bladder must not be confused with an appearance which has much in common with it, but which arises from a quite different cause. In prostatic hypertrophy the growth of the lateral lobes produces a deep, cleft-like urethra at the bottom of which, if the cystoscope is held at a suitable distance, the floor of the passage, together with the verumontanum, can be clearly seen. The two conditions are easily distinguished from each other by the different appearances of the vesical meatus, which are described in the appropriate places.

IMPORTANCE AND FREQUENCY OF THE SIGN.

There is little doubt that this sign is frequently met with in disease of the central nervous system and that when encountered it is strongly suggestive of such disease. Many observers, including the writer, have seen the characteristic hiatus in subjects who were not at the time known to be suffering from any nervous lesion, but who on closer examination were found to give evidence of such disease. Some, indeed, amongst these cases have not presented any further symptoms or signs even on the most careful investigation, but have developed tabes dorsalis or other trouble at a subsequent time, a funnel-shaped neck having sounded the first warning of its approach. It may thus be the initial sign and is frequently an early development. On the Continent some neurologists refer doubtful early cases of tabes, etc., to the cystoscopist for confirmation.

This symptom, important and common though it is, has attracted surprisingly little attention in this country, as also in America and France. The few available papers come from Germany and Russia, but the views expressed in these papers are so contradictory that it is difficult to gather from them any real idea of the value of the sign.

From amongst studies *attributing* diagnostic significance to the funnel-neck deformity of the bladder may be selected for quotation that of Epstein, Juschelevsky, and Michelson, partly because it contains the largest series of patients (500) as yet examined. Two hundred of these patients were known to be sufferers from central nervous affections, the remainder being the ordinary cystoscopic material of the writers' clinic. This investigation appears to have established the fact that the phenomenon depends, not so much on the type of the disease, as upon its localization. The majority of cases showed lesions of the spinal cord, though in brain disease it was found that if both cerebral hemispheres were involved, the sign might be positive. Lesions of the peripheral nervous system do not produce it. In spinal injuries the writers found the sign present in 90 per cent of the cases, in tabes in about 84 per cent, and in syphilitic myelitis in 83 per cent. Cases of spina bifida, though not numerous in their series, showed a high percentage of affected sphincters, and it is interesting that a few patients in whom the sign was positive and yet no nervous disease was discoverable were found by X rays to have some clinically unrecognizable degree of spina bifida. These observers hold that it is doubtful if a funnel-neck is ever discovered in completely healthy men, and they think that it is likewise questionable whether it occurs in purely functional disturbances of the central nervous system without any anatomical substratum. In true organic disease of the central nervous system—all varieties taken together—it was absent only in about one-third of the cases which they examined.

Several other articles express comparable views (Otto Schwarz, Perlman, et al.). Some authors, indeed, produce a higher percentage of cases showing the sign than do the above writers, and Halperstein says that in tabes 100 per cent of cases are affected. Of these writers some think that neurasthenics may exhibit a hiatus.

There are not wanting, however, those who *deny* any value to this phenomenon, foremost amongst whom is Oswald Schwarz. By this school it is maintained that :—

1. The sign may be absent in unmistakable nervous disease, which is indeed admitted (*see above*), though it is hard to see why this should detract from its importance when present.

2. Overfilling of the bladder is said to produce a hiatus in normal people. It has been shown above that the first phase of normal micturition is the opening of the bladder outlet by the trigonal muscle in a way which will produce an appearance identical with a pathological hiatus. Overdistension of the bladder causes spasm of the trigonal muscle and opening of the sphincter, at the same time provoking a call to micturition. In fact, it produces a physiological hiatus, which differs from the pathological one only in being transient, passing off when over-distension is relieved. The overfilling which brings it about is unnecessary and undesirable and does not occur if a proper technique is employed (*see* page 51).

3. The symptom is present on one occasion and absent on another, or it comes and goes during a single cystoscopic examination.

4. The longer the cystoscope is in the bladder, the more likely is the phenomenon to present itself, and if the ocular end of the instrument is unsupported its vertical drag will cause a dilatation of the meatus so that a hiatus is artificially produced.

5. Sacral anæsthesia is said to be responsible for the occurrence of a hiatus. On theoretical grounds this would appear not unlikely, the inhibition of the internal sphincter leading to its dilatation just as sacral anæsthesia can produce dilatation of the anal sphincter and so lead to incontinence of fæces. The innervation of these two muscles is similar.

Some of those who refuse to allow any diagnostic value to this sign have found it positive in a very much smaller percentage of cases than do its upholders. Thus Dunajewsky and Michejew, examining 42 cases of tabes, found it present in but 16·6 per cent, which contrasts strangely with the figures previously quoted, showing 84 to 100 per cent. To explain this discrepancy it must be remembered that the dilatation is not always equally developed and that the slighter degrees are easily overlooked. Moro, indeed, has tabulated four grades (*Fig.* 147), which show respectively :—

1. Radial streaking in the region of the inner bladder opening and the gradual transition of the bladder into the posterior urethra.

2. The urethra and colliculus seminalis are indistinctly seen as a result of lying close up against the prism, showing that the dilatation is inconsiderable.

3. The field of view is dark in its proximal part, but, as the cystoscope is further withdrawn, it enters a relatively spacious,

spindle-shaped chamber, in which the illumination is bright. On the floor of this chamber the colliculus is clearly seen, together with its surrounding valleculum.

4. The condition is fully developed (*Figs.* 144 and 147, 4). The bladder neck gapes widely and the normal angulation at the point of transition fails. The prostatic urethra can be easily examined in its complete length.

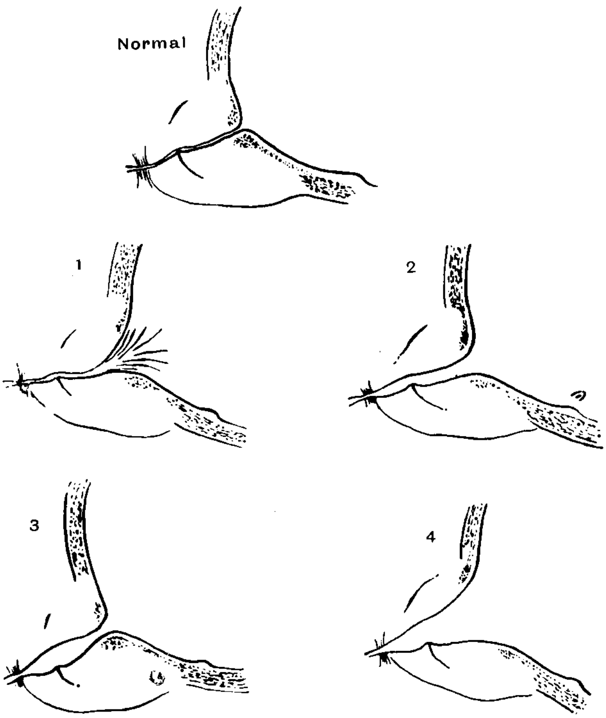


Fig. 147.—To illustrate Moro's gradings (*see* text).

That varying degrees of the phenomenon present themselves is unquestionable. In the above table, Types 1 and 2 are easily overlooked, and even Type 3, which is sufficiently distinctive, will escape observation unless the cystoscopist is actually on the lookout. These facts probably explain some of the prevailing contradictions relating to this manifestation.

In an attempt to obtain a personal view of the incidence and significance of the funnel-necked bladder Poole-Wilson and the present writer examined a series of 25 men suffering from central nervous disease. Twenty-one of them were tabetics or general paralytics and in these two classes the phenomenon was positive in all except three patients. In addition a single example was discovered in a case of disseminated sclerosis. We classified our material according to Moro's gradings and soon discovered the difficulty of being quite sure of, and hence the unreliability of, Types 1 and 2. Our figures refer, therefore, exclusively to Types 3 and 4. On many occasions we noted that by increasing the distension of the bladder a funnel would develop when not previously present, or that a minor degree of funnel formation would give place to a major. In the table appended this accounts for the presence of two figures attached to many of the cases.

Disease and Number of Patients	Principal Symptoms	Grading (*Moro*)
Tabes dorsalis (16) ..	Dribbling .. } Enuresis .. } 7 Automatic micturition }	4 ; 4 ; 2→4 ; 3 ; 3 ; 3 or 4→4 ; 0
	Difficulty .. 3	4 ; 0 ; 1 or 2
	No symptoms .. 3	4 ; 0→4 ; 4
	Copious evacuation of urine 3	2→4 ; 4 ; 2→4
G.P.I. (4)	Incontinence .. 2	3 ; 4
	No symptom .. 2	3 ; 4
? Tabes ; ? G.P.I. (1) ..	Sensation of distension without residual urine	0
Disseminated sclerosis (3)	—	0 ; 0 ; 3
Spastic paraplegia (1) ..	—	0

To obtain a good view of the verumontanum is the best test of the sign, and to do so the ocular end of the cystoscope must be steeply depressed between the patient's thighs ; otherwise the condition escapes observation. It is only the inferior wall of the urethra which comes into view by this examination, for if the cystoscope is rotated the field becomes dark as soon as the side walls are approached, and even by manœuvring the instrument we have never been able to get a proper view either of the lateral or upper boundaries of the canal.

In addition to the patients referred to above, all of whom were known to be suffering from some form of nervous disease, we have examined the records of 171 consecutive cystoscopies on males in the ordinary cystoscope clinic, and amongst these found 15 examples (8·8 per cent) of a funnel neck. In the early part of this series of cystoscopies no special watch had been kept for funnel-neck deformities, and we found in our records only 3·5 per cent of examples, which serves to illustrate how often they are overlooked in routine work. Paralysis of the internal sphincter may serve as a satisfactory explanation when the condition occurs in spinal disease, but when it is discovered unexpectedly a different explanation must be sought. Straining to micturate may account for a few, and the fatigue of a long cystoscopy for some others. Several have been discovered in patients under spinal or sacral anæsthesia and no significance must be given to the sign unless it is confirmed by subsequent cystoscopy without anæsthesia. One or two may perhaps be examples of early nervous disease. But a considerable remnant is unexplained, and it appears probable that a hiatus may develop in the completely healthy man. Even if this proves to be the case and the pathognomonicity of the lesion is not established, the marked difference between the incidence of the funnel-neck deformity in health and in nervous disease is very striking. The discovery of the condition calls for a complete neurological overhaul and an examination of the Wassermann reaction, etc. No cystoscopy in the male is complete until the instrument has been withdrawn down the urethra and a hiatus has been searched for, and this holds true with particular force for such cases as have obstruction, especially unexplained obstruction, as a symptom.

Central nervous disease is frequently responsible for derangement of bladder function, and it has been well known since the days of Romberg that dysuria may be the first symptom of various spinal diseases and particularly of tabes dorsalis. When occurring as an isolated symptom its cause is likely to be diagnosed only by exclusion of other conditions. Trabeculation of the bladder of a special kind is a recognized sign of nervous disease and has certain characteristics which have been described on page 131, and which distinguish it from other types of trabeculation. Yet this trabeculation is inconstant and easily overlooked and its diagnostic significance is not completely reliable. Even though the presence of a funnel-shaped neck is probably not pathognomonic it nevertheless suggests some derangement of the central nervous system. A combination of the two conditions —a trabeculated bladder and a funnel-shaped outlet—certainly carries considerable diagnostic weight.

CHAPTER XVII.

PROSTATIC HYPERTROPHY AND OTHER DISEASES OF THE PROSTATE. ENDOSCOPIC PROSTATIC SURGERY.

INDICATIONS FOR CYSTOSCOPY.

When the diagnosis of prostatic enlargement is clear apart from cystoscopy, as is usually the case, that examination should be omitted, for, although legitimate and desirable when doubt exists, it is not entirely free from danger, and in any event an elderly and perhaps feeble patient should not be submitted to cystoscopy unnecessarily. Previously the patient should be carefully examined for symptoms suggesting incipient uræmia. Wherever they are found cystoscopy is contra-indicated.

When, however, a patient presents himself with ambiguous symptoms—for instance, hæmorrhage, which may be prostatic or vesical, or especially where enlargement is intravesical and the rectal examination is inconclusive, and in any other doubtful circumstance—the cystoscope should be resorted to without hesitation. My experience is that after eliminating cases in which it is not required, there remains an important field of usefulness. The proportion of patients in which the symptoms and signs are unconvincing is a fairly big one, and it is risky to undertake operative measures without confirmatory cystoscopy. Hæmorrhage often comes from a vesical neoplasm in an elderly patient, and I have several times seen the combination of an epithelial tumour with a prostatic adenoma, and in some instances have treated the tumour successfully by perurethral means without having to interfere with the prostate.

Cystoscopy may bring to light a number of concomitant bladder lesions which will be discussed later. Most of them are sequelæ of the prostatic disease, and can be diagnosed by other agencies, as, for instance, stone by X rays, cystitis by pyuria, etc. More precise knowledge of the state of the bladder wall is not indispensable, for its condition has a subordinate bearing on treatment. The important thing is to make a diagnosis of prostatic hypertrophy, and when that has been done the decision for or against operative interference will rest, not on the local complications, but on such things as the renal function and the general health of the patient.

THE DANGERS OF CYSTOSCOPY IN PROSTATIC ENLARGEMENT.

The dangers of cystoscopy in hypertrophy of the prostate are as follows :—

1. **Sepsis.**—Scrupulous care is required to avoid soiling a viscus which cannot evacuate itself completely. Careful urethral irrigation should precede the examination, and after it 2 oz. of antiseptic, such as $AgNO_3$ 1–2000, should be left in the bladder to be passed by the patient subsequently. Many bladders are already infected when first seen. It is well known that these give less cause for anxiety than does the uncontaminated viscus. Once they have overcome their preliminary infection they seem to acquire a degree of immunity to sepsis which renders subsequent instrumentation safer.

2. **Urethral Shock and Suppression of Urine.**—These conditions will occasionally occur unexpectedly in apparently good subjects, but the latter is particularly prone to happen where an over-distended bladder is too suddenly emptied. Such an organ should not be submitted to cystoscopy until some time has been allowed to elapse, during which it is slowly evacuated and the kidney thus gradually decompressed. The clinical picture in this type of case is, as a rule, so characteristic that cystoscopy is superfluous.

3. **Hæmorrhage.**—(*See* pages 243, 244.)

4. **Epididymitis.**—This is a complication to which these patients are susceptible after instrumentation, and also following operation. Paralysis of the vas deferens by the exhibition of small doses of atropine or belladonna will lessen this risk, but may further parch an already dry tongue.

5. **Retention of Urine.**—Retention, which was probably incomplete before cystoscopy, is sometimes aggravated and may become complete as a result of the congestion caused by cystoscopy.

PATHOLOGICAL ANATOMY.

The structural alterations resulting from prostatic hypertrophy must be understood before it is possible to appreciate the cystoscopic manifestations of the disease. Those which interest us are: (1) *Prostatic changes*; (2) *Urethral changes and alterations of the urethral meatus*; (3) *Vesical changes* (*Fig.* 148).

1. **Prostatic Changes.**—Adenoma formation affects chiefly that median segment of the prostate gland lying between the urethra and the ejaculatory ducts. It is here that the first changes are observable, and here also that in maturity they generally become most pronounced. Other parts of the organ are not, however, exempt. Independent

adenomata commence to grow on the lateral aspects of the urethra, and as they extend establish continuity with the median group, which, indeed, they may exceed in size and antedate in origin. Anteriorly the change is less evident and is often absent. The increase in bulk of the gland occurs in part extravesically and in part intravesically.

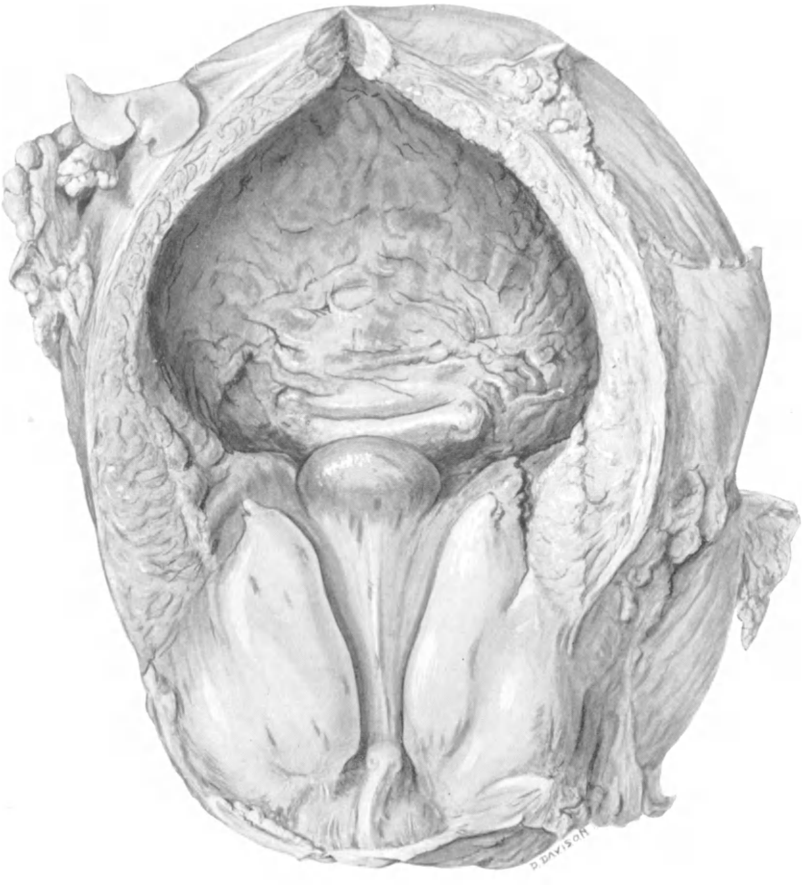


Fig. 148.—General view of the bladder and posterior urethra in prostatic enlargement. Laid open anteriorly.

Extravesically its growth causes it to encroach on surrounding structures. It is, however, rigidly fixed inferiorly by its attachment to the triangular ligament, and anteriorly its proximity to the pubes prevents advance, so that the only three directions which can provide increased accommodation are posteriorly, where it bulges towards, or actually into, the rectum; laterally, where it displaces the levatores ani; and superiorly, where it elevates the bladder base. In its expansion it also encroaches on the urethra and compresses it.

The elevation of the vesical floor is important, for the vesical outlet, which in normal circumstances occupies the lowest point, is now situated on the top of an elevation and surrounded by a vallecula.

Intravesical Changes.—But another important factor enters into the elevation of the vesical floor, and especially that of the meatus. The elevation consists of adenomatous tissue covered by a thin layer of mucous membrane. This came to be an intravesical structure through pushing aside the internal sphincter in such a way that this

Fig. 149.—An enucleation specimen seen from the front. The intravesical projection retains its covering of mucosa. The lateral and middle lobes, and the cleft-like urethra are well seen. Note particularly the ribbon of internal sphincter muscle which has torn away with the gland, and observe its position close to the meatus in front, and how the lobes have pushed through the ring especially posteriorly and laterally. There is a furrow on the surface of the gland where it has been gripped by the internal sphincter.

muscle, particularly in its posterior and postero-lateral parts, is divorced from the meatus. At the front of the urethra, where there is little or no hypertrophic change, the muscle still retains its old position at the margin of the orifice, but as it is traced backwards it will be found to recede gradually from that opening, having been pushed away by the growing lobes of the prostate so that it now forms a band thrown round the base of the intravesical section of the prostate and dividing this off from the extravesical part (*Fig.* 149).

The encroachment of the prostate on the vesical cavity and its relationship to the sphincter was difficult to explain so long as it was thought that prostatic hypertrophy originated in the body of the prostate gland itself. It is now widely believed that the point of origin of prostatic enlargements is not really in the prostate gland at all but in certain glandular structures situated immediately below the mucous membrane of the trigone and urethra and known as the submucosal glands (*Fig.* 150). Though these submucosal glands form a practically continuous chain it is convenient to classify them into three groups according to their anatomical site. They are known, therefore, as subtrigonal, subcervical, and prostatic glands. The 'subcervical' group, which is the most important collection, lies beneath the uvula vesicæ. It is also called 'Albarran's group', because this French surgeon first showed the rôle it played in the production of the so-called middle lobe. These glands are accommodated in the submucosa and are thus internal to the muscular layer, though a few of them penetrate amongst the adjacent muscular fasciculi. When we realize that prostatic enlargement begins in a structure having this position there is but little difficulty in explaining the relationship to the internal sphincter which I have just described and how that muscle comes to be ousted from its customary situation at the meatus. The growth arises actually within the ring of the muscle, which it distends and displaces by its increasing bulk. It is eventually divorced widely from the meatus and comes to lie below the level of the orifice in a position where it functions at great disadvantage, being unable either to contract or to expand freely.

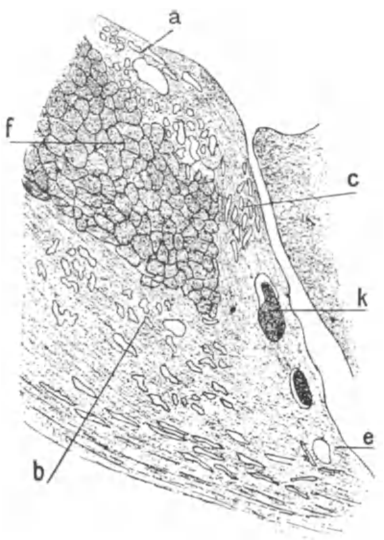


Fig. 150.—Sagittal section of the urethra and bladder neck in the earliest stage of prostatic hypertrophy. a, Submucous cervical glands; b, Glands of the intermediate portion; c, Submucous urethral glands; e, Urethral mucosa; f, Internal sphincter; k, Glands undergoing cystic change. (*Jores.*)

The central and posterior portion of the gland is the one where change is most marked (*Fig.* 151), and from it is produced in this way the so-called middle lobe of the hypertrophied prostate. A similar alteration is usually evident at other parts of the meatus, especially laterally, where the adenoma, though less markedly, distorts the meatus, the neoplasm here also curling the sphincteric musculature outwards. The anterior region is the one least involved, and indeed there is generally no intravesical bulge at this point.

The *distribution* of the hypertrophy is not constant, though when one part is affected it is customary to find a certain amount of gland proliferation in other regions. Nevertheless, we speak of a middle or a lateral lobe enlargement, according as these respectively bear the brunt of the increase. Occasionally one comes across a case in which

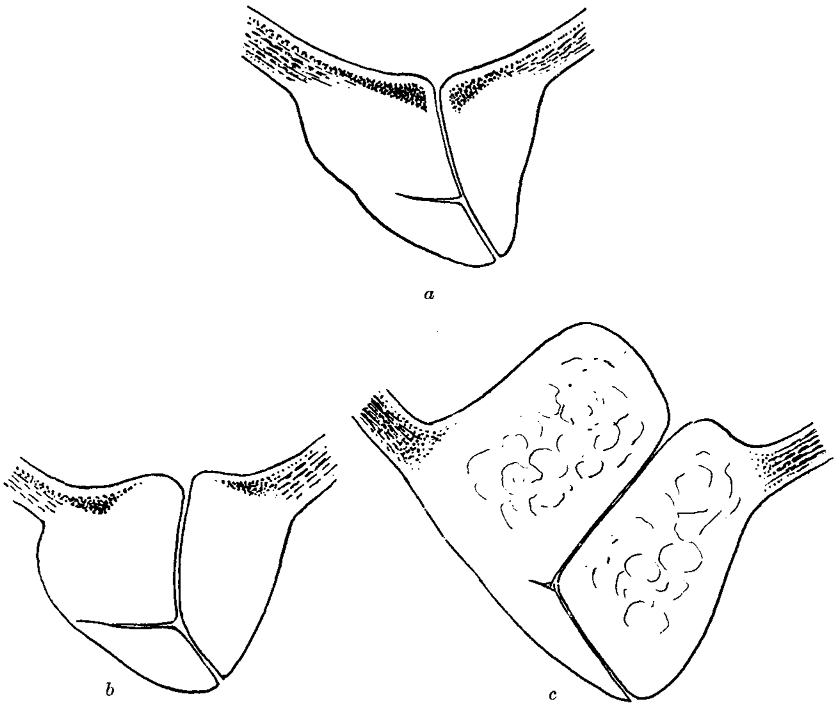


Fig. 151.—*a*, Normal relations of vesical sphincter to prostate, etc. *b*, *c*, Alterations produced at vesical neck by increasing degrees of prostatic hypertrophy.

there is no evidence of increase cystoscopically, except in one lobe, and when this occurs the middle lobe is the one usually affected. I have seen cases in which the lateral lobes were enlarged and the middle one quite unaffected, though this is comparatively rare. The floor of the urethra is continued into the trigone on the same plane, and by elevating the cystoscope into the cleft between the two hypertrophied lobes it can be traced backwards for a fair distance.

2. **Urethral Changes.**—The urethra undergoes modification as a result of the changes in the shape and size of the prostate. It becomes

16

longer. The increase is confined to that portion of the tube proximal to the verumontanum, and this section is augmented by about half an inch to an inch and a half, but when the hypertrophy is marked, it may on rare occasions amount to many inches. Obviously such an elongation would preclude the use of the ordinary cystoscope, and special instruments have been made with the object of overcoming this difficulty. They are, however, unnecessary, as so large a gland is quite rare and with so great an increase in length the diagnosis becomes self-evident.

The urethra becomes more *bent.* There is an angle in the normal prostatic urethra at the level of the verumontanum (*Fig.* 49 *a*, page 56). This becomes increased in the ordinary type of hypertrophy, owing to the development of the middle lobe (*Fig.* 152 *a*). The angle may

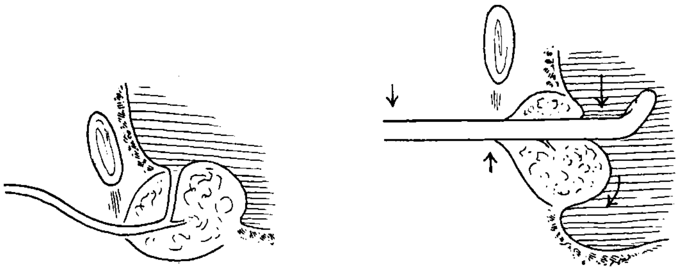


Fig. 152.—*a*, Urethra in prostatic hypertrophy. Note increase in the curve of the prostatic urethra as compared with the normal shown in *Fig.* 49*a*, page 56. *b*, Urethra in prostatic hypertrophy after introduction of cystoscope. Marked retroversion of prostate causing exaggeration of the retroprostatic pouch.

become so acute as to prevent the passage of the cystoscope or occasionally even that of an ordinary catheter. It must be straightened out during the passage of the cystoscope. This straightening is accomplished partly by bending forward the distal, but chiefly by retroverting the proximal, segment. Such retroversion has an effect on the shape of the bladder base, emphasizing the retroprostatic declivity, and making the pouch deeper and more impenetrable (*Fig.* 152 *b*). A secondary effect of the antero-posterior bending of the urethra is that the meatus comes to occupy a position which is relatively, if not actually, more anterior (*Fig.* 151).

A *transverse section* of the urethra also shows changes. The urethra, as it lies between the two lateral prostatic lobes, is altered from being a small rounded tube to become deep and slit-like. The cystoscope, withdrawn into this cleft, can make visible the lower wall of the prostatic urethra as far back as the verumontanum, a proceeding which is quite impracticable in the normal state (*see also* Funnel-neck

Deformity of the Bladder, Chapter XVI). This visualization of the urethra becomes possible because of the increased depth of the channel in which one is working allowing one to hold the lamp and prism of the cystoscope at a good working distance from the floor of the passage.

The passage may be *deviated laterally* owing to a general or localized enlargement of one lateral lobe as compared with its fellow. Lateral deviation is sometimes responsible for impeding the cystoscope during introduction until the instrument is rotated on its long axis and its beak thus liberated.

The urethra becomes *more vascular*, and quite often large tortuous vessels can be seen on its surface at cystoscopy (*Plate XII* A). Its vascularity is most marked where the glandular enlargement is furthest advanced, and it is therefore best developed posteriorly and least anteriorly. It causes hæmorrhage during instrumentation, unless great gentleness is used.

Effects on the Urethral Meatus.—In the foregoing description of the way in which the adenoma encroaches on the bladder, it has been shown that the internal opening is : (*a*) Elevated, both actually and also in reference to the base of the bladder ; (*b*) Displaced anteriorly ; (*c*) That the sphincter is dilated and dislodged by the growing gland, which usurps its position at the meatus ; (*d*) The adenoma is overlaid by a thin covering of mucosa, probably carried up with it from the urethra.

The orifice is usually patulous and is inconstant in shape, varying according to which part or parts of the gland are affected. The varieties will be discussed when their cystoscopic appearances are described.

3. **Vesical Changes.**—The bladder proper is involved in the alterations at the urethral meatus which have already been described, the production of a retroprostatic pouch and the displacement of the internal sphincter being the most important manifestations. In addition the organ suffers from certain disabilities which are common to all types of vesical obstruction, and these will be described on page 251.

TECHNIQUE OF CYSTOSCOPY.

Before commencing cystoscopy the patient is instructed to empty his bladder as completely as possible, so that the residual urine may be subsequently estimated. This is a departure from the usual procedure (*see* page 49). Good anæsthesia is important, and the writer employs sacral injection with satisfactory results, though urethral instillation is preferred by many. As the urethra is prone to bleed, an irrigating cystoscope is almost indispensable. If a rubber catheter is used for lavage, blood invariably fouls the eye of the cystoscope during its introduction.

The cystoscope is introduced in the usual way until the membranous part of the canal has been traversed and the increased angle at the verumontanum is encountered. Manipulation must be very gentle at this stage if hæmorrhage is to be avoided. The optical end of the instrument must be steeply depressed between the thighs in order to round the corner. Adequate lowering maintains the beak in contact with the anterior wall of the prostatic urethra, and so avoids bruising of the friable and hæmorrhagic posterior surface. A flexible guide, screwing on to the end of the lamp to assist the cystoscope in negotiating the bend, has been devised, but is not to be recommended, for where the angle is so acute bruising is liable to occur when the straight portion of the cystoscope enters the canal.

If the above-mentioned manœuvres are not successful, lateral movements should be employed in an attempt to make the beak follow the sulci between the median and lateral lobes or pursue a

PLATE XII.

A, Prostatic hypertrophy. Right portion of middle lobe seen in foreground with large submucous vessels coursing along it. These are greatly magnified. The right ureter is seen in the distance. B, Prostatic hypertrophy. Junction of right lateral and median lobes with small fold of translucent mucosa between them simulating an extra lobe. C, Small ureterocele. The orifice can be seen and is surrounded by numerous fine vessels. D, The same as C after burning with the diathermic current through the cystoscope. E, Lateral view of a ureterocele showing site of origin. Its thin walls and vascular supply are indicated. The orifice could not be seen as it was situated at the apex (*see also Fig.* 130, page 206). F, The left ureteric orifice corresponding to a severely infected kidney. The orifice is dilated, surrounded by bullæ, and there is intense cystitis.

channel which has deviated. Assistance may be gained by pressure of a finger in the perineum or rectum, elevating the optical end and helping it to negotiate the sharp bend. Generally the introduction, if performed as described, is easy; occasionally it is difficult, and sometimes impossible. No roughness or force must be employed, and if unsuccessful after a short trial the attempt should be abandoned, as obstruction in the prostatic urethra is in itself presumptive evidence of hypertrophy.

When the instrument is in the bladder any residual urine will be withdrawn and must be measured. The bladder may not empty itself completely if the musculature is overstretched and inefficient. It should be assisted by gentle suprapubic pressure. If the evacuation has been incomplete, the first wash will return stained with urine, and it will be realized that too low a figure for residual urine has been registered.

Prolonged lavage may be needed when there is an old-standing cystitis or when quantities of purulent débris and membranes adhere

PLATE XII.

PROSTATIC HYPERTROPHY. URETEROCELE. PYONEPHROSIS

to the parietes. In some instances it is impossible to remove adherent membranes and muco-pus. If, however, the vesical medium itself is clear, the prostatic margins will be visible, and the main diagnosis can be established. At other times hæmorrhage causes delay. It may be urethral in origin or vesical, but in either event ordinarily comes from the exposed prostatic surface and is traumatic in origin. It must be combated by the means already enumerated (page 53). It generally subsides fairly rapidly. Occasionally it owes its origin to an epithelial neoplasm or comes from the turgid and velvety mucosa.

Quantity of Vesical Fluid.—Bladders containing much residual urine are necessarily of large size. They may have a capacity of several pints. When the viscus is catheterized it is usually possible to replace an equal amount of fluid. This is, however, not invariably true. An inflamed bladder sometimes contracts immediately and refuses to be re-distended by more than a few ounces. This should be borne in mind during irrigation, the initial washes being small and the increase gradual, until the measure of the organ has been taken as described on page 51.

Given, then, an organ of large capacity, it must be decided how much lotion shall be employed. If too much, the vesical walls will be remote and their inspection rendered more difficult. If too little, the voluminous parietes will be undistended, and redundant folds may conceal some features of the bladder. The relaxed mucosa also screens the musculature, and the effects of hypertrophy and trabeculation are lost, whilst the membrane itself may appear more œdematous than when seen under greater dilatation.

A portion of the retroprostatic recess is usually concealed from view by the gland margins, but it varies with the degree of distension employed. With more lotion the pouch deepens and one would expect it to become less visible. At the same time, however, it is extended in a backward direction and the mean result is that a larger surface is displayed. It is easy with the irrigating cystoscope to vary the quantity of fluid, and examine at varying distensions. Start therefore with the usual 8 oz. of lotion and investigate the prostatic margin and the general surface of the vesical mucosa. If a satisfactory exposure of the latter is not obtained, the medium can be rapidly augmented, say to 16 oz., and a fresh survey undertaken. This stratagem is valuable also when, as occasionally happens with big prostates, the ureteric orifices hide themselves behind the overhanging gland. An increase in the vesical distension may bring them into view.

Examination of the Bladder.—It has been shown above that the principal object of cystoscopy in this complaint is the diagnosis or confirmation of hypertrophy. The state of the bladder wall is of minor interest and would not in itself constitute a justification for the examination. Begin therefore by investigating the shape of the prostatic border. The instrument is withdrawn until the fenestra is flush with the meatal rim, which, crossing the cystoscopic field, commences to cut off the view of the vesical cavity. It is on the appearance and shape of this rim that the diagnosis rests.

In the normal condition of the parts (*see Fig.* 58, page 65), it will be remembered that the uppermost four-fifths are concave, whilst the lowest fifth is slightly flattened, so that if the instrument is made to follow the margin by rotating it on its long axis within the lips, the prefectly regular, circular disposition of the upper four-fifths, and the slightly flattened, or rarely convex, lower fifth, are easily appreciated. In the upper four-fifths the edges are sharply defined and translucent, due to the fact that the margin is thin and sharp. In the lowest segment they are absent owing to the similarity in direction of the trigone and posterior urethra.

All this is changed in prostatic enlargement. The gland bulges into the meatus and throws up a rampart around it. Seen cystoscopically this rampart has margins which consist of a number of convexities separated by sulci or recesses. Rotate the instrument within the lips of the orifice and a general impression of the arrangement will be obtained (*Fig.* 153). Having done this, scrutinize each segment individually. Each cystoscopic field represents about a sixth of the total internal meatus. The number of these convexities varies according to the shape assumed by the gland. Young has tabulated the various possibilities, and his diagram is reproduced in *Fig.* 154. His figures require no text. He says that "they cover (diagrammatically, of course) the great majority of cases of prostatic hypertrophy. There are certain irregular and bizarre types which are not included, but which can be interpreted by a comparison with the foregoing".

The commonest seats of change are the middle and lateral lobes. The meatus is then shaped as seen in *Fig.* 154 (*a*) (*see also Fig.* 153). The median lobe presents a sharper curve than that of the two lateral lobes, whose convexity is often slightly flattened by mutual pressure. Above, the two lateral masses meet at an angle, and their upper extremities, together with the intervening recess, are easily seen in a single cystoscopic field. The junction of the lateral lobes with the median is less acute than that formed anteriorly. A fold of redundant mucosa is often to be observed in the bottom of these sulci. Occasionally it is œdematous and may, by close magnification, suggest an additional lobe (*Plate XII* B, page 244). Sometimes, indeed, sequestered adenomata do rest on the surface of the main tumour and form additional irregularities. Anterior and circular enlargements are rare, but on occasion are of large development.

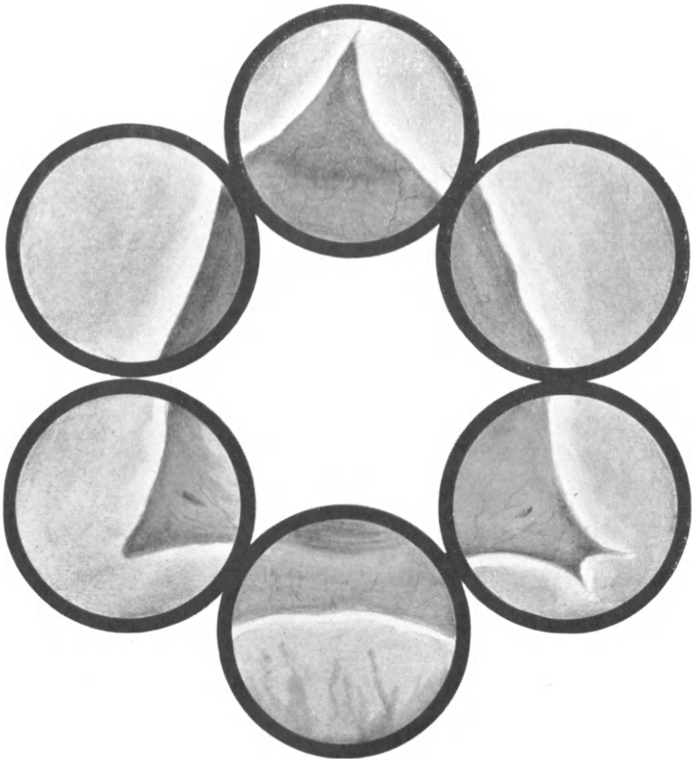


Fig. 153.—Series of cystoscopic fields showing collectively the contour of the *vesical* aspect of an enlarged prostate. (Cf. *Fig.* 58, page 65, and *Fig.* 155.)

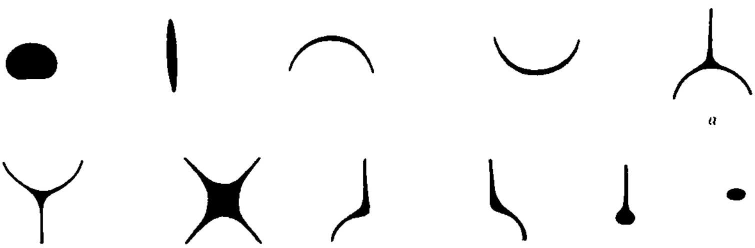


Fig. 154.—The first figure represents the outline of the normal meatus; the remainder show the possible changes which the orifice may undergo in prostatic hypertrophy. (*Redrawn from Young.*)

The *margin*, instead of being sharp, as in the normal state, is rounded and less well defined. It rolls away from the window of the instrument (*Fig.* 159), and is therefore in less close apposition. Its colour is deeper than that of the bladder except when the latter

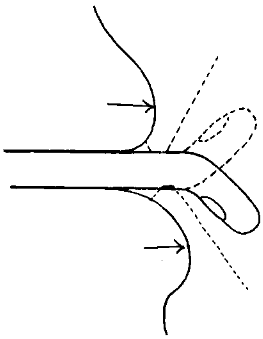


Fig. 155.—Cystoscope examining prostatic hypertrophy appreciates increase of the gland occurring in the sagittal body plane.

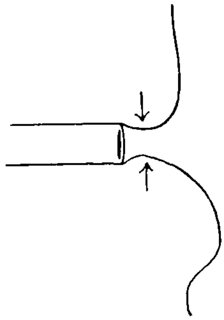


Fig. 156.—Urethroscope examining prostatic hypertrophy appreciates increase of the gland occuring in the transverse body plane (cf. *Fig.* 157).

is reddened with cystitis. Owing to its shape it receives the light from the lamp directly on its surface in contrast with the normal neck, which is transilluminated.

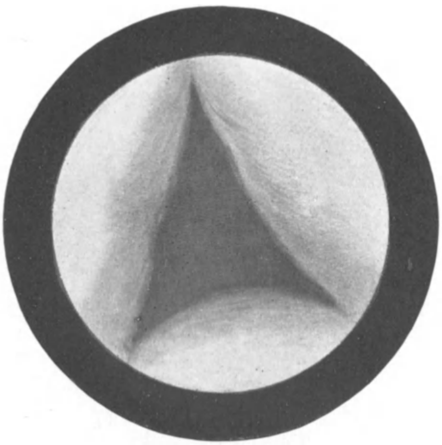


Fig. 157.—Internal meatus in prostatic hypertrophy seen through the posterior urethroscope. (Cf. *Fig.* 156.)

It must be recalled that the window of the cystoscope is so placed that deformities of the bladder neck are appreciated only when they occur in the sagittal plane of the body, that is, parallel with the urethra (*Fig.* 155). Those occurring transversely require a urethroscope or a retrograde cystoscope for their recognition (*Figs.* 156, 157).

Much might be expected in this disease from retrograde cystoscopy, and it was employed in 1900 by Young, but he soon abandoned it, finding that the instrument was optically less efficient, and that the interpretation of the images was difficult. Marion and Heitz-Boyer also indicate that it is less generally useful than the ordinary cystoscope.

Inspection of the Retroprostatic Pouch.—The production of a vallecula surrounding the prostatic prominence has been described. Its development varies in different individuals and at different stages in the growth of the adenoma. Usually deepest behind, it produces a pouch at this point whose depths cannot always be displayed. The larger the gland the deeper will the pouch become. The thicker the median lobe the farther will the window be held away from the edge of the declivity, and the more difficult will it be to explore the recess. It has been shown that an acute bend in the prostatic urethra increases the depth of the fossa as seen cystoscopically (page 242). On these three factors will depend the extent to which the bladder base is concealed. In the least pronounced it can be exposed in its entirety. Where the gland is very large the whole of the trigone may disappear from view together with the ureters (*Fig.* 160). Suggestions for uncovering it to some degree have been made on page 245. Stones and growths and the mouths of diverticula, etc., may be overlooked when sheltered in this retreat.

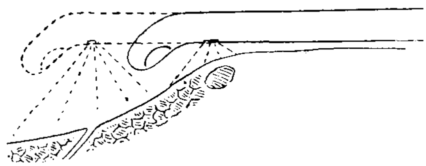


Fig. 158.—Showing that in the normal condition it is not possible to see the prostatic margin and ureter in the same field.

In the normal individual it is never possible to bring the edge of the meatus and the ureter into the same field (*Fig.* 158), but in prostatic hypertrophy the margin of the middle lobe and the ureter can be seen simultaneously save when the gland actually hides it (*Figs.* 159, 160). This observation is of much importance. It is true not only of late but also of early cases. By it, early enlargement, in which it may be difficult to satisfy oneself about the hypertrophy solely by reference to the configuration of the meatus, may invariably be identified. It should be noted, however, that it is not entirely confined to adenoma of the prostate, for other elevations of the bladder neck, such as occur, for instance, in prostatitis and prostatic carcinoma, act similarly, whilst lowering of the bladder base, as by cystocele in the female, can produce a corresponding phenomenon (*see* page 273).

It very rarely happens that we desire to catheterize the ureter in prostatic hypertrophy, but when the occasion does arise it may be found to be difficult or impossible. The beak of the cystoscope cannot be approximated to the orifice, and a greater length of catheter has to be passed into the bladder.

Renal function tests in this disease are usually carried out by the estimation of the blood-urea and by the urea-concentration test. It is, however, possible to observe the efflux of indigo-carmine at the ureteric orifices when these are not concealed, and even when hidden the flow of dye into the bladder medium can be seen and its time and volume noted.

Evidence of dilatation is sometimes observable at the ureteric orifice when back-pressure has been marked (*see also* page 325). In the presence of cystitis the dilatation of the orifice may be masked by the œdema of its lips.

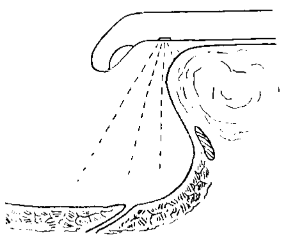


Fig. 159.—Showing that in prostatic hypertrophy it may be possible to see the prostatic margin and ureter in the same field.

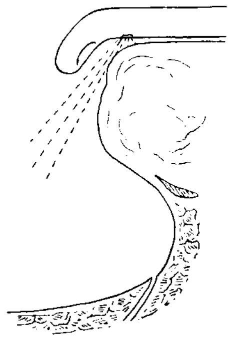


Fig. 160.—Showing that the ureter may be hidden by a very large gland.

The *size* of the prostate is difficult to estimate cystoscopically. Some indication may, however, be gained by the extent to which the trigone is hidden, and also by the difficulty experienced in approaching the fundus. The fenestra is so close to the edge of the enlarged gland that the extent of the portion lying beyond, which is foreshortened, is not appreciated.

The following method of estimating the relative sizes of the lobes is suggested by Cuthbert Wallace :—

" If the cystoscope is introduced with the window forwards, and the point noted at which the edge of the internal meatus is first seen, the distance of the anterior margin of the internal meatus from the exterior can be measured on the stem of the instrument. If this process is repeated, gradually turning the cystoscope round on its long axis, a very good picture can be obtained of the inequalities of the projecting prostate. Thus, if the urethral margin is first noted on the posterior side when the cystoscope is introduced eight inches, whilst on the opposite side it is noted at seven inches, this shows that the prostate on the former side is projecting one inch further into the bladder than on the latter."

A fair idea is usually attained by rectal examination, especially if this is undertaken whilst the cystoscope is still in position, so that the amount of tissue intervening between the shaft and the finger may be computed.

THE VESICAL COMPLICATIONS OF PROSTATIC HYPERTROPHY.

Some degree of alteration in the bladder, in addition to that which has already been described, is invariable. The earliest changes are dilatation and hypertrophy.

Dilatation.—The increased vesical capacity has already been referred to. Cystoscopically it is not evident unless the maximum quantity of bladder lotion is employed, when the walls of the viscus will appear more extensive and more remote, and wider excursions of the instrument will be demanded in order to display them.

Hypertrophy.—This is an invariable attendant. It is evidenced by trabeculation. The musculature of the inner coat becomes over-developed. The change is slight in the earlier stages, but becomes more marked as the obstruction increases. Eventually the vesical wall presents a reticulum of countless muscular bundles, intertwining inextricably, and recalling to mind the columnæ carneæ cordis (trabeculæ carneæ).

Diverticula.—Both false and true diverticula are found in prostatic enlargement. The false variety is an invariable counterpart of trabeculation and hypertrophy, small triangular or rhomboidal crypts separating the fleshy bundles and showing the effects of increased intravesical pressure. The rounded orifices of true diverticula are seen less frequently, but their incidence is greater amongst prostatics than in the general population, which suggests that they owe their evolution in part, at least, to obstruction.

Cystitis.—A certain degree of hyperæmia is present even in the uninfected bladder, and results from the irritation of retention. Tortuous vessels may be traced as they run amongst and across the trabeculæ, whilst the mucosa is pinker and somewhat granular. Many cases, when first seen, are infected. On cystoscopy every variety of cystitis is found. A 'spontaneous' (hæmatogenous) *B. coli* infection is discovered with fair frequency, and when, at some previous time, unclean instrumentation has been resorted to, the havoc which the urea-splitting group of organisms is capable of may be illustrated. This may vary from a mild blush to the most fœtid of ammoniacal infections with thickened and velvety mucosa and coarse purulent membranes.

Stone.—Stone formation is observed, and may be of the primary, but is usually of the secondary, type. The calculus occupies the retro-prostatic pouch, and, as before remarked, may be concealed behind the median lobe. Retention and sepsis are the etiological factors. The stone may be single, but occasionally calculi are to be seen in great numbers, as in the instance depicted in *Plate XI* E, page 196, which also demonstrates the manner in which the gland hides objects in the pouch. Occasionally a stone forms in a diverticulum (page 138).

When a calculus is discovered radiographically in an elderly man and lithotrity is proposed, a cystoscopic examination should precede the operation in order to exclude prostatic hypertrophy, the supra-pubic route being preferable in the presence of the latter.

Growths of the Bladder.—Vesical tumours are not uncommon in conjunction with adenoma of the prostate. They may be simple or malignant. They may occur fortuitously, but an epithelioma may be engrafted on a patch of leukoplakia resulting from prolonged cystitis.

MISCELLANEOUS DISEASES OF THE PROSTATE.

Chronic Prostatitis.—Cystoscopy is not much used in this disease. In the presence of a urethritis it is actually contra-indicated. The pathological changes affect the posterior portion of the neck, which becomes hyperæmic and may be œdematous. It is slightly elevated in all cases (Young) and may simulate early hypertrophy. The over-lying mucosa may be granular in appearance. Obstruction to urination is uncommon.

Tuberculous Prostatitis.—This disease should be diagnosed by rectal palpation and by concomitant disease in other parts of the genito-urinary tract. Cystoscopy should be avoided when the diagnosis has been made. In the early stages the appearances resemble those seen in chronic prostatitis. Later tuberculous lesions of the bladder may be found if that organ is also implicated. When the trouble is primary in the male genital tract the lesions are situated over the anterior region. Rupture of tuberculous abscesses into the bladder from the prostate and vesicles with the formation of crateriform sinuses has been described (*see also* Chapter XIV).

Cancer of the Prostate.—Prostatic carcinoma is another disease in which cystoscopy should be avoided as a general rule, though occasionally it is justifiable where rectal palpation has proved inconclusive. The latter will, however, generally be suggestive by the time that the disease is sufficiently advanced to present pathognomonic evidence in the bladder.

The first observable changes are located in the anterior portion of the trigone, behind the sphincter, and consist of irregular puckerings of the mucosa, occasionally associated with a certain degree of œdema. They are probably attributable to contraction at the site of the growth, and may be compared with the puckering of the skin seen over a mammary scirrhus. This change is atrophic rather than hypertrophic, and, in fact, elevation of the vesical neck is rare at this stage, though it may occur in minor degree. Later the growth invades the bladder, and irregular nodules of neoplasm may be observed. Evidence of obstruction may be noted in residual urine, dilatation, and trabeculation. Harsh resistance to the cystoscope when traversing the deep urethra, and hæmorrhage on instrumentation, are characteristic signs.

In many cases the carcinoma arises deep in an area of prostatic hypertrophy. The only cystoscopic signs are then those associated with simple enlargement, so that whilst positive evidence of prostatic carcinoma is valuable, the cystoscopic appearances which characterize simple prostatic hypertrophy do not necessarily exclude prostatic carcinoma.

ENDOSCOPIC PROSTATIC SURGERY.

" There is no new thing under the sun." Guthrie, over one hundred years ago, attempted the perurethral treatment of prostatism by means of a concealed knife, and in 1874, Bottini produced a galvano-cautery blade hidden in a catheter, which, when heated, destroyed the tissue of the bladder neck.

PROSTATIC PUNCHES.

Modern perurethral therapy, however, derives from the Young punch (1908), a simple instrument consisting of a metal catheter, having near its vesical end a large fenestra. When in position the prostatic prominence engages in this window, and a knife in the form of a sleeve with a sharpened edge punches away the portion of tissue caught in the window. The original instrument worked by indirect illumination, but to it other workers duly added a lamp and a telescope. In 1920 Caulk substituted an electro-cautery for the cold blade, whilst later Kenneth Walker introduced his diathermy punch. In this latter instrument the margin of the window becomes a diathermy electrode and renders ischæmic the engaged tissue, which is then removed by a tubular punch similar to that of Young. The insulation of Walker's diathermy punch is by a sheath of bakelite, an innovation in insulation which has since been copied in other instruments, including the McCarthy electrotome. Many modifications of these instruments exist, but all suffer from the disadvantage that severe sepsis is liable to follow their use. The principle which they share in common is that of coagulation by diathermy followed by removal of the ischæmic mass with a punch. As they are somewhat slow in action, repeated treatments become necessary.

The Braasch-Bumpus punch (*Fig.* 161) enjoys some popularity still in this country and is in regular employment at the Mayo Clinic. An examination of the illustration will show that it consists of a cystoscope, on the convex side of which a window is cut. The area

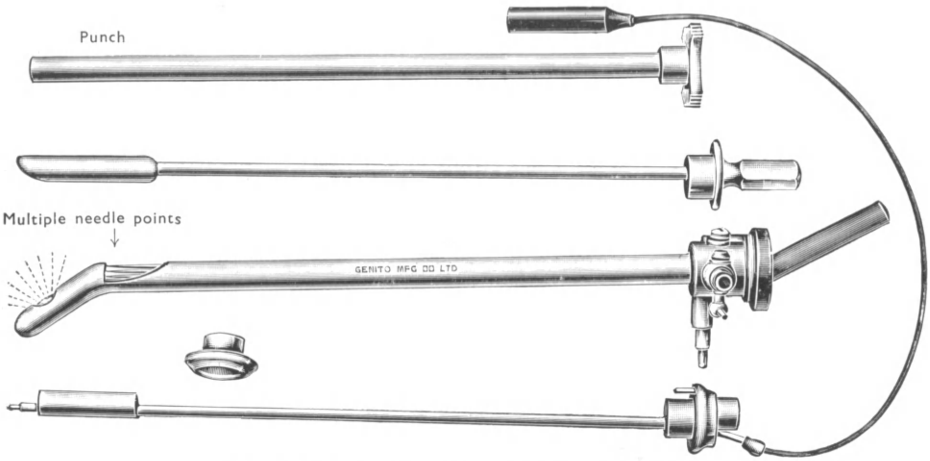


Fig. 161.—The Braasch-Bumpus prostatic punch.

to be treated is made to occupy this window, and it is pierced and coagulated by an electrode having multiple needle points. A punch then removes the coagulum.

INSTRUMENTS USING THE HIGH-FREQUENCY CUTTING CURRENT.

On its discovery the high-frequency cutting current was early applied to the treatment of bladder-neck diseases, although there was at first some difficulty in making the current effective under water. The most popular instrument at the present time for use with this current is that designed by McCarthy in 1931, with which slices of tissue can be removed by a wire loop electrode, under vision. This instrument, and the technique employed in using it, will be described in detail, for it presents several important advantages over the older punches, notably in the rapidity of the treatment and the relative immunity from sepsis. It should be realized, however, that modern endoscopic prostatic surgery continues to be developed along two similar but independent lines—the original, using coagulation and the punch, and the more recent, employing the cutting current.

The McCarthy Electrotome (*Fig.* 162).—This consists of a sheath, an obturator, lighting arrangements, a foroblique telescope, an activated and mobile loop for electric cutting, and irrigating parts.

The Sheath.—This is a tube 8½ in. long, and its size corresponds to 28 on the French catheter scale. It is sloped away at the bladder end in order that the loop may have access to the prostatic lobes. At the external end is a short metal tubular attachment with a coned chamber to receive the loop carrier. This is fitted on each side with

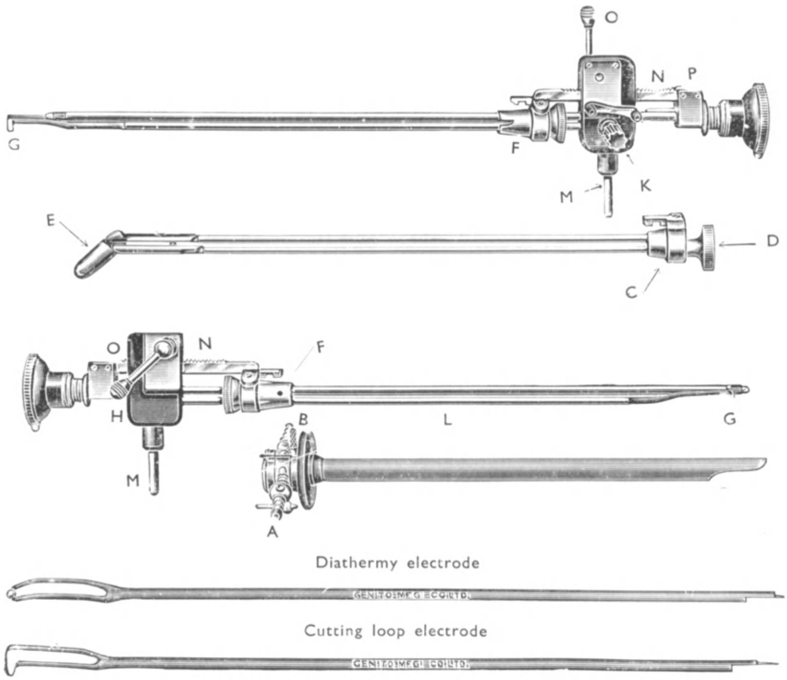


Fig. 162.—McCarthy's prostatic electrotome.

a stopcock. The one on the surgeon's right hand (A) connects with an irrigator, that on his left hand is an outlet. A bayonet lock (B) is provided to secure the loop-carrier (or obturator) in position. The sheath is made of bakelite, an insulating and heat-resisting material.

The Obturator.—At the outer end of the obturator is a cone (C) shaped to fit the coned chamber of the sheath. The sheath and obturator can be locked together by the bayonet catch (B) on the sheath. A milled screw (D) operates the hinged beak (E) at the vesical extremity. This beak when raised aids the introduction of the instrument.

The Foroblique Telescope.—This resembles a direct vision telescope. In front of the objective is placed a deviating prism. The system (*Fig.* 163) consists of eighteen lenses and one prism. As the prism is a deflecting prism an odd number of inversions is required to obtain an erect image. This is different from the cystoscope, where

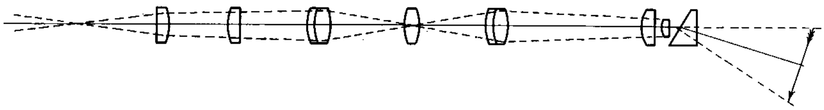


Fig. 163.—The lens system (simplified) of the foroblique telescope.

an even number of inversions is needed behind the right-angled prism (*see* page 19). The telescope is housed in the loop-carrier, into which it is secured by friction.

The Loop-carrier.—The cone (F) on the loop-carrier is received into the cone chamber of the sheath, and is fixed in position by the locking device already noticed. Through this cone pass :—

1. The telescope, carrying with it the parts concerned in lighting. The whole is removable as a unit.

2. The electrode (G), likewise a removable unit. It consists of a long shaft which passes through a guide tube and the cone to reach the electrode carrier (H), into which its flute-shaped tip is received. It is fixed by the screw (K). On loosening this screw the electrode is easily withdrawn, and this is frequently necessary, either when it is damaged to replace it by a new electrode, or to insert the diathermy ball electrode for purposes of hæmostasis. At the vesical end the electrode divides into two arms which carry the loop. The arms are made of fine quartz tubing, and these and the loop which they carry are frail and must be treated with great gentleness. A break in the quartz tubing may not be apparent on superficial examination because the tubes are covered with silk tissue to prevent splintering. Close inspection is necessary to detect such a break. A broken electrode is quite useless and must be returned to the makers for repair.

3. The water inlet tube (L), the external end of which lies opposite the inlet cock (A) on the sheath.

The electrode carrier (H) is a block of bakelite which connects below by a large plug (M) with the cable from the endothermy apparatus. This electrode carrier is a mobile unit working on a rack (N), the latter being firmly screwed to the cone. It is operated by a pinion and handle (O) and in its movement carries with it the loop electrode which we have seen to be inserted into it. The total excursion of the loop is one inch. An extension of the rack (P) supports the proximal end of the telescope.

Selection of Cases.—Great difference of opinion prevails on the subject of the selection of cases, for a few surgeons perform perurethral resection every time, whilst others adhere faithfully to the older operation. Yet, greatly though men's choices differ, each procedure appears to have a place, and all urological surgeons should attempt to master both techniques. The writer chooses the perurethral route in about 20 per cent of his patients, and, though preferring the open operation for routine work, he would not willingly forgo the advantages of resection in selected cases. For a straightforward prostate he feels happier with the open technique because the results are more assured.

It is generally conceded that large prostates, especially the large intravesical type, should be dealt with by the open method because of the increased difficulties—the greater mass to be removed, and the greater vascularity which is so often observed in large adenomata. But, as shown on page 250, considerable difficulty attends the accurate determination of size, for its cystoscopic recognition is notoriously fallacious. It is by no means a unique experience for an experienced cystoscopist to open a bladder which he has carefully investigated only to find that his impression of the size of the prostate was completely wrong, and, though the estimation of the length of the urethra by urethroscopy is more dependable, it cannot be relied upon implicitly. Again, the rectal examination is likewise deceptive, a trifling enlargement as felt per rectum being often associated with a large intravesical prominence. The identification, therefore, of suitably sized prostates presents real difficulties.

Conversely, the small prostate should be suitable for perurethral resection, and with some operators it is becoming standard practice to do a prophylactic resection on the first appearance of prostatic symptoms.

Fibrous contractions of the vesical neck and median bars give admirable results in a large proportion of cases. The operation is easier than it is in adenomatous disease, less tissue needs to be excised, and bleeding is less troublesome. Though it fails to cure the condition in a few cases it is definitely the operation of choice in this group.

Opinion is not quite unanimous regarding the desirability of using perurethral resection as a palliative operation in cancer of the prostate, though the majority of surgeons are in favour. Without doubt the malignant tissue cuts well, there is a striking absence of hæmorrhage, a complete, even if temporary, relief of obstruction is obtained, and a suprapubic fistula is thus avoided. To set against these advantages is a fair body of evidence to prove that the disease is disseminated by the treatment, that distant metastases occur earlier, and presumably life is somewhat shorter than it might have been had a cystostomy been done. The writer holds the view that the advantages of resection for carcinoma of the prostate outweigh its disadvantages, but that its use should be strictly limited to cases where there is real obstruction to micturition, and that the patient should be encouraged to carry on so long as he is reasonably comfortable and there is but little residual urine.

Sepsis of any severity is a definite contra-indication to the perurethral operation, which is very liable to add fuel to the fire (*see also* page 267).

Renal insufficiency is no reason for preferring resection. From the point of view of the kidney the two procedures are equally trying. Function must be improved by identical means and must stand equally high whichever route is selected.

What about the rather feeble patient on whom one hesitates to do an open operation ? Is he suitable for resection ? The matter rests on the knees of the gods. If success attends at all, it probably attends in generous measure. If, on the other hand, one meets with hæmorrhage, clot retention, or sepsis, the strain on the patient's vitality is just as great as that of the major operation. It is a gambler's throw, with the odds perhaps on the resection. One factor, however, is definitely favourable to the perurethral route when dealing with enfeebled subjects—a low spinal anæsthetic, one affecting only the sacral nerves, is adequate and is better borne than the higher level anæsthesias required for the open operation. But the patient must not be led to think that the operation is a minor one and devoid of risk.

Two cases may be cited to illustrate a type of work in which the electrotome plays a valuable rôle.

Case 1.—A man at the age of 69 developed torsion of an inguinal testis, and the testis was removed. Retention of urine occurred as a post-operative complication and, as it persisted, was rectified by prostatic resection. Convalescence from this second operation was a matter of but a few days.

Case 2.—A patient, aged 65, was referred to me from the hospital of a distant town. He had an advanced mediastinal growth, and for some weeks had also been confined to bed with an inlying catheter. The removal of a few strips from his prostatic urethra restored the function of micturition, and the operation, performed under low spinal anæsthesia, was without ill-effect on his general condition.

In cases such as these the procedure is invaluable.

Pre-operative Treatment.—The pre-operative examination of patients who are to be submitted to endoscopic resection of the prostate differs but little from that employed when the open operation is contemplated. The cardiovascular and respiratory systems are carefully examined, the optic discs and blood-pressure not being overlooked. Renal function tests are routinely performed, and when there is residual urine a period of decompression precedes the operation, just exactly as it does a suprapubic prostatectomy. The condition which is under treatment is not so much the prostate as the obstruction and its effects. It is well known that the mortality following the first stage of a two-stage suprapubic operation is higher than that of the second. The first stages and the accompanying mortality are identical for the perurethral and for the open operation. This feature appears to be remediable only by earlier application for treatment.

Bladder drainage is usually by an inlying catheter, but for the more severe or protracted cases a suprapubic fistula is good practice. The presence of a fistula modifies the subsequent operation very little. McCarthy recommends that " one should introduce suprapubically a fairly large Pezzer catheter which, prior to operation, is gently but firmly lifted, pulling the bladder wall with it. A Kelly clamp is then applied to the taut catheter, close to the abdominal wall. This step effectively seals the bladder opening. Otherwise the operative steps are the same."

Though the foroblique telescope is an excellent instrument for the study of the bladder neck, it is but a poor implement for investigational work within the bladder. Partly for this reason, and partly because time is saved at the actual operation, a pre-operative study of the bladder neck by cystoscopy and urethroscopy is made with a view to determining the configuration of the prostatic lobes, and the length of the supramontanal urethra. It may also reveal various complications—stone, diverticula, etc.—in the bladder which might decide the surgeon in favour of the open operation.

Technique.—For endoscopic resection of the prostate a quite low spinal anæsthesia is all that is necessary. One of the heavy solutions of novocain is given, with the patient sitting up to encourage the anæsthetic to sink to the lower end of the spinal theca. Though only the sacral nerves are affected, the anæsthesia is excellent and there is a minimum of shock or physical disturbance.

The patient occupies the usual cystoscopic position, and his sacrum rests on a large indifferent electrode. The surgeon takes up his position between the thighs. Some men prefer to stand, others to sit. The former escape the considerable spilling of bladder lotion which is almost inevitable in this procedure, but the standing position is uncomfortable and awkward, and would appear to be impossible to men above medium height. In comparison with cystoscopy this operation calls for much mobility on the part of the surgeon, especially when the loop is being placed, and this is a fact favouring the standing position, always provided that the table can be raised suitably. The sitting position makes it necessary to protect oneself with waterproof leggings, of which one of the types made for the motor cyclist may be recommended. Rubber gloves are worn for their aseptic value. They were previously stated to offer protection against high-frequency discharges when the current is running. No such protection, however, is needed, and the minute displacement current is not perceived by the surgeon if the instrument is firmly held.*

The sheath is loaded with its obturator, and the elbowed end of the latter is lifted by means of the screw. The large size of the instrument makes for difficulty in introduction, and this is particularly noticeable at the entrance to the urethra, which may require to be freely slit up. The meatus should be incised rather than forcibly dilated, as incision leads to less eventual harm. Once the sheath is in the bladder, the obturator is withdrawn, its beak being first lowered, and the bladder contents flow out through the lumen. The inlet and outlet tubes are next coupled to the appropriate fittings. The outlet tube overhangs a bucket. The inlet tube connects up with a large reservoir containing sterile water. It is very important that no antiseptics should be added to this lotion because they are electric conductors, and, by carrying off the current, interfere with the cutting. Irrigation of the bladder follows, a thumb being placed over the end of the sheath during the inflow of fluids. When a reasonable amount is in the bladder the inlet is closed and the thumb is removed from the terminal opening. As soon as the wash returns clear, irrigation is discontinued.

Before introducing the loop-carrier the shunt setting for the lamp is determined. Its light must be quite bright if the illumination is to be satisfactory, but it is remarkable how these little lamps stand up to bright lighting. It must be seen also that the electrode itself makes good electric contacts and is securely screwed up. Rotate the lever (O) so that the loop is in the fully withdrawn position. The loop-carrier is now gently passed down the sheath and locked by the bayonet catch, and the lighting and endothermy leads are connected. The setting necessary for the cutting current on the machine in use should be known beforehand. It is a good thing to ask the makers about this, or to experiment on a piece of raw meat under water.

The left hand holds the extra-urethral end of the resectoscope, and the writer is accustomed to grasp it in such a manner that the index finger can comfortably control the bayonet catch, and the thumb, the inlet and outlet cocks. Movements of the left hand itself are thus obviated. It is a good plan to rest the left elbow on

* Personal communication from Mr. Schranz, who has kindly read through this section and offered helpful criticism.

some fixed support such as the end of the table or the knee. The right hand is free to manage the lever which moves the loop.

As the inspection of the bladder begins the inlet is opened, and lotion passes into the bladder, displacing air from the interior of the sheath. Bubbles of air may hang about the intravesical end of the instrument, and, acting as tiny mirrors and lenses, interfere with visibility. This small annoyance is apt to recur at intervals throughout the operation. It generally rectifies itself quickly, the air-bubbles being washed away by the inflow, but their liberation may be assisted by rotating the instrument so that its under surface, where the air tends to be held, faces sideways, and perhaps by giving the instrument a tap with the finger. Care must be taken whilst making these preparations not to overdistend the bladder with the running water.

The prism is still lying within the sheath, the walls of which fill the visual field. It may now be advanced about half of its excursion, when the sheath will no longer appear. This done, it will probably be found that the foroblique telescope visualizes the bladder base about the level of the interureteric bar, that part first coming into view. It is somewhat remote, and as neither magnification nor illumination is good, its details are indistinct.* Keeping the eye glued to the optic, gradually withdraw the whole instrument and observe that, somewhat suddenly, the prostatic margin appears in view, as a highly illuminated streak crossing the field. It is of the greatest importance to identify the prostatic margin with absolute certainty. Until the surgeon is sure of this landmark there must be no cutting, as not a few fatalities have resulted from holes being cut in the floor of the bladder, some of which have even involved the rectum. Two methods help to confirm the fact that the object lying in the field of view is indeed the prostatic margin :—

1. By rotating the instrument it can be followed as a more or less continuous ring keeping close contact with the prism, its shape, as seen through this instrument, conforming roughly to that of the prostate as already seen through the right-angled prism of the examination cystoscope (compare *Figs.* 155, 156, and 163).

2. When the resectoscope is further withdrawn, however little, it becomes evident that its end now lies in the tubular posterior urethra.

Rotating the instrument slowly, examine the contour of the lower half of the meatal circle, and select a point to start work. The point chosen is usually a low-lying or central one; any such spot where illumination is easy and the view clear may be adopted. In the

* If the eyepiece is lifted, both these features improve materially and the bladder base can be examined.

existing position of the loop-carrier the wire will probably cross the field of view about its middle. Holding the sheath perfectly steady, advance the loop by means of the lever to its full extent, meantime watching it recede into the distance. When the working conditions are poor, as in the later stages of the operation, it may be quite difficult to see the loop in this position.

The next step is to sink the wire behind the prostatic margin in preparation for making the cut (*Fig.* 164). The whole instrument is first withdrawn bodily till the majority of the field visualizes only prostatic urethra, and the meatal rim is about to disappear from view. This movement is a very important one. By it the loop is drawn up against the bladder neck. If the loop lies at some distance from the neck the first part of the cut will be fruitless. It will be wasted on the bladder spaces, no strip, or only an insignificant one, being obtained. Fortunately the retroprostatic pouch recedes steeply from the meatus, and in the event of the faulty placing of the loop under discussion, the bladder wall still escapes injury. It will, however, easily be appreciated that some distension of the bladder is a necessary safeguard against its being burned, and that therefore the wire should never be activated until there are 5 or 6 oz. of fluid in that viscus.

Suppose, on the other hand, that the loop is pulled up too tightly or too roughly against the prostatic lobe before the current is thrown in, the wire itself, or the quartz tubes which support it, will then very likely break. When the wire is activated it is a different matter. It then becomes a powerful weapon, fully capable of looking after itself and of ploughing its way through the obstructing prostate. It will be seen that the success of the whole operation may depend on the way in which this small movement is carried out. The correctness of the loop's position can in part be determined by vision, but it may be confirmed by moving the loop lever gently forwards, when the wire will be felt to impinge on the prostatic lobe. Once the loop is satisfactorily placed it may, by carrying the optical end of the instrument in the reverse direction, be depressed behind the prostatic margin, out of sight.

Now close the inlet cock, leaving the outlet open. Grasping the lever between the index finger and thumb of the right hand, and holding the instrument very still, throw in the current by means of the foot switch. Its swirl will be seen. The loop is immediately set in motion by the rotation of the lever, but it should progress quite slowly, taking between fifteen and twenty seconds to complete a cut. Experience will soon tell the best speed to move the loop. Too slow a speed causes unnecessary charring ; one which is too quick leaves the vessels unsealed and leads to subsequent difficulty from

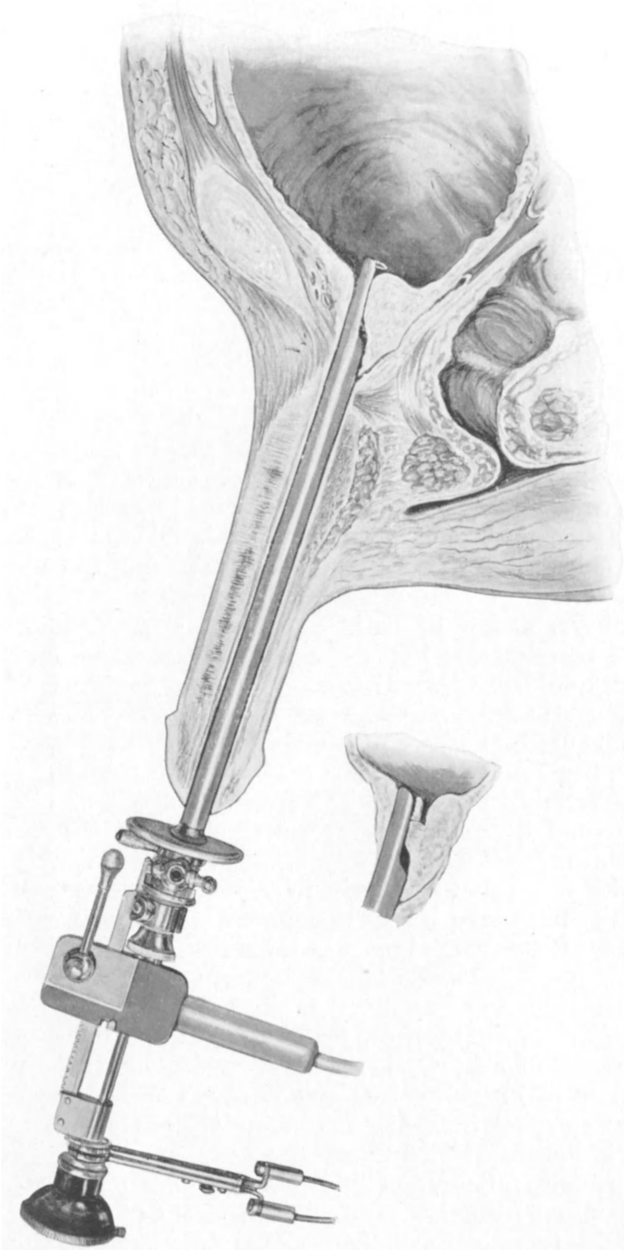


Fig. 164.—Resectoscope in position ready to remove a slice from middle lobe. *Inset*—Cutting in progress.

hæmorrhage. Sometime when such is available, it makes an instructive experiment to test the ease of cutting and the current required on a prostate which has been acquired suprapubically. During the cut the actual loop itself is hidden from view below the surface and is invisible to the cystoscopist, but at the edges of the slice the emerging wire makes a bright, spluttering flame.

The cut finished, the bayonet catch is unlocked and the loop-carrier is withdrawn. Usually the slice will be found adhering to the wire. It is most gently removed from this vulnerable structure by means of dissecting forceps. If the slice fails to come out with the loop it may be washed out by the rush of fluid which follows the withdrawal of the carrier. This fluid should be caught in a specimen glass by an assistant, and the piece of tissue is thus recovered and kept. Should the portion of prostate fail to present in either of these ways, (1) It may on replacing the telescope be seen sticking in the urethra ; it is then quite likely to get entangled in the wire and can be seen there; it will possibly come out on the loop if again withdrawn. (2) The slice may have fallen back into the bladder; this is the more likely to happen if the inflow has inadvertently been kept running whilst the cut was in progress. (3) No strip may have been cut. For this there are two main causes—faulty positioning of the loop as described above, and a break in some part of the wiring circuit, generally in the electrode itself.

The length of a slice is variable, anything up to the total distance through which the loop moves, namely, one inch. The first slice is covered on its urethral aspect with mucosa, and its cut surface, which is shaped to the form of the loop, is grey in colour from the charring, and is transversely ridged from the uneven progress of the electric knife. A second slice cut from any position where a previous cut has been made is charred on each surface, and from the double contact with the wire is concavo-convex in transverse section. Between the two charred surfaces of such a specimen there is uninjured tissue which has not felt the effects of the heat, and is thus suitable for microscopical examination.

The slice having been recovered, the loop-carrier is returned to the sheath for a repetition of the operation, but first the surgeon will examine the line of his last effort. It is usually clearly visible as a shallow trough of greyish colour and is transversely ribbed by the action of the cutting wire. At one or more places may be seen cone-shaped jets of blood springing from a small point. The bleeding often appears to be quite furious, and pulsation may sometimes be observed, but is more usually absent. The surgeon may decide to seal these spots immediately with the diathermy electrode, but as a rule leaves them for a time, whilst further strips are removed.

The position of the cuts is regulated by that of the main enlargement, and the number taken away by the size of the prostate, i.e., by the depth of tissue which the surgeon judges he has to work upon. Usually the middle lobe is the first to be attacked, and when a sufficiency of this has come away the operator turns his attention to the lateral prominences. As soon as he thinks he is reaching the danger zone he will stop. One of the anxieties of this operation arises from the impossibility of knowing just how much tissue is left between the new channel and the prostatic sheath. An attempt may be made to compute the size of the prostate beforehand, although this is but an approximation (*see* pages 250 and 257), and one still can only guess when the limit is being approached. The principal attack is on the most inferior section of the meatal circle. One rarely cuts above the the equatorial line, and indeed the prostate becomes so thin anteriorly that the possibility of perforation into the space of Retzius makes this an area to be avoided. Generally, then, the operation is limited to the lowest third of the circle. A good gutter in this situation will be found to do all that is required, and it is here that the greatest thickness of tissue exists, and therefore the biggest safety margin. The whole slice comes from the supramontanal region. That structure must on no account be damaged.

McCarthy recommends that the middle lobe should be first approached, because if anything happens to interfere with the subsequent progress of the resection " it may at this point be terminated with resultant symptomatic relief ". He also points out that sometimes when the middle lobe has been removed the lateral lobes move inwards towards the centre of the endoscopic picture and their demand for treatment is accentuated.

The sections removed are laid out on a piece of lint in the bottom of a kidney bowl. Having removed a certain number, the surgeon looks at them with a view to deciding their aggregate size. A good way is to gather them side by side between the fingers. Estimate thus the bore of the new channel, and, allowing for inward pressure from remaining parts, consider whether an adequate passage has been provided.

At the end of the operation the bladder is irrigated to empty it of blood and clot. The diathermy electrode (*Fig.* 162, page 255) is meanwhile being fitted to the carrier, and any bleeding points which can be seen are now touched under vision. Time spent in sealing the bleeding points will be amply rewarded by relative freedom from post-operative hæmorrhage. The surgeon must be prepared if necessary to spend as much time in controlling hæmorrhage as on the operation itself. Complete hæmostasis and a clear wash is the ideal, but is not always achieved. The correct current for this purpose must be learned. Too strong a current will puncture a vessel and prolong hæmorrhage, even making it come from a deeper and more inaccessible plane. Again, too severe and too deep coagulation is dangerous, in that it may produce a large slough which takes time to separate and meanwhile causes much sepsis. It may even lead to late extravasation of urine or secondary hæmorrhage. A properly regulated coagulating current produces a slow blanching of the bleeding point with an almost entire absence of spluttering.

Finally, a catheter of large size (24 French) with a whistle-shaped terminal opening is placed in the urethra and is fixed in position with strapping applied round the penis. The catheter is given a wash with lotion to make certain that it lies properly and that its lumen is clear.

After-treatment.—Frequent irrigation through the catheter helps to ensure that the lumen is kept free from clots, or at least gives prompt warning of catheter blockage, which is more easily overcome at this stage and does less harm if caught early. The catheter is retained for three days, but in cases where only a small amount of tissue has been removed, as, for instance, in the excision of a median bar, it may be dispensed with after twenty-four hours. Urination is usually immediately successful, though there may be some hesitation at first. A poor stream and even some residual urine may sometimes result from œdema of the vesical neck, but when this is the cause it quite soon rectifies itself, though the full benefit of the operation may be delayed occasionally for a few months.

If in the pre-operative treatment a cystostomy opening has been made, it should be retained in the post-operative period until the catheter has been removed. Then, by clamping the cystostomy tube, it becomes possible to prove that the bladder function will be satisfactorily restored. Should there be any doubt about this, the tube may be kept for a further length of time, or, if necessary, until a repeat session is judged to be called for.

Repeat sessions are not very common. They may be required if the excised mass has been insufficient. Sometimes this is due to the operation having been cut short by technical difficulties such as hæmorrhage. Everidge considers that at least a month should elapse before the second operation is embarked upon, thus giving time for the urethral convalescence to become well advanced. Alcock is moving in the direction of designedly doing the operation in two sittings, and claims that the second resection is always easier to do than the first, and that tissue can be removed in larger quantities and more rapidly.

Complications.—The principal complications are hæmorrhage, sepsis, epididymo-orchitis, extravasation of urine, uræmia, and stricture.

Hæmorrhage.—Primary hæmorrhage is virtually a continuation of the bleeding at operation which has refused to be satisfactorily controlled. In addition to the resulting shock it plays an important part through clot retention. Loughnane, as a preventive of clot retention, recommends the continuous irrigation of the bladder through a two-way catheter with a 3 per cent solution of sodium citrate, starting from the time of leaving the theatre. This, I believe, is very effectual, but in criticism it may be argued that it defeats nature's own method of hæmostasis. Clot retention may be rectified by lavage, by a change of catheter, or may require the use of a Bigelow's evacuator. A better method than using the rubber aspirator is to pass the large, thin-walled catheter belonging to that instrument and to apply suction by an ordinary bladder syringe. The suction thus obtained is under better control and is more steady and gentle than is that obtained with the evacuator. It is a valuable means of overcoming clot retention in this, as also in hæmorrhage from other causes. Once emptied of clots, the bladder is irrigated with hot lotion (115° F.) and an inlying catheter is again inserted.

Should hæmorrhage and clotting prove obdurate, the bladder must be opened and the clots evacuated. Hæmorrhage may then be controlled by a Pilcher bag or by packing with gauze. On two occasions in the writer's experience a suprapubic opening, originally employed for the treatment of deficient renal function, has proved serviceable for the escape of clots and the treatment of bleeding. Some writers have indeed spoken favourably of suprapubic drainage prior to endoscopic resection, as a routine measure.

Secondary hæmorrhage occurs in about 3 per cent of cases and may prove a very serious complication. If the usual urethral evacuation is not quickly successful the bladder must be promptly opened.

Clot retention is an important cause of death. In Doyle and Feggetter's statistics it accounted for one-third of the deaths recorded, and excessive hæmorrhage was noticed by them in 21 cases out of a series of 156 resections.

Sepsis.—This is present in greater or less degree in all cases, and in some it assumes very great importance. It is well known to be virtually impossible to avoid some measure of sepsis when bladder drainage is instituted. The pre-operative period is therefore responsible for some degree of infection, and after the operation this thrives on the charred areas left by the burn. In the presence of severe sepsis resection is inadvisable. Some sepsis being inevitable, it must be treated from the beginning by local and general antiseptics. Occasionally a fulminating or gangrenous cystitis is observed. Extension of infection to the kidney is not uncommon.

Epididymitis.—Many surgeons appear to have suffered severely from this complication, one observing it in nearly 50 per cent of his cases. The present writer has been almost free from this trouble and thinks that this may be due to care in avoiding injury to the verumontanum. In those patients who do develop epididymitis it usually makes its appearance shortly after the catheter has been removed, but it may delay its onset till some time following the patient's discharge from the hospital. If a series of cases were giving trouble with epididymitis it would be rational to counter it by section of the vas before, or at the time of, operation, a procedure which has become routine practice in suprapubic prostatectomy.

Extravasation of Urine.—Extravasation following prostatic resection is a very fatal accident. It may take place immediately after the operation, when it is without doubt due to perforation of the bladder by the electric knife. Not a few cases are due to a direct cut through the bladder base, the landmarks having been mistaken. Some of these have involved the rectum. The importance of avoiding the anterior commisure has already been pointed out (page 265). Less commonly extravasation makes its appearance some time after the operation and is then probably due to sloughing of coagulated tissue, the section having been carried too near to the exterior of the gland. As soon as urinary extravasation is discovered, open operation offers the only hope of successful treatment.

Uræmia.—This is met with in a few cases. It may occur early as a reflex arising from instrumentation, or later, when ascending renal infection is the probable cause.

Stricture.—This is a late complication and may affect the vesical end of the tube, the actual site of the cutting. Too deep hæmostatic coagulation is thought by Doyle and Feggetter to be possibly responsible. Alternatively stricture formation may involve the anterior urethra, when the trauma caused by the large size of the sheath must be held accountable. The incised external meatus sometimes becomes strictured.

Results.—When the results are good they may be brilliant. The convalescence is short and function is completely restored. In the best cases there is practically no shock and little or no post-operative disturbance. To regard endoscopic resection, however, as a minor operation, and especially to give patients that idea, is unjustifiable, for the procedure carries with it a very definite mortality. This is a sphere in which the unbridled enthusiasm of its advocates has run riot in even greater measure than in some other new provinces. Many of the excessive claims advanced stand self-condemned and will be immediately discounted by such as have had some practical experience. The type of risk from which prostatics are drawn, many of them old, worn-out men with no resistance and perhaps suffering from independent disease would show a mortality from the most trivial surgical interference. Such a statement would not be necessary had not too much been claimed for the operation, and it is made without the least intention of disparaging what is undoubtedly a valuable addition to our resources. Moreover, the procedure is still in its infancy, and it may be confidently expected that there will be further advance on both the instrumental and technical sides.

Perhaps the most reliable and balanced paper dealing with results is that by Doyle and Feggetter. It is compiled from a study of the work at the All Saints Hospital, London, where this form of treatment for prostatic hypertrophy is much favoured. These writers found that out of 123 operations, 62 patients might be regarded as good results, showing improvement of the general health, an absence of difficulty of micturition, scalding, frequency, or pyuria. Cystoscopically these patients had no cystitis, and urethroscopically a good shelving floor. In a second group 19 patients were placed " who have been greatly improved by the operation, but in whom all the above requirements have not been fulfilled." In 9 further cases the symptoms were not alleviated. Fifteen died after operation, 6 died within three years, and 12 were untraced. In 156 cases there were 18 deaths (11 per cent). Clot retention was responsible for 6, uræmia for 3, pyelonephritis for 2, extraperitoneal rupture of the bladder for 2, and the remainder were due to pneumonia, embolism, etc.

One fact appears in all published figures—that the results of the operator improve materially as he gains experience. The instrument is an exceptionally dangerous one in unpractised hands, and the operation—one of the most difficult in cystoscopic surgery—is essentially one for the specialist. Even those who are experienced in ordinary cystoscopy and urethroscopy would be well advised, when entering this field, to select for their early ventures the simplest kind of enlargement, and indeed in this country most surgeons tend to limit themselves more and more to this variety.

It is still too early to speak dogmatically regarding the permanence of the results, for the first cases were treated only three or four years ago, but there is good reason to expect a permanent symptomatic cure. Caulk has made a statement which has received much publicity, to the effect that after the removal of a portion of the prostate the remainder of the organ tends to shrink. There appears to be but little scientific basis for this belief, and it has been challenged by Swift Joly ; but how far it is true will be shown in due course, as will also another important question, whether fibrosis will follow and, if so, what its effect will be.

CHAPTER XVIII

ALTERATIONS IN THE BLADDER RESULTING FROM PHYSIOLOGICAL AND PATHOLOGICAL CHANGES IN THE UTERUS.

ALTERATIONS DUE TO PREGNANCY.

It is not uncommon to be called upon to perform cystoscopy during pregnancy, the additional strain thrown on the kidney and the increased vascularity of the bladder being instrumental in bringing to light some latent form of urinary trouble. Alterations of two kinds are found in the bladder: (1) *Mechanical*; (2) *Vascular.*

1. **Mechanical Effects.**—These vary with the stage of the pregnancy. At about the end of the first month the normal uterine salient

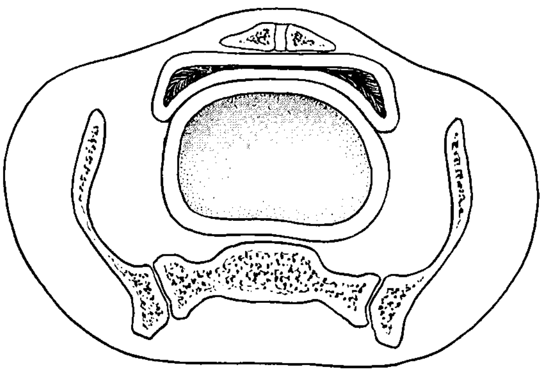


Fig. 165.—Distortion of the bladder by pregnant uterus near term.

commences to be increased in extent. This gets more and more marked until about the fourth month, when the uterus rises out of the pelvis and becomes an abdominal organ. A slight diminution of the antero-posterior measurement of the bladder remains, but does not impede cystoscopy. In the last month of pregnancy the descent of the presenting part causes renewed pressure on the bladder. The rounded anterior surface of the uterus bulges in the posterior wall of the bladder, so that the latter becomes convex instead of concave (*Fig.* 165). A horizontal section of the organ is now crescentic in outline, the median antero-posterior measurements being much diminished, whilst the lateral horns become more emphasized. The ureteric orifices open on the segment of the bladder which now lies approximately in the sagittal plane; they face directly outwards, and their identification may be a matter of some difficulty.

2. **Vascular Phenomena.**—The bladder shares in the pelvic hyperæmia of pregnancy. All types of vessels are dilated, so that the mucosa shows pronounced vascularity. The veins become greatly dilated, tortuous, and even varicose. They occasionally rupture, giving rise to profuse hæmaturia. This hyperæmia, more marked in the trigone and base, is observable over the whole of the mucosa. The plicated appearance of the vesical neck, which was noted as being normal in the female, is increased in pregnancy, the furrows and ridges becoming deeper and longer.

Cystoscopy does not become much more difficult owing to the pregnant state until the last month arrives. As full term approaches the uterus sinks into the pelvis and the investigation is almost impossible. After parturition cystoscopy again becomes easy. It reveals, as a rule, the effects of trauma on the bladder, the viscus being more or less bruised and œdematous. Such lesions may explain the vesical trouble so frequent after accouchement (Marion and Heitz-Boyer).

UTERINE DISPLACEMENTS.

Anteflexion.—This is an exaggeration of the normal position of the uterus and has little effect on cystoscopy. It increases the slight

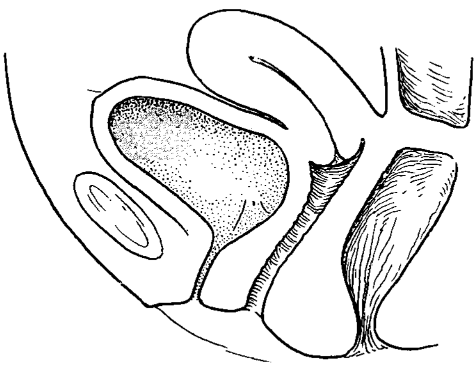


Fig. 166.—Normal relations of bladder and female adnexa.

boss formed by the fundus of the uterus and approximates the postero-superior and anterior walls of the bladder. The normal condition is shown in *Fig.* 166.

Retroversion and Retroflexion.—In these conditions the uterus is bent over backwards so that the cervix indents the vesical wall (*Fig.* 167). It comes into relationship at the level of the interureteric bar and the 'bas fond'. Here a median elevation is produced, so that

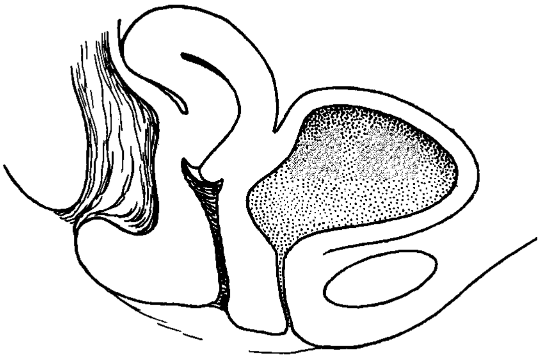


Fig. 167.—Effect on the bladder of retroflexion of the uterus.

in this position the bladder becomes convex from side to side and its lateral recesses are deepened. The ureters now open on the declivity which leads into these recesses, and instead of facing forwards they look to some extent outwards.

Prolapse: Cystocele.—Uterine prolapse (*Figs.* 168–170) may be slight or may be so extreme that the greater portion of the bladder

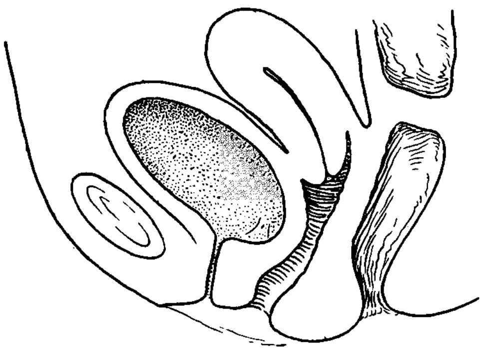
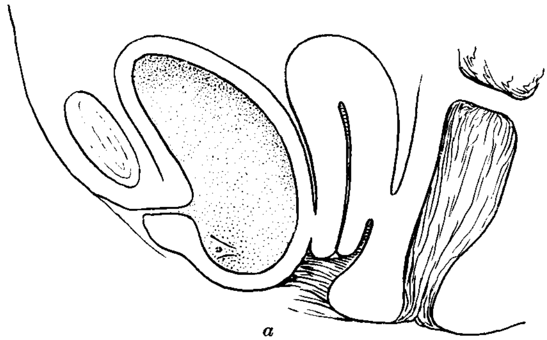


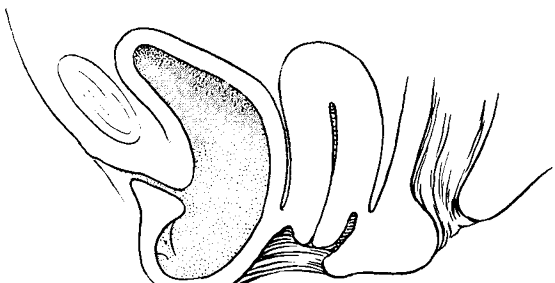
Fig. 168.—Effect on the bladder of a slight degree of uterine prolapse.

comes to lie outside the vulva. In either case, but particularly in the latter, bladder symptoms are likely to be dependent on the anatomical distortion. Concomitant disease, vesical or renal, may, however, require investigation.

The cystoscopist is liable to stumble unexpectedly on minor degrees of cystocele (*Fig.* 168) without having suspected its presence whilst preparing the bladder. Ths vesical base recedes more steeply than is customary, and until he recognizes the reason he may find difficulty in distinguishing the individual features of the base, owing to their distance from the prism. Once the cause is recognized it is immediately counteracted by raising the optical end of the instrument. The concavity of the cystocele produces an effect comparable with that observed in prostatic hypertrophy, in that the ureteric orifices



a



b

Figs. 169, 170.—To illustrate (*a*) moderate and (*b*) advanced degrees of cystocele due to uterine prolapse. Note position of trigone.

and the margin of the internal meatus can be viewed in the same cystoscopic field. In the former case this results from the falling away of the bladder base, in the latter it is due to the raising of the prostatic rim (*see* page 249).

If the cystocele is of moderate severity, the deformity of the anterior vaginal wall will be observed during vesical preparation. A tampon should then be inserted into the vagina to restore the normal relationship of the parts and should be left in position during the course of the operation. If this is not done, the cystoscopist will be hampered by the presence of a well or sump of greater or less development, according to the size of the cystocele. The trigone forms the anterior wall of this sump, and in some cases (*Fig.* 170) recedes so steeply that it cannot be brought into view even with the widest possible excursions of the cystoscope. According to the extent of the cystocele, the ureters are situated either in the base or on the anterior wall of the recess. They are frequently unrecognizable, and, *a fortiori*, uncatheterizable. When distension of the bladder is inadequate, the anterior and posterior walls of this recess may lie in apposition and the entrance thereto will be represented by a deep crease running transversely across the bladder.

When the cystocele is reduced by a vaginal tampon the bladder base can, as a rule, be examined satisfactorily. It will generally be found to have suffered considerable change from its displacement. The mucosa is thickened and coarsely vascular, whilst bullous and other varieties of œdema may be observed. Redundant folds, due to stretching of the membrane, are present. The musculature is generally hidden by the thickened mucosa, but if not, it is seen to be hypertrophied. The interureteric bar appears over-developed, possibly owing to the presence of an exaggerated ‘bas fond’, whilst the ureters are more widely separated than normal as a result of the strain to which they have recently been subjected.

TUMOURS OF THE UTERUS.

Uterine Fibromata.—Uterine fibromata affect the shape of the bladder variously, according to their position, number, and size. Their effects are most pronounced when they occupy the anterior wall of the uterus, since they are then in most intimate relationship with the bladder. Occurring in the *cervix*, they frequently cause pressure on the vesical outlet, resulting in retention of urine with its consequences—dilatation, hypertrophy, and perhaps cystitis. Sometimes the cystoscope passes many inches before it reaches the vesical cavity, and this may be due to an actual elongation of the urethra itself, or may in part result from effacement of the lowest segment of the bladder by pressure from the fibromatous cervix. Changes similar to this are also found when the gravid uterus is retroflexed. When the myoma occupies the *isthmus*, distortion of the bladder occurs in the region of the trigone and ‘bas fond’. It is similar to that noted in retroflexion, except that the fibromatous cervix is usually broader than the normal one. Occurring in the *body* of the uterus, fibromata cause deformity, which is very variable according to their size. It may be so slight as to be only the merest exaggeration of the normal uterine imprint, or when severe it may cause compression of the bladder against the pubes with complete obliteration of the vesical cavity (*Fig.* 171). In general the tendency is for a reduction to occur in the antero-posterior measurements of the organ.

Carcinoma of the Uterus and Cervix.—The indications for interference in uterine cancer rest almost entirely on vaginal and bimanual palpation in this country, though some Continental observers have resorted routinely to cystoscopy in order to ascertain whether there is any evidence of involvement of the vesical wall. The following changes may be observed, according to the age and the character of the neoplasm :—

1. Mechanical distortion due to displacement of the bladder wall by the neighbouring tumour, and of type similar to that observed in

enlargemen[redacted]stortion is usually of slight degree.

2. The earliest signs of invasion are increased vascularization, petechiæ, and œdema of the vesical mucosa at the spot which overlies the neoplasm. Transverse ridging of the mucosa is a variety of œdema not often seen apart from carcinoma of the cervix. It affects the trigone and retrotrigonal areas (*Fig.* 172). It must be regarded as indicating " a serious alteration in the circulation of the bladder due to compression of its vessels by the close proximity of malignant disease or the inflammatory zone which accompanies that disease " (Gemmell). Few cases showing transverse ridging will be found to be operable, and this is true in spite of the fact that the cystoscope is unable to differentiate between inflammatory and neoplastic adhesions.

3. A bud of carcinoma appears and gradually spreads (*Plate VIII* D, page 160). It is often preceded by pitting and retraction of the vesical mucosa. It is irregular, nodular, and may be partly covered by pus or blood, or exhibit evidence of superficial necrosis. In Chapter X the appearances presented by vesical carcinomata are more fully described.

4. When ulceration is marked, perforation and formation of a fistula into the genital passages occur.

In many instances where the growth is on the borderline between operability and inoperability the vaginal examination is inconclusive. The cystoscope may then provide evidence regarding involvement of the bladder which should not be neglected, and which may save

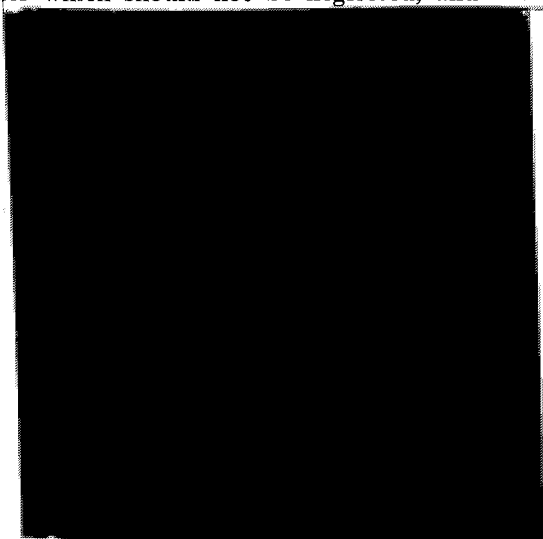


Fig. 172.—[illegible]

the surgeon from embarking on an inexpedient operation. Probably even the minor evidences of invasion, presented by local vascularization and œdema, should be regarded as contra-indications to hysterectomy. A normal cystoscopic picture is regarded by many authors (Zangemeister, Popoff, Luys, and others) as reliable evidence that no difficulties will be encountered in the separation of the uterus from the bladder. This view, however, is not universally supported (Schauta, Hochloff). In general the cystoscopic picture reflects faithfully the stage of advancement of the disease and forecasts truly the measure of operative difficulty which will be met.

Where there is much encroachment of the growth on the bladder, radium therapy, if used too vigorously, may lead to the production of a urogenital fistula. It is essential that due attention be paid to the neighbouring organ, both as a guide to technique and dosage and for purposes of prognosis (Wade and Band, also Gouverneur and Fabre, Heynemann, et al.).

Involvement of the Ureter.—Involvement of the ureter by carcinoma of the cervix is a very common complication of that disease, so much so that one-half of the mortality in unoperated cases is said to be attributable to renal back-pressure and sepsis with its resulting uræmia. The importance of estimating the state of the upper urinary tract would seem to be sufficiently obvious, but this phase is still much neglected, though there are signs of an awakening to a realization of its value. The means described in other sections of this book are available for the appraisement of these organs in cervical cancer.

Meatoscopy.—According to Wade and Band, the first signs of the advance of a cervical carcinoma may be found at the ureteric orifice. In order of gravity these are fixation, retraction, circulatory changes, irregular gaping, ulceration, and formation of nodules.

Chromocystoscopy registers the effects of renal and ureteric back-pressure quickly and effectively.

Ureteric Catheterization.—In some instances the ureter is strictured and will not take the catheter. It must then be decided whether failure is really due to the growth or results from one of the causes enumerated on page 296. A smooth passage for the catheter has in Gemmell's experience meant an easy dissection of the ureter at operation. From meatoscopy alone it is rarely possible to form any estimate of the ease with which the ureter will be mobilized.

Gynæcologists in this country have not yet, I believe, universally adopted this measure in order to assist in the identification and to ensure the safety of the ureter during hysterectomy. Damage to the ureter is not very uncommon, and this simple preliminary would not only eliminate the risk, but probably also expedite the operation proper.

Urography.—The passage of a ureteric catheter may be supplemented by the making of a urogram to demonstrate any existing renal deformity. If, however, the catheter is obstructed, excretion urography may be called on to corroborate the existence of a stricture, showing the hold-up of dye at the level of the growth and perhaps the presence of dilatation above that point. The ureter may be dilated to the breadth of a thumb. Werner has stressed the fact that a hydro-ureter contra-indicates operation.

CHAPTER XIX.

URETERIC CATHERIZATION.

THE CATHETERIZING CYSTOSCOPE.

THE catheterizing cystoscope differs from the examining instrument in the addition of special parts for the accommodation and direction of the ureteric catheter. The other portions—lighting arrangements, equipment for bladder irrigation, and the optical apparatus—remain identical with the corresponding parts of the examination cystoscope which have been described previously. Recent improvements in the optical apparatus, to which reference was made in the section on the telescope, have benefited the catheterizing model materially, for it is

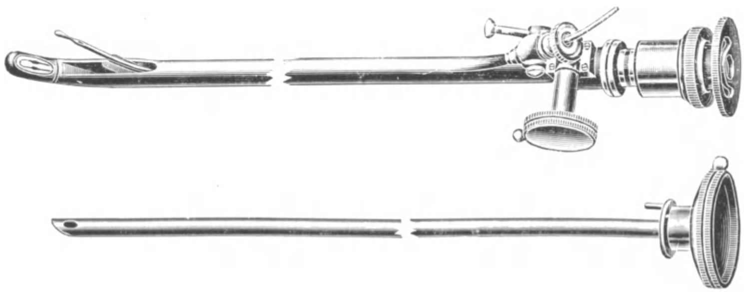


Fig. 173.—Single catheterizing cystoscope.

now possible to obtain a large and bright field with a small telescope. The modern telescope is at the same time sufficiently small to be suitable for the catheterizing instrument and gives optical results which are adequate for the purpose of bladder investigation, so that it has become customary for instrument makers to supply a combination set, containing an examining and a catheterizing sheath, together with a telescope which is common to the two. Diminution in the size of the telescope has, moreover, made possible a reduction in the dimensions of the catheterizing sheath, as compared with the comparatively clumsy instruments in use a few years ago, and even so has left increased accommodation for catheters and various operating devices.

The provision of extra space for the catheter nevertheless imposes on the sheath a larger size than is necessary for the simple examination instrument. It usually corresponds to No. 22 or 23 on the Charrière scale, and in transverse section is oval in contrast to the examining sheath, which is circular. Instruments may be made with the catheterizing parts above or below the telescope—that is, with a concave or convex sheath. The former is the model almost invariably employed nowadays. The latter was the type originally designed, and has been superseded for routine work. It is still retained, however, for use in special cases—such, for instance, as contracted bladders or where the ureter opens abnormally close to the internal vesical meatus.

Each of these instruments may be made for single or double catheters. The single catheterizing concave sheath will be described, and the modifications necessary for double catheters and the convex sheath will be enumerated subsequently.

The Single Catheterizing Instrument (*Figs.* 173, 174).—In modern instruments the catheter is accommodated between the wall of the sheath and the upper surface of the telescope, so that the latter forms the inferior wall of the catheter barrel. In obsolete models the catheter chamber was shut off from the telescope by a partition. The omission of this partition effects a reduction in the size of the cystoscope, and also facilitates the cleaning of the interior of its sheath. It only entails one minor disadvantage—namely, that the ureteric catheter should not be in position until the telescope is re-inserted after bladder preparation.

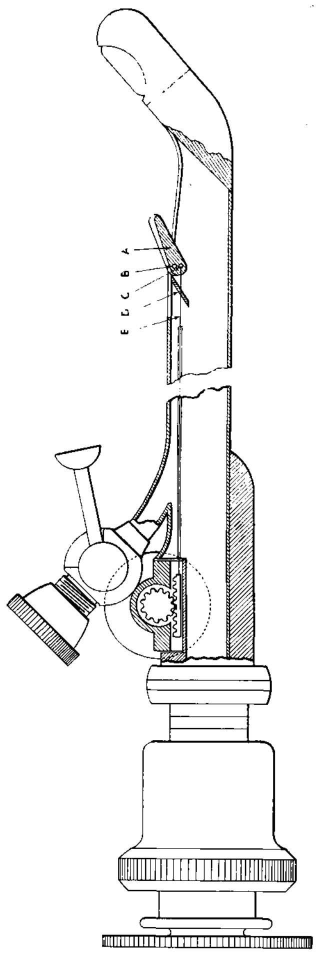


Fig. 174.—Single catheterizing cystoscope. A, Albarran lever; B, Pin on which the lever works; C, Pinhole through which the wires pass—pushing in order to lift the lever, and pulling to lower it; D, Sloping guide to direct ureteric catheter towards the lever; E, Wire connecting lever with rack.

The fenestra in the wall of the sheath is increased in size to allow egress to the catheter, which emerges at a point just proximal to the position occupied by the prism. A slope is here provided which directs the catheter to the external surface of the cystoscope, and on to a lever which forms a portion of the elevating mechanism. By means of this lever the catheter is directed towards the ureteric orifice. It is a small grooved metal plate $\frac{5}{16}$ in. long, free at its vesical extremity, and lightly hinged at the other end. It is connected by two wires to a pinion handle at the external end of the instrument. This handle controls a rack and pinion, whereby the lever can be elevated or depressed. It is capable of movement through 90°, its axis lying parallel with the shaft of the cystoscope when it is depressed, and at right angles when fully elevated. When lowered the lever does not project beyond the sides of the sheath, and is therefore prevented from injuring the urethral mucosa during introduction.

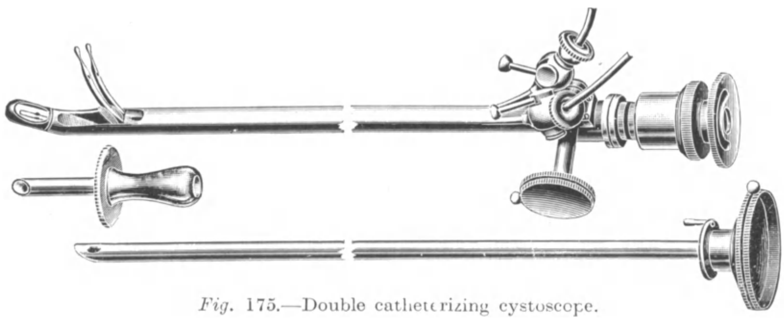


Fig. 175.—Double catheterizing cystoscope.

At the ocular end of the cystoscope the catheter channel is continuous with a tube about $\frac{3}{4}$ in. long which emerges from the superior surface of the cystoscope. Through this the catheter reaches the surface. It is capped by a screw perforated at its centre to allow the passage of the catheter. Beneath this screw is a small space containing a rubber washer, likewise perforated, for the transmission of the catheter. When the screw is tightened the washer is compressed against its seating and bulges centripetally towards the catheter, making a water-tight joint similar to the one surrounding the telescope. The degree of compression required of the screw naturally varies with the size of the catheter employed. On the tube is a tap which is closed to prevent escape of bladder contents when the catheter is not in position, and which must be opened to allow its admission.

The Double Catheterizing Instrument (*Fig.* 175).—This differs from the single model in that the catheterizing parts are duplicated throughout. The catheters are separated from each other by a partition. If not kept apart, friction may dislodge the catheter which is supposed to be stationary, during the manipulation of its neighbour. The size of the instrument remains at 23 on the Charrière scale. A larger catheter can be employed with the single than with the double instrument.

The Swift Joly Instrument.—In this model (*Fig.* 176) several excellent modifications are adopted, and the cystoscope has become deservedly popular.

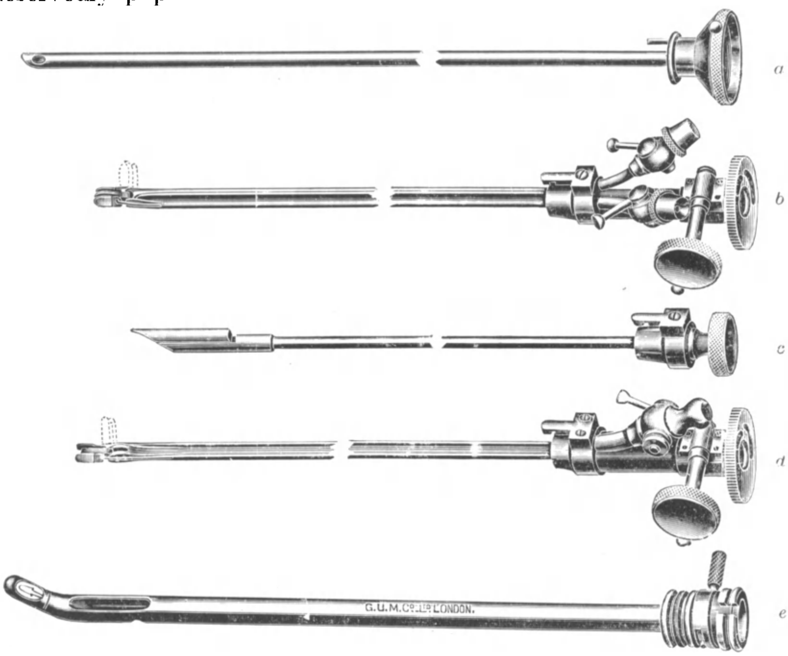


Fig. 176.—Swift Joly's catheterizing and operating cystoscope. *a*, Telescope : *b*, Double catheterizing attachment ; *c*, Obturator ; *d*, Operating attachment : *e*, Sheath.

1. The catheterizing mechanism is separable from the sheath, and both unilateral and bilateral fittings are supplied. The unilateral model is capable of admitting a No. 11 Charrière catheter, and with it small scissors and forceps can be employed. These catheter fittings are attached to the sheath by means of an expansion at the ocular end which fits snugly into a seating at the corresponding end of the sheath. It is locked in position by an interrupted screw or bayonet catch. An aperture in the expanded end lies opposite the lower compartment in the sheath and receives the telescope, which is held in position by friction.

2. During introduction the fenestra of the sheath is occupied by an obturator which is removed as soon as the instrument is *in situ*. The obturator protects the wall of the urethra from damage by the margins of the fenestra.

3. There is no valve at the ocular end, a finger being used to retain the bladder lotion after irrigation until the telescope is inserted. A faucet containing a valve is, however, made for use during irrigation (*Fig.* 177).

Fig. 177.—Andrews' ball-valve faucet for use with Swift Joly cystoscopes.

4. An ingenious attachment for retrograde vision, owing its properties to a second prism fixed where the usual window is placed, gives a view of the bladder neck (*Fig.* 178). To it is attached an instrument carrier capable of taking a No. 6 fulguration electrode for the destruction of tumours in this otherwise inaccessible region.

5. All parts can be boiled with the exception of the telescope.*

Swift Joly claims for his instrument that: (*a*) It is aseptic, in view of its capacity to withstand boiling; (*b*) It is possible to change from a double to a single catheter, or a retrograde cystoscope, without removing the sheath from the bladder; (*c*) It is the only instrument in which the operating attachment can be used in conjunction with a retrograde cystoscope.

Fig. 178.—Telescope and operating attachment of Swift Joly's retrograde cystoscope for examination and fulguration of the internal meatus,. Note double-reflecting prism.

A 19 Charrière examining sheath can be supplied with this instrument.

Buerger's Instrument.—Leo Buerger, of New York, has done much valuable work in the development of the cystoscope and cysto-urethroscope in America. His cystoscope evolved from and improved upon that of Tilden Brown. It is shown in *Fig.* 179. It will be seen that:—

1. The sheath and lighting apparatus form one unit introduceable with the assistance of an obturator occupying the fenestrum.

2. The telescope and operating attachments are combined and form a second unit. These two units are assembled and fixed by means of a rotating catch.

* A boilable telescope will be supplied if ordered. *See also* page 24.

3. There is no valve.

4. Concave and convex sheaths are provided.

5. Retrograde vision can be obtained by rotation of the prism backwards (*see Fig.* 27, page 22).

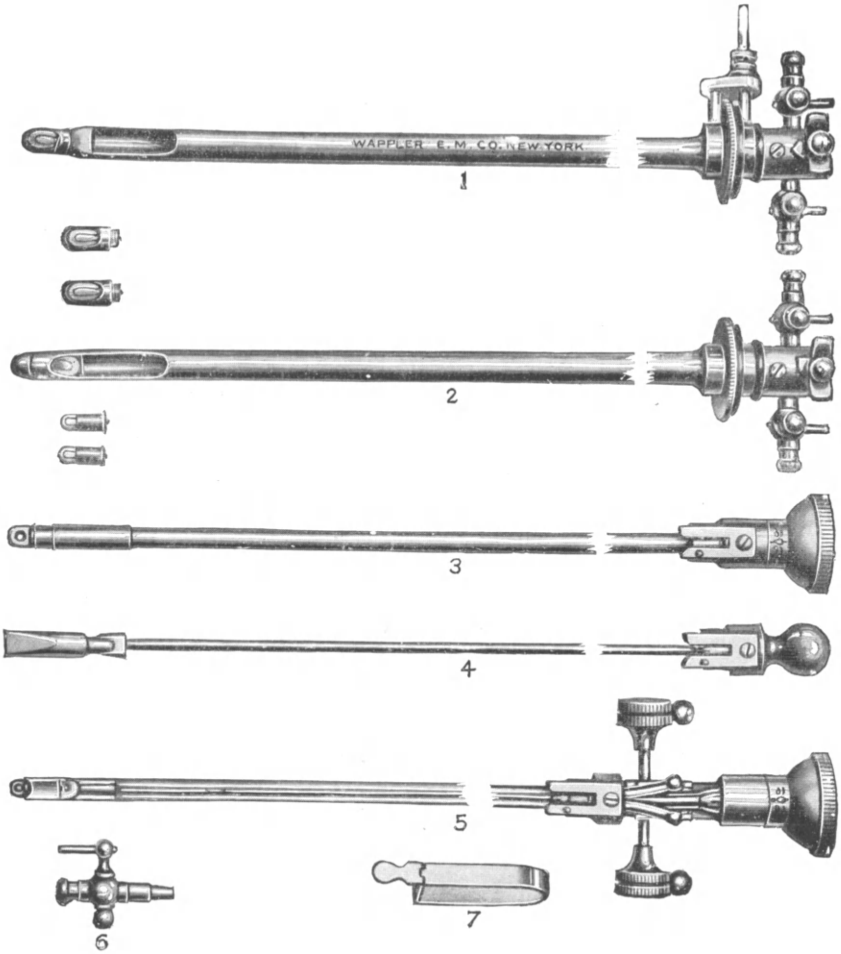


Fig. 179.—Brown-Buerger combination cystoscope. 1, Concave sheath and lamps; 2. Convex sheath and lamps; 3, Telescope; 4, Obturator; 5, Telescope combined with catheterizing apparatus; 6, Stop cock for irrigation; 7, Catheter clip.

Buerger does not recommend the convex sheath in routine cystoscopy, but claims that it is valuable in close vision work and in contracted bladders.

URETERIC CATHETERS AND BOUGIES.

Catheters and bougies are made of cotton, linen, or silk thread into which is worked a special form of shellac varnish called 'gum-elastic'. They measure about 30 in. (70 cm.) in length, and correspond in diameter to 5, 6, 7, and 8 on the French scale. Some surgeons use larger sizes, but those mentioned will be found to be most generally serviceable. Many catheters are made in France, so that it is useful to note that in Pasteau's scale the sounds are numbered from 10 to 24, 10 corresponding to No. 5 Charrière, and 24 corresponding to 12. A range of sizes is necessary because ureters vary in capacity, both congenitally and pathologically, and also because the instruments fulfil varying tasks; thus, if one is catheterizing a ureter to estimate the renal function, it is desirable to use a large size in order to occupy the lumen as fully as possible, so that there will be no leakage around the catheter and no urine will be lost. On the other hand, when some drug is being introduced into the renal pelvis, as in lavage or in pyelography, one desires to avoid over-distension, and therefore a small catheter which leaves plenty of room for leakage alongside it will be selected.

a *b* *c*

Fig. 180.—Ureteral catheters. *a*, Olivary ended ; *b*, 'en bec de flute' ; *c*, Catheter with collar to prevent leakage.

The tip of the catheter is made in several different patterns (*Fig.* 180). It may be rounded or olivary, in either of which cases two or three lateral orifices are placed at different levels and on alternate sides in the first inch or inch and a half of its length. In other patterns there is a terminal orifice which should be combined with lateral orifices in case the terminal one becomes occluded. The terminal opening is generally cut 'en bec de flute', and this pattern of catheter the writer recommends as being the most serviceable. The disposition of the lateral eyes is of importance for two reasons: (1) They must be so placed as to avoid weakening the terminal portion of the catheter, which is always the part most exposed to trauma by the lever ; (2) They must, nevertheless, be of good size and on opposite sides of the catheter so as to diminish the likelihood of both being blocked simultaneously by contact with the mucous membrane. Behind the terminal of the two eyes in some patterns is a thickening of the shaft of the catheter, intended to prevent urine from passing down alongside the instrument. It increases the measurement locally by a degree on the Charrière scale.

The catheter is divided into centimetres (or sometimes half inches) by alternating light and dark segments of coloration, and at every 5 cm. a ring, or rings, which are easily recognizable through the cystoscope, indicate to the observer the distance that the catheter has proceeded up the ureter. Thus one ring appears at 5 cm., two rings appear at 10 cm., and an extra ring is added for each further 5 cm. till at a distance of 25 cm. from the tip 5 rings occur. At 30 cm. a fresh beginning is made with a single ring which is added to as previously. In some catheters alternate segments are rendered opaque to X rays by the addition of some impenetrable substance. Others are opaque throughout their whole extent. In combination with the X rays these instruments provide valuable indications in the localization of shadows occurring in or near the line of the ureter.

A correct degree of rigidity is essential, and should be one of the first things looked for when purchasing a catheter. This is, however, a constant feature in the instruments supplied by the best firms, such as Eynard and Gaillard. It must be sufficiently firm to make its way up the ureter without coiling up, and yet sufficiently pliable to lend itself to the movement imparted to it by the lever of the catheterizing cystoscope, and to the shape of the ureter, without unduly distorting the latter. Too stiff a catheter is liable to push its nose into the mucous membrane of the ureter (*see Fig.* 187, page 296) when it should be manœuvring a curve, and by so doing it will probably pick up a fold of mucosa. In this way pain, hæmorrhage, and injury are liable to occur, and the catheter will be impeded in its ascent.

A stilette of brass or steel wire is supplied, and serves the dual purpose of keeping the lumen patent, and of preventing bending or kinking. The stilette is removed before use. The catheter should be kept in an extended position, for if coiled up it will retain the curve when in use. This curve may throw the tip on one side of the lever, and so displace it from the field of view, and render it difficult to introduce into the ureteric orifice.

Sterilization of the Ureteric Catheter.—Sterilization of the *exterior* of a ureteric catheter may be accomplished by methods similar to those used for gum-elastic urethral instruments. After cleansing with soap and water they may be placed in antiseptic lotion, such as carbolic (1–40) or mercury oxycyanide (1–500). Formalin sterilization is preferable, and may be carried out in a hot or a cold sterilizer. Modern gum-elastic is capable of withstanding boiling for a minute or two, provided that it is gently removed from the sterilizer and placed on an aseptic towel to allow the shellac to harden before using. With the improvement in these instruments, heat sterilization is becoming more general.

Apart from boiling, the sterilization of the *interior* of the catheter is difficult on account of its great length and narrow lumen. The importance of obtaining perfect sterility of this tube has greatly increased since the practice of injecting fluids into the renal pelvis for lavage, pyelography, etc., has evolved. So long as the flow of the liquid was all towards the exterior there was less danger of infection; but nowadays perfect catheter asepsis is absolutely imperative. A catheter which has been used on a septic case must therefore be destroyed. The high cost of these instruments, however, forbids the use of a fresh catheter in every case, and where one has been employed on an aseptic kidney it may safely be retained for further use.

Fig. 181.—Thomson-Walker's ureteric catheter and syringe nozzle.

Before sterilization the patency of the lumen should be proved by flushing it through with a syringe attached to the extremity, thus mechanically removing débris, etc. The connection shown in *Fig.* 181 will be found useful, as it is universally adaptable to any syringe or

Fig. 182.—Ureteric catheter syringe.

catheter. The syringe shown in *Fig.* 182 may be employed with it, or with the tapering nozzle seen in *Fig.* 235, page 393. Should obstruction prove obdurate, it may usually be overcome by introducing the stilette.

The methods used for sterilization of the lumen are:—

1. By means of antiseptic lotions driven through the lumen by a syringe, as described above.

2. A hot, formalin sterilizer is depicted in *Fig.* 183, and this is a satisfactory way of obtaining asepsis. Prior to placing the catheter in this sterilizer it must be carefully dried, both

inside and out, as otherwise the formalin acts on, and destroys, the shellac. Dryness of the interior is difficult to obtain. The instrument should be attached to a syringe, and a current of air blown through it several times. It should then be allowed to stand for twenty-four hours in a warm, dry place in the presence of calcium chloride. When dry, the end of the catheter is firmly plunged on to

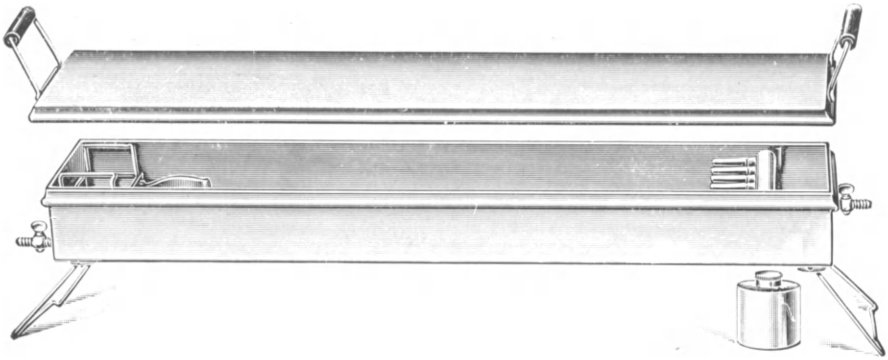


Fig. 183.—Ureteral catheter sterilizer.

one of the nozzles shown in the illustration. Some paraform tablets are placed in a depression in the floor of the sterilizer and some calcium chloride is scattered about on the bottom, in order to absorb excess of atmospheric moisture. The small lamp is placed under the paraform tablets. Formalin is released and is compelled to traverse the lumen of the nozzles and catheters to obtain an exit. Through

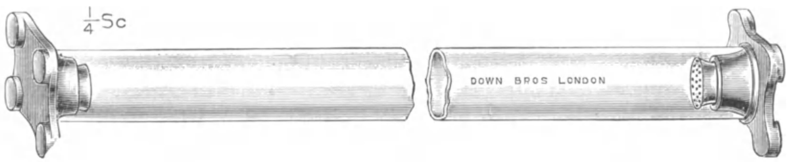


Fig. 184.—Glass catheter tube, for storage and sterilization of ureteric bougies and catheters, with formalin container at each end.

these it reaches the cavity of the sterilizer, and here acts on the exterior of the instruments. The sterilization obtained by this method is complete at the end of half an hour. The joint between the nozzle and the catheter should be tight, so that the lumen is assured of the action of the formalin.

Long tubes for cold-formalin sterilization are obtainable (*Fig.* 184). The catheter box (*Fig.* 185) serves a similar purpose and has the merit of portability. The coil on the catheter, though undesirable, is not so acute as to injure it materially. The formalin is held in the centrally placed receptacle with the perforated cover. Some time before the instrument is required the fumes are allowed to escape from the catheter box in an anteroom through the perforations in the lid which are opened from the exterior by a slide. The action of cold formalin should continue for twenty-four hours.

The best results are obtainable by the hot method, and thereby the interior of the catheter is more searchingly treated than it can be by means of cold formalin or lotions. It is doubtful if the vapour comes sufficiently intimately into contact with the whole length of the catheter lumen when cold vapour is employed.

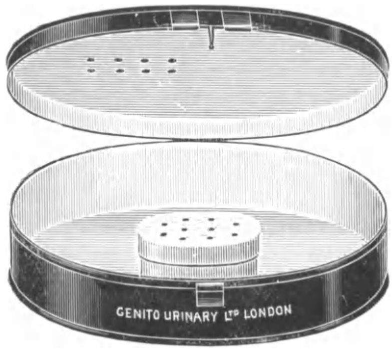


Fig. 185. — Everidge's catheter box for ureteral catheters, with formalin container.

THE TECHNIQUE OF URETERIC CATHETERIZATION.

The details of anæsthesia, bladder preparation, sterilization, equipment, etc., have been studied in various sections of the book, and are the same when a bladder is being prepared for ureteric catheterization as when one is in preparation for ordinary cystoscopy. The patient occupies the position already described, and care is taken that the pelvis is placed at a convenient angle (*see* page 44).

When the bladder is being prepared through the cystoscope it is preferable to postpone the introduction of the ureteric catheter until the irrigation is finished, lest the external portion of the catheter be soiled by coming in contact with unsterile parts. Furthermore, the bladder urine may be septic prior to irrigation, and it would unnecessarily contaminate the catheter as it lay in the barrel. During vesical irrigation the tap on the catheter barrel is closed, and is not opened until the introduction of the catheter. If the bladder preparation has already been accomplished with a rubber catheter, the loading of the cystoscope barrel is performed before introducing the cystoscope. In those models where there is a partition between the catheter and the telescope it is immaterial whether the latter is in place or not at the time when the catheter is inserted, but where the telescope forms the floor of the catheter channel it should be in position before loading.

When introducing the catheter into the instrument care should be taken that it is inserted as far as is possible without its projecting at the fenestra. Attention should then be paid to the washer, and the controlling screw tightened sufficiently to ensure that the washer is lightly in contact with the sides of the catheter, but yet allows it to run freely backwards and forwards. If leakage occurs at this joint the bladder gradually empties itself on to the knees of the cystoscopist. Finally a turn should be given to the pinion handle which elevates the lever in order to make sure that it is functioning well. The introduction of the instrument into the bladder differs in no respect from that described for the examining cystoscope save that its larger size renders it slightly more troublesome. During the whole operation a properly prepared assistant should make himself responsible for seeing that the free end of the catheter does not become contaminated by trailing on unsterile objects.

As soon as the instrument is in place it is rotated over, and the ureters are searched for. They are found by the methods described on pages 63 and 74. (It is presumed that the bladder has been explored on a previous occasion. If not, a preliminary investigation should be carried out.) The cystoscopist now takes the barrel of the instrument in his left hand, holding it at a point just in front of the junction of the shaft with the expansion of the optical end. Meantime he steadies his left arm by resting the elbow on any convenient fixed point—generally the end of the table. His right hand is free to undertake the more delicate manipulations of the catheter and lever. Keeping the ureter in view, the optical end is now raised or lowered until the surgeon estimates that the prism is about one inch, or if anything rather less, from the ureteric orifice. The instrument still being kept perfectly steady with the left hand, the right hand now feels for the ureteric catheter, and having grasped it, gently pushes it forwards so that its point advances into the bladder. The eye of the cystoscopist applied to the ocular observes its progress across the field, and just as the tip is about to pass out of view it is arrested (*Fig.* 186*a*). The catheter occupying this position lies almost parallel to the shaft of the cystoscope and is quite close to the prism. It is therefore seen as a magnified band crossing the field and having parallel sides. Further, as the light from the lamp fails to reach the surface presented to the operator, it appears as a dark unilluminated object.

The right hand now passes from the catheter to the pinion handle and gently rotates it through half a turn, the surgeon meanwhile watching the effect produced on the tip of the catheter. This is observed to recede and become foreshortened. Perspective now makes it appear pointed, whilst the surface suddenly becomes illuminated owing to its altered relationship to the lamp. The recession of the catheter has uncovered about half of that portion of the bladder

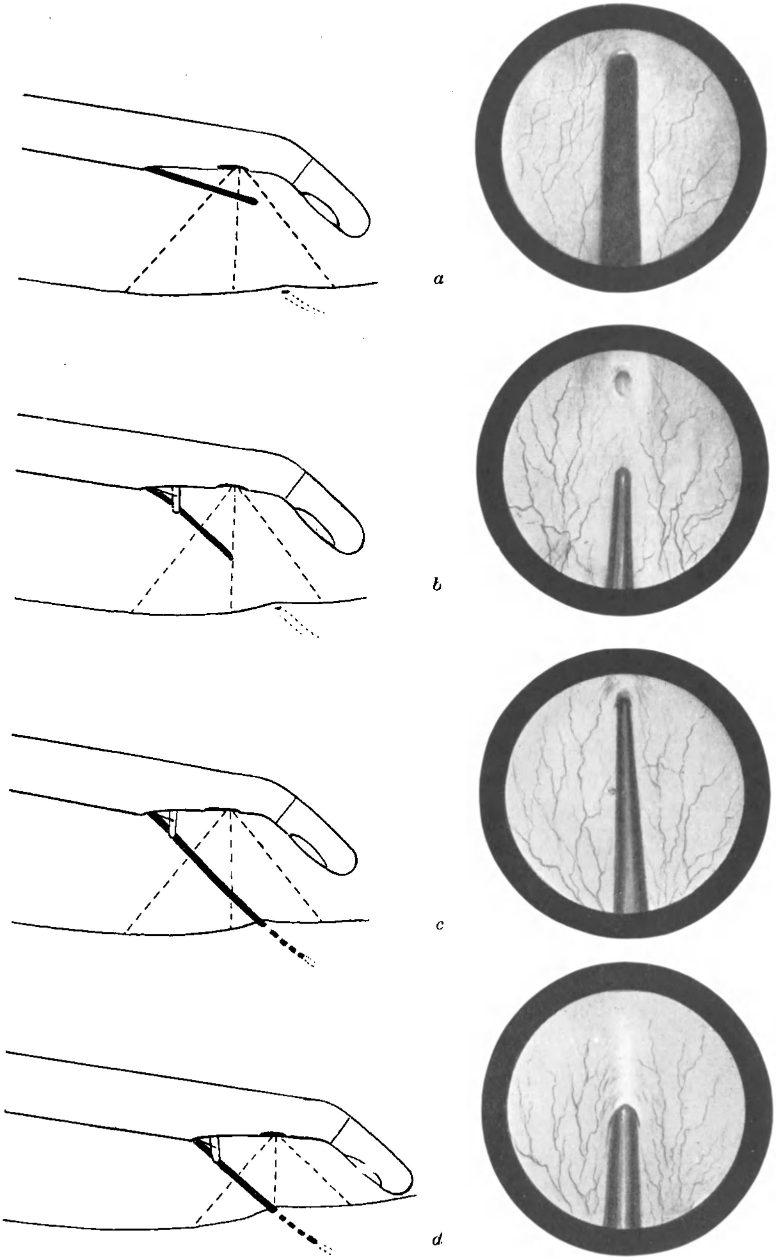


Fig. 186.—To illustrate the technique of ureteric catheterization.

wall which was previously hidden by it, and if the manœuvre has been accurately carried out, its apex should occupy the central point of the field (*Fig.* 186*b*). It is a matter of importance that the catheter should not be kinked too acutely, for it may thereby be injured (*see*, however, footnote on page 295). A suitable angle is found at about 45°. If the positions of the catheter tip which have been described above have been accurately followed (that is, the first position being one in which the catheter bestrides almost the whole of the central portion of the field, and the second that in which the tip has receded to coincide with the central point of the field), the bend on the catheter will be approximately the correct one—namely, 45°. At this angle the relationship of the terminal segment of the catheter to the ureteric orifice facilitates its insertion (*Fig.* 186*c*).

Now, by a slight adjustment of the position of the cystoscope, the surgeon brings the ureteric orifice into the upper (distal) portion of the field so that the apex of the catheter is pointing towards it. About a quarter of an inch more catheter is paid out, care being taken that it moves in the direction of the orifice and that too great a length of catheter is not free in the bladder. It is a sign of inexperience to rely too much on the elevating mechanism and the length of catheter. When three-quarters of an inch of catheter is paid out into the bladder the entrance of the tip into the ureter should be secured by infinitely small adjustments of the position of the cystoscope shaft itself. At the stage described it is probable that the tip of the instrument is lying quite close to the entrance, so that by a movement of the body of the cystoscope penetration may be obtained (*Fig.* 186*d*).

The catheter may now be fed quickly but gently forward for an inch or two in order to consolidate the ground gained, and then the surgeon should return to the elevating screw and depress the lever, as it is no longer necessary and is a menace both to catheter and to the bladder mucosa. When this precaution has been taken, the catheter may be fed into the ureter as far as is deemed advisable (*see* page 299), and as it runs home the cystoscopist observes the markings on the exterior so that he may know approximately the point in the ureter which the apex of the instrument has reached. As the catheter passes into the ureter it elevates the walls of the intravesical portion so as to form a tunnel-shaped opening, the entrance of which is repelled by the friction of the advancing catheter. The cystoscopist nevertheless should make it his object to cause as little deformity of the ureter as possible, for such deformity means that the cystoscope and the ureter are not in perfect alinement, and unnecessary trauma is occurring. By a combined movement of depression and retraction of the beak the salient will be diminished.

Occasionally it is found more difficult to catheterize the left than the right ureter; especially is this so in the case of an operator who uses his right eye. The reason is that the cystoscope is too near the median line and is viewing the orifice as it lies on its side. The catheter therefore is working on an incorrect line, and unless it happens to catch the outer lip of the ureteric orifice, is liable to slip past the opening. The trouble is rectified if the ocular end of the cystoscope is swung farther over towards the patient's right thigh and rotated so that the beak faces downwards. The catheter thereby is brought more vertically over its work and more into opposition to the ureter.

The writer uses the method of handling the cystoscope above described for the catheterization of each ureter. Some cystoscopists, however, recommend that the hands be disposed as described above when dealing with the right ureter, and that an interchange be adopted in the case of the left. There is little, if any, advantage to be gained by so doing, and the hands have to be doubly trained. Gorodichze and Hogge have described and figured a complicated grip which has gained a certain popularity. In their method the one hand holds the barrel of the cystoscope between the little and ring fingers, and the index finger and thumb of the same hand control the deflecting mechanism. The other hand inserts the catheter. This technique requires a good deal of practice, and when acquired the movements—particularly of the cystoscope itself—lack the delicacy which can be imparted in the method described above.

The Removal of the Cystoscope.—When the catheter is being left *in situ* for ureteric drainage the cystoscope must be removed. The light should be switched off first and the deflector lowered. The faucet is inserted and all the urine except about 2 oz. withdrawn. This quantity I generally leave in the viscus in order that, when the catheter is pushed forward into it, there may be a certain amount of space to accommodate it. The cystoscope is next held steadily whilst the catheter is paid into the bladder until its end has almost disappeared from view into the barrel. Having rotated it on its long axis so that its beak looks upwards, the cystoscopist now withdraws the instrument. As soon as the fenestra appears at the external meatus, the catheter is seized in the left hand in order to prevent its further removal from the urinary passages. The short urethra of the female makes it easy to obtain a hold on the catheter at an early moment, before the slack in the bladder has been taken up. In the male the penis should be pressed back to shorten the urethra. The catheter is now withdrawn completely through the barrel.

Catheterization of Both Ureters.—In the catheterization of both ureters a double catheterizing cystoscope may be employed; or, after one ureter has been catheterized and the cystoscope withdrawn, the instrument may be reloaded and the second ureter catheterized. The disadvantage of the double catheterizing cystoscope is that with an ordinary bore instrument the larger sizes of catheter cannot be employed. Against double catheterization with a single catheterizing instrument is the fact that it involves the use of the cystoscope when the urethra is already occupied by a ureteric catheter. This difficulty is particularly felt in the case of the male. Larger catheters can, however, be employed, and there appears to be a tendency in this country to discard the double instrument in favour of the single.

Some means of distinguishing the right from the left catheter must be adopted. For this purpose instruments of different colours or types may be employed, or a label may be tied on to act as an indicator.

DIFFICULTIES OF URETERIC CATHETERIZATION.

Catheterization of the ureter is generally a simple operation in practised hands and when the bladder is normal. In the diseased bladder it may be easy, difficult, or impossible. Trouble may be encountered as a result of a large number of conditions, most of which are pathological in origin. The majority of these have been fully described in other sections of this book, and only require a brief mention here.

1. **Introduction of the Cystoscope.**—Difficulty may be encountered in the introduction of the cystoscope and may be due to narrowing of the passage congenitally, by stricture, or by prostatic hypertrophy. The larger size of the catheterizing instrument renders its progress along the urethra more difficult than that of the smaller examining instrument.

2. **Vesical Conditions.**—The chief causes of difficulty arising in the bladder are cystitis and covering of the orifices.

Cystitis.—The difficulties experienced in freeing the organ from pus and blood and in overcoming its irritability have been dealt with in the section on bladder preparation. Even when efficiently prepared a very irritable organ may inopportunely empty itself during ureteric catheterization. A red and swollen mucosa may effectively conceal the ureteric opening, which in severe cystitis may be very difficult to find. Simple cystitis is less troublesome as a rule than tuberculous cystitis, where reduction in capacity, and irritability, redness, œdema, ulceration, and hæmorrhage may all contribute to impede ureteric catheterization.

Catheterization is possible when the bladder will hold 2 oz. of fluid, but if the capacity is further reduced it becomes increasingly difficult or even impossible. For extremely small bladders Buerger recommends his convex sheath. In this instrument the catheter comes into very close approximation to the ureteric orifice owing to the direction of the curve of the beak. The same instrument may be found valuable when dealing with an orifice which receives insertion near the vesical neck, though the cysto-urethroscope may then be preferred.

Hidden Orifices.—The ureteric orifices may be hidden by a growth or a stone. Their discovery, however, is not important in these diseases because treatment will be directed to the bladder and not to the kidney. Blood and pus constitute an obstacle to ureteric catheterization when they are present in quantity, either by occupying the vesical sump and covering the orifices, or by rendering the medium turbid. For their treatment *see* Chapter III.

3. **Prostatic Disease.**—In both simple and malignant enlargement of the prostate, separation of the urines is unnecessary except in rare instances. In the former, however, I have had to undertake it owing to there being concomitant disease in the kidney. In minor degrees of hypertrophy the operative difficulties are not greatly increased, but when the median prominence is considerable it may be difficult or impossible to reach, and perhaps even to see, the openings of the ureters (*see* Chapter XVII).

Tuberculosis occurring in the prostate frequently complicates a similar lesion in the kidney. It will generally be held to contra-indicate any surgical measures directed against the latter, and cystoscopy will therefore be unnecessary. Urethral instrumentation is dangerous in prostatic tuberculosis, as it may fan the disease to renewed activity, whilst difficulties may arise in the introduction of the instrument owing to the urethra being narrowed.

4. **Uterine Conditions.**—Changes produced in the bladder by physiological and pathological enlargements or by displacements of the uterus may in some instances impede this operation. They have been described at length in Chapter XVIII, where the difficulties encountered in ureteric catheterization have also been discussed.

5. **Ureteric Conditions.**—

The Meatus.—The ureteric opening may be difficult to find even though *normal.* It may be surrounded by folds and recesses of similar appearance to itself, amongst which it remains inconspicuous. Often an abnormal distribution of blood-vessels occurring around it may confuse the eye, or the rich vascularity of the trigone may extend up to overlap and obscure the orifice. The missing opening may sometimes be found on the external aspect of the ureteric bar, and the beak of the cystoscope must be manœuvred farther afield towards the lateral recess in order to bring it into view. To catheterize it, the fenestra must then be rotated inwards, so as to face its mouth. The operation may be difficult, but frequently the anteriorly lying lip of the orifice gives way before the pressure of the ureteric catheter and thus uncovers the entrance.

Actual *displacement* of the meatus sometimes occurs, abnormal situations on the ureteric and interureteric bars being the most common (*see* Chapter XXII, page 364). The history of urine coming away from the rectum or vagina, or dribbling away from the urethra apart from micturition, would suggest an abnormal termination. Occasionally when a *double* ureter is present only one has been catheterized, the other having escaped recognition. Faulty observa- [redacted] examinations. [redacted] Chapter XXII, page 352). [redacted] be made before deciding [redacted] is diseased, and indigo- [redacted] its identification before the [redacted]

[redacted] to be observed is an [redacted] the ureter normally emerges. [redacted] of the operator to hit off [redacted] dip straight home without [redacted] does not find this [redacted] entering the ureter cleanly [redacted] a septic bladder he may [redacted] into the ureter. [redacted] origin may give rise [redacted] of flexion should be given [redacted] of the lever* in order that it may come directly over the orifice. If this method does not succeed, the tip of the catheter may be allowed to rest on, and to depress, the margin of the elevation just in front of the opening, and then as it is advanced it can generally be persuaded to enter the tube.

In the presence of a *ureterocele*, or of a ureter opening into a *diverticulum*, catheterization is impossible. Occasionally an orifice is *congenitally so small* that it will not admit the finest bougie. When this happens I have sometimes met with success by employing a stiletted catheter, the additional rigidity of this instrument being sufficient to overcome the friction of the contracted opening. This manœuvre must be used with gentleness in order to avoid ureteric injury, but as the stenosis is strictly localized to the termination of the

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* It may be pointed out that, though the elevating mechanism of the cystoscope can be raised through a right angle, only a portion of this angulation can be communicated to the catheter, which, as may be demonstrated extravesically, passes obliquely from the distal end of the fenestra to the tip of the lever.

ureter, the remainder of the tube being of normal or more than normal size, there is little likelihood of much harm resulting.

The Ureter Proper: Obstruction.—The progress of a ureteric instrument may be checked by a fold of mucosa, by a stricture, or by an obstruction within the channel—for instance, a stone. Of these, the two latter are dealt with in the chapters on ureterography and stone in the ureter, respectively.

It is a very common accident for a catheter which is ascending the ureter to be arrested in its progress by its tip picking up a fold of mucosa (*Fig.* 187). The intravesical segment is then seen to become arched (*Fig.* 188). Much the most usual site for this to happen is the first two or three inches of the tube. It may or may not be possible to overcome the obstruction, but if it does not quickly yield, the following remedies have been recommended :—

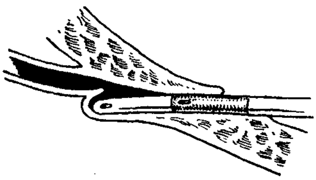


Fig. 187.—Ureteric catheter caught in a fold of mucous membrane.

[redacted]

[redacted]*ig.* 18[redacted]atheter o[redacted] intravesical portion bends up.

a. Occasionally the trouble is caused by faulty alinement of the catheter with the ureter, and careful readjustment may be followed by success.

b. A movement of rotation on its long axis should be imparted to the catheter so that it may free itself from the impeding fold.

c. A smaller catheter may be employed, and, failing this, a larger one or one with a differently shaped tip may prove successful.

d. Sterile lotion, or, better still, parolein, may be injected through the catheter. This will sometimes distend the channel and disengage the catheter tip.

e. Varying the quantity of vesical fluid sometimes produces the desired effect. A reduction in distension will diminish the curve of the ureter lying immediately behind the bladder—it should be quite easy to catheterize in 4 oz. of fluid. On the other hand, over-distension may drag on the intravesical ureter and occasionally succeeds where other methods have failed.

f. Alteration in the position of the patient sometimes overcomes the trouble. The catheter tip naturally catches when manœuvring a bend in the tube, and it is therefore more common in women—owing to the more pronounced curve of the ureter—than in men. If the lumbar spine is hyperextended, sufficient straightening may be effected in the ureter to allow the instrument to progress. If this is not enough, the pelvis is raised and the shoulders are dropped. The weight of the intestines is thereby taken off the upper surface of the bladder, allowing that viscus to rise, and in addition the kidney moves towards the diaphragm and straightens out the ureter.

Even if none of the above expedients succeeds, the catheter may yet collect urine from the kidney. The surgeon should examine the portion of the instrument which is under his view in the bladder to see whether any of the eyes are exposed. If so, not only will bladder fluid drain away by the catheter, but also some of the renal secretion will be lost in the bladder. There will thus be an interchange of fluid. If no eye is visible, the catheter may be left in position, but it is then advisable to leave the cystoscope also undisturbed, as its removal might withdraw a little of the catheter. It also gives the surgeon the opportunity of inspecting the catheter from time to time to see that it is still in the ureter. Marion recommends that some methylene blue be introduced into the bladder to show whether there is any leakage through the catheter.

DANGERS OF URETERIC CATHETERIZATION.

Sepsis.—When ureteric catheterization was new and was first provoking discussion the possibility of introducing sepsis into a healthy ureter aroused much anxiety in the minds of the profession. This is natural in view of the fact that many catheterizations take place across infected bladders, where, for example, unilateral pyogenic or tuberculous disease of the kidney has started a similar condition in the bladder, the other kidney being still healthy. It is frequently the healthy ureter which requires catheterization. Experimental work carried out by many observers has now established the fact that the danger of infection is inconsiderable. The ureter has been found to behave in the same way as does the bladder to sepsis artificially introduced into it, and, in the absence of injury or obstruction, it will quickly throw off the infection. In 1913 Hess described the bacteriology of bladders immediately following cystoscopy, and showed that in the first few days following instrumentation bacteria could usually be found in the bladder, that they produced neither symptoms nor signs of cystitis, and that they quickly disappeared.

Albarran was the pioneer in experiments on the ureter, and demonstrated that the injection of pure cultures of organisms into the ureter was harmless, provided that the ureter was not damaged or obstructed. Sampson and other workers have confirmed his experiments. Moreover, nature is daily verifying them in that she uses the kidney as an excretory gland for the removal of organisms from the blood-stream. It is known that many patients suffering from pulmonary phthisis have tubercle bacilli in their urine, and in cases of suppurative peritonitis, extreme constipation, and typhoid the corresponding organism is generally found in the urine if looked for. Yet the urinary passages as a rule escape infection. Albarran showed, however, that if injury or obstruction exists, the organisms then obtain a foothold. It will be shown immediately that hæmorrhage is common after ureteral catheterization, indicating some degree of trauma which might predispose to sepsis. Nevertheless, experience demonstrates the rarity with which renal or ureteric inflammation supervenes. This will not, however, excuse slackness in our aseptic ritual. The ureteric catheters should be kept out of the cystoscope in septic cases until the bladder has been cleansed. When the ureteric catheterization is taking place the surgeon must try to introduce the tip into the orifice without allowing it to be soiled by unnecessary contact with the bladder, whilst it should be advanced slowly and gently in order to avoid injury to the ureter. Only catheters which are smooth and well preserved should be employed.

When catheterizing across an infected bladder in order to ascertain the functional value of a kidney it is rarely necessary to advance the catheter as far as the renal pelvis. A specimen will be obtained if it is introduced only a sufficient distance to ensure that it does not slip out again. Nevertheless permanent damage is undoubtedly done on occasion by the catheterization of an aseptic ureter across an infected bladder, and the cystoscopist would do well in such circumstances to pause and ask himself whether any useful purpose will be served by such catheterization or any information acquired which could not equally well be got from meatoscopy, the carmine test, and excretion urography. The writer has long held that catheterization of a healthy upper tract across a septic bladder is too light-heartedly undertaken by some surgeons.

Hæmorrhage.—*Microscopical* hæmorrhage is the rule following ureteric catheterization ; generally it is insignificant in quantity. It has this importance, however, that it renders the operation valueless for the detection of the origin of renal hæmaturia—which is unfortunate, as often meatoscopy also fails, owing either to the absence of hæmorrhage at the time of operation, or to its being insufficient to be appreciated by the eye as it emerges.

Macroscopical hæmorrhage may occur and may continue for a day or two. Occasionally it is copious enough to cause colic from small clots passing along the ureter. The most marked instances are seen when the instrument has been passed as far as the renal pelvis, and probably result from bruising of vascular papillæ. It is, however, rarely severe, but its occasional presence should be kept in mind, and special gentleness should be exercised when the tip of the catheter is approaching the renal pelvis.

Degree of Advancement of the Catheter.—From what has been said in the two preceding paragraphs it will be seen that the catheter should not be advanced to the kidney unnecessarily, for fear of causing hæmorrhage or sepsis. For the estimation of renal function, and especially where a septic bladder has been crossed, only a short length is necessary. When, however, the catheter is employed for excluding ureteric obstruction, it must be advanced right to the kidney. Also for pyelography it is customary to push the tip to the renal pelvis, though satisfactory distension is usually obtained, even when the catheter is obstructed in the lower ureter, by elevating the buttocks and allowing the solution to gravitate to the kidney.

CHAPTER XX.

STONE IN THE URETER.

DIAGNOSIS.

URETERIC calculi may be diagnosed by the following methods: (I) *Radiology*; (II) *Ureteric meatoscopy*; (III) *Ureteric catheterization.*

I. RADIOLOGY.

The diagnosis of a ureteric stone made by the X rays requires confirmation in all cases. This is especially true of stones within the limits of the bony pelvis. Shadows in this area may be very deceptive and demand much care in their interpretation. The radiographic evidence may be imperfect in two opposite directions :—

1. It may *fail to show* a stone when one is actually present. There is some discrepancy in the figures given by various writers of the percentage of failures to demonstrate a calculus in the X-ray diagnosis of ureteral stone. Braasch states that a correct diagnosis is made radiographically in only 60 per cent of cases, whilst Lange considers it possible to detect 95 per cent of stones, and Kümmel thinks that calculi of all sizes and of any composition should be detected. These latter opinions are contrary to common observation. Merritt, averaging a series of statistics, arrived at the conclusion that there are about 75 per cent of positive findings by radiography, which agrees approximately with one's own experience. It is obvious that the debit side in this account does not include cases in which the diagnosis of stone fails by all methods, but only those where the subsequent passage of the concretion or its discovery on exploration proves one to have been present. To this extent, then, the debit side must be augmented. Failures to the extent of 25 per cent may be considered important, though it should be observed that the smaller the stone the more likely it is to be missed and also to be evacuated naturally. In 15 cases (Geraghty and Hinman) where the X rays missed the stone the calculus was subsequently passed in 7, in 6 it was diagnosed by the wax-tipped catheter, and in the others by exploration. Failures occur with very small stones, stones permeable to the rays (uric acid, pure cystin, and xanthin), and with faulty radiographic technique. The cystoscopic features will be valuable under such circumstances.

2. On the other hand, an extramural shadow in the area of the ureter may be *mistaken for a stone.* Fenwick and Kidd investigated 30 bodies and found the following to be the most common fallacies: phleboliths, lymphatic glands undergoing calcareous changes, patches of atheroma in the blood-vessels, and appendical or intestinal concretions. To these may be added "calcareous deposits in old scars, or chronic inflammatory tissue, or on ligatures from a previous operation, or calcareous deposits in the seminal vesicles (*see Fig.* 191, page 307), intestinal contents such as scybala, foreign bodies in the bowel (Blaud's pill, etc.), fæcal matter coated with bismuth, calculi in the appendix, and enteroliths" (Thomson-Walker).

Phleboliths or 'vein stones' are the most fertile source of difficulty, and their great frequency increases their surgical importance. They are found in one of every five subjects over thirty years of age. Little was known of vein stones till the discovery of the röntgen ray, but after that it took a period of ten years (1908) before the origin of the shadows seen in so many plates could be determined—an interval in which many errors of diagnosis were made. In 1924 Culligan examined 1555 consecutive pelvic plates from the Mayo Clinic and found phleboliths in 39 per cent. The average age of these patients was 37 years, the youngest being 16. The sexes were affected in the proportion of 3 men to 2 women. Anything from one to twenty shadows might be observed, and in nearly half the cases they were bilateral. Phleboliths are usually rounded, though occasionally oval. They are rarely larger than a pea, have good and homogeneous density and sharply-cut margins. They occupy the pelvic area (vesicoprostatic venous plexus in the male, pampiniform plexus in the female) and therefore invariably lie in the ureteric environs. When multiple they often lie in chains, but a line joining them up will not correspond to the line of the ureter. If ovoid, their long axis often corresponds with that of the ureter, but multiple shadows will probably have varying axes.

Calcareous glands are generally seen along a line corresponding to the mesenteric root. They are commonest in the right iliac fossa and may frequently be found as low as the upper margin of the great sacrosciatic notch, being rarely seen in the pelvis. They are usually larger in size than an average ureteric calculus, often multiple, and occur in groups, whilst their shadow has an irregular edge and is very uneven in density, and mottled.

Various methods have been devised to supplement the X rays and to confirm the presence and effects of ureteric stones. Of these the most important are the shadow-casting bougie, pyelography and ureterography, and the wax-tipped bougie, which are dealt with later.

II. URETERIC MEATOSCOPY.

Ureteric meatoscopy may or may not provide evidence of the descent of a stone, but as a rule there is some recognizable change, which may take the form of: (1) *Alterations in the appearance of the orifice*; (2) *Changes in the character and speed of the act of ejaculation and in the nature of the efflux.*

1. **Appearance of the Meatus.**—When the stone first enters the ureter the lips *swell* and the orifice becomes rigid and patulous. As it descends the œdema increases. A rampart surrounds the opening, or numerous radiating folds choke the central ostium, which is with difficulty discerned. The swelling spreads to the trigone and inter-ureteric bar. In severe cases the whole trigone may be involved. At other times, especially when the stone is approaching the exit. bullous œdema occurs, large spawn-like masses occupying the situation of the ureter. In some infected cases in the writer's experience the ureter has prolapsed into the bladder like an everted coat-sleeve and appeared as a tower-like structure, the orifice being situated at the summit. (*See also* Chapter XIII, page 212.)

PLATE XIII.

A, Stone descending ureter. Hæmorrhage subjacent to orifice. B. Ureteric stone, ecchymoses around ureteric bar. Orifice small, and slightly œdematous trigone prominent. C, Stone presenting at orifice. A rampart of œdematous mucosa surrounds the orifice, which is slightly everted. D, The same stone seen in the bladder after extrusion. E, End of broken catheter in the bladder. Slight phosphatic deposit. Cystitis. F, Tip of hat-pin perforating apex of bladder. Slight cystitis.

Hæmorrhages occur around the meatus (*Plate XIII* A and B). At first, and especially when the calculus is high up, they are minute, multiple, and punctiform. They are situated chiefly over or near the intramural part of the ureter, the mucosa appearing to be stippled with bright-red dots. At other times stellate hæmorrhages, which are larger but less numerous, may be observed. Later gross extravasation takes place and may occur above or below the ureter, more commonly the former. The changes are more pronounced with spiculate stones than with smooth ones.

If the stone becomes impacted during its descent, the meatal manifestations generally recede, and may in part or entirely disappear. When the vesical section of the ureter is encountered the œdema and ecchymosis greatly increase, and a fusiform prominence corresponding to the underlying calculus may appear above and external to the orifice. The stone may halt here, and in some cases ulcerates into the bladder; or it may present at the meatus, where it appears as a dark or glistening object surrounded by a collar of œdematous mucosa

PLATE XIII.

STONES DESCENDING THE URETER. FOREIGN BODIES IN THE BLADDER

(*Plate XIII* C). When the stone escapes into the bladder cavity its presence there will be obvious cystoscopically (*Plate XIII* D), together with the bruised, prolapsed, and possibly lacerated ureteric orifice. The meatus soon commences its return to the normal, and in the course of a week or two all signs of damage may have vanished. At other times irregularity and scarring, together with either dilatation or contraction of the ostium, remain. The likelihood of permanent damage to the meatus is increased by the passage of multiple calculi. Occasionally when a stone occupying the intramural ureter ulcerates into the bladder a permanent false orifice may be left.

2. **The Efflux.**—Alterations in the normal characters and frequency of the efflux are various, according as the stone is impacted high or low or obliterates the lumen completely or only partially, but the wide variations in periodicity and volume which healthy organs present complicate the recognition of any deviation from the normal. When swollen, the lips of the meatus are incapable of their usual range of contractility, and appear torpid and immobile.

The *frequency* of the ejaculation may be increased or decreased. Increase is noticed when the stone is recently impacted and irritation is marked. After the obstruction has been present for a time, and especially when dilatation of the kidney, with or without infection, is in progress, the movement becomes feeble. When the stone is high up the ureter the efflux is vigorous and copious, but when it has descended to the lowest segment the output is lessened and enfeebled.

The *quantity of fluid* may be greater or less than the normal. When the duct is *completely* occluded no fluid can escape and ineffectual muscular contractions may be witnessed. An absent efflux is made more striking if indigo-carmine is issuing from the opposite ureter. Old-established stones as a rule obstruct the ureter only *partially*, and in the oldest examples channels may be seen on the stone along which the urine has trickled (*Fig.* 197, page 312). When the block is incomplete varying amounts of urine may be emitted, proportionate to the extent of the obstruction and that of the renal damage. It may be below the normal, but when there is chronic aseptic nephritis from back pressure, combined with a fairly permeable ureter, it may equal, or even exceed, the normal. Fullerton made a study of diuresis in cases of ureteric calculus, and stated, on the basis of some hundreds of observations, that there is a definite reflex polyuria on the affected side which passes off when the stone is got rid of. The jets follow one another in more rapid succession than on the opposite side and the quantity in each jet is larger in amount. The specific gravity of the urine is estimated by glass beads, and is found to be proportionately reduced. Thus it may be 1005 or less on the affected side as against 1015 to 1030 on the healthy side. Fullerton placed much reliance on these phenomena in diagnosis. With obstructions which are incomplete it will almost invariably be found that the output of indigo-carmine is delayed and its intensity is diminished.

The *efflux* may be clear and normal or may be blood-stained from the trauma to, and œdema of, the ureter. When infection occurs pus in varying quantity may be observed. It may be small in amount and scarcely evident or may be copious (*see* page 327). The worm-like stream shown in *Plate XIV* B, page 328, emerged from a calculous pyonephrosis.

III. URETERIC CATHETERIZATION.

Sounding the Ureter for Stone.—When a catheter or bougie is passed along a ureter containing a calculus it may be arrested (*see Fig.* 193, page 307), when its intravesical portion will be seen to curl up (*see Fig.* 188, page 296). Efforts to induce it to pass may or may not be successful. In many instances, however, the instrument negotiates the stone without the slightest hitch noticeable to the surgeon, and its subsequent progress along the canal is just as smooth beyond the stone as it was prior to encountering it. The temporary or final arrest of the bougie and a grating sensation as it rubs against the calculus have, however, been regarded as of diagnostic significance. The writer does not attach much value to these signs. Even when the catheter is obstructed it does not follow that a stone is responsible, as the stoppage of instruments is not peculiar to stone-bearing ureters (*see* page 296). This is especially true of the pelvic ureter; with obstruction higher up it is more significant. Further, it is quite rare to experience the sensation of friction between the stone and the catheter.

Auscultation of the Ureter.—This is of historical interest only. Newman employed a metallic sound which was connected to an earpiece worn by the operator. It was supposed to carry to his ear the sound produced by the impact of its metal tip on the calculus.

Wax-tipped Catheters.—Howard Kelly introduced his wax-tipped instruments in 1895, before the introduction of X rays, and his method has to some extent survived the competition of the latter. It depends upon the fact that when the wax encounters the rough exterior of the calculus its surface is scratched. The coat is composed of "dental wax and olive oil mixed together and melted in the proportions of two parts wax and one part oil. . . . This is poured into an open bottle holding an ounce, or into a test-tube, where it quickly solidifies. The waxing of the catheter is carried out by first melting the wax in the bottle and then dipping the point of the catheter into it, taking care not to occlude its eye. The wax should be distributed in an even, smooth coat. It hardens on the catheter immediately". The wax can be applied to the catheter at various places according to choice, the tip being selected in the olivary instruments, or a spot immediately behind one or more of the eyes. It has been suggested by Sampson that the whole of the catheter should be waxed so that the position of the stone may be judged by the extent of the scratching. In searching for scratches the eye should be assisted by a hand lens.

At first the method could be used only in the female and with the Kelly open-air cystoscope, as the wax receives a flat facet from contact with the lever or other metal parts if employed with the indirect cystoscope. Recently more attention has been given to this means of diagnosis, and Hinman and Keyes, jun., have devised ways of using it in the male and with the prismatic cystoscope. Several methods have been employed. The wax-bearing catheter may be introduced into the bladder first, and then threaded backwards into the cystoscope. It is possible then, with care, to manœuvre the waxed end into the ureter without contact occurring with metal surfaces. Another way is to introduce two catheters into the bladder, their tips covered by a single soluble capsule. One of the catheters is wax-tipped, the other not. They are threaded backwards into a double catheterizing cystoscope, and when the latter is introduced into the bladder the capsule is pushed away by the second catheter and left to dissolve in the vesical fluid. The wax-covered instrument is now fed into the ureter.

Keyes has shown that these complications are unnecessary, for the flat facet produced by the metal is easily distinguished from the scratches of a stone. The catheter is threaded backwards into the cystoscope and the wax tip is gently placed in the barrel. When the cystoscope has been introduced into the bladder the catheter is projected beyond the end of the lever before the latter is elevated so as to avoid bruising. Before it is introduced into the ureteric orifice the surgeon examines the wax surface as it lies in front of the cystoscopic fenestra, using the magnification of the lens in place of the above-mentioned hand lens. He makes a mental note of the surface peculiarities on the bulb, rotating the catheter on its long axis in order to bring all sections into view. The catheter is manœuvred into the ureter by manipulation of the cystoscope itself, the catheter remaining immobile in the sheath until engaged in the orifice. It is now passed up the ureter and withdrawn. It is again inspected under cystoscopic enlargement for scratches or other irregularities. It is withdrawn from the bladder *following* the cystoscope so as to avoid contact between the two, and is again examined, with the hand lens.

By this method a positive diagnosis can be arrived at in many cases where the X rays have failed to show an existing stone. Stones may, however, be missed by this method also, as shown by Geraghty and Hinman, and also by Keyes. The former nevertheless consider that this is the most accurate method of detecting ureteral calculi.

Shadow-casting Bougies and Catheters.—These are the most valuable accessory means of diagnosis at our command. When introduced along the ureter and exposed to the rays they show the exact situation of that tube and whether or not the suspected shadow coincides (*Figs.* 189–191). This gives important evidence of the relationship of the two structures. If further testimony is desired, stereoscopic plates may be taken, or, as suggested by Kretschmer, two exposures from slightly different positions may be given, in order, if possible, to divorce the two shadows (*Fig.* 192). Occasionally none of these manœuvres is successful in suspicious cases, and Bransford Lewis has recommended the passage of a rigid instrument, as, for instance, his dilator shaft, which straightens out the ureter, making it take a different course that separates it from phlebolith and other shadows. The stiletted catheter may sometimes serve the same purpose. If the instrument is obstructed by the calculus, the shadow of the latter will be seen to cap that of the former (*Fig.* 193).

If, prior to the passage of the catheter, a plate be exposed whilst the patient is on the cystoscopic table, and a second be taken immediately after catheterization, the patient not having moved, the stone's position on the two negatives can be compared. Pozzi and Proust have shown that a second photograph will indicate that the instrument has driven the stone up the ureter to a greater or less extent.

Pyelography and Ureterography. — A shadow-casting ureteric catheter is nowadays invariably preferred to a bougie, so that advantage can be taken of its presence to fill the kidney pelvis with sodium iodide. On radiography it will show the extent of dilatation of the kidney pelvis and ureter (*Figs.* 194, 195, 197). Even when the catheter cannot be passed beyond the stone, the fluid will generally gravitate into the renal pelvis, especially if the buttocks are raised. It may also outline the contour of a stricture of the ureter. In this way the degree of dilatation of the renal pelvis and ureter can be ascertained. The onset of dilatation is important and should not be allowed to advance far without operative interference.

Sometimes, when a stone shadow has not been seen on the first X-ray plate, the ureterogram will show an area of decreased density within the shadow of the filled ureter, indicating the presence of a stone transparent to the X rays. The proximal ureter may be dilated. Both these conditions are illustrated in *Fig.* 195. Graves has reported two such cases, in one of which the calculus was of cystin. Stevens has reported a similar occurrence, the stone being of urates, and

Fig. 189.—Two stones in ureter. Relation of shadow to ureter made evident by opaque bougie.

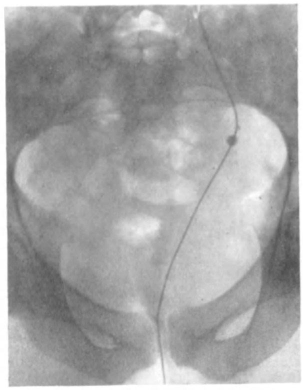


Fig. 190.—Opaque bougie in ureter. Portion of the stone has been chipped off by bougie and lies ¼ in. above the main stone.

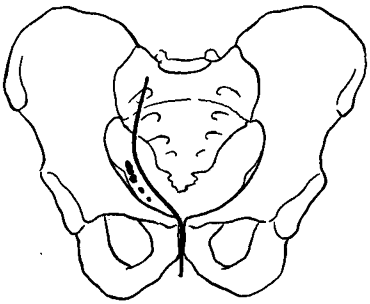


Fig. 191.—Calcified deposits in a seminal vesicle, an important and quite common finding which in many instances indicates healed tuberculosis.

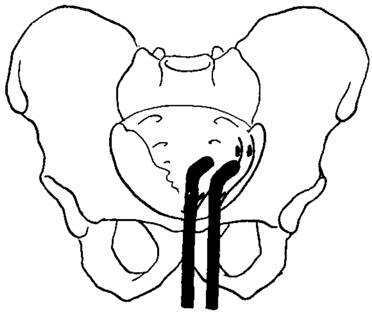


Fig. 192.—Two exposures on a single plate with different tube positions. Relationship of shadows of the stone and the catheter is constant.

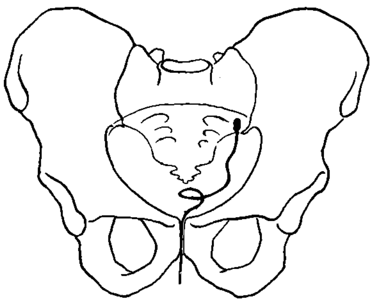


Fig. 193.—An obstructed catheter capped by a stone.

instances of the same phenomenon occurring in the renal pelvis are not very uncommon.

The ureter is a very mobile tube capable of a range of movement of 1½ or perhaps 2 in. on each side of its customary position. Pressure on a ureteric catheter often displaces the ureter widely in the retro-peritoneal connective tissues, with the result that it may be seen over the spine internally, or well outside the psoas shadow externally. The deduction that peri-ureteral adhesions are present at the position of a stone can sometimes be made when a catheter tip

Fig. 194.—Almond-shaped stone just below the brim of the true pelvis. Note the hydronephrosis and the hydro-ureter and the hold-up of the contrast fluid by the stone.

meets a stone and the ureter proves to be unyielding at that site although below that point it has shown its customary mobility (*see Fig.* 195).

Accentuation of the Stone Shadow.—When a faint indeterminate radiographic shadow is seen in the line of the ureter it can sometimes be accentuated by the introduction around it of sodium iodide or bromide solution, which adheres to and impregnates its surface, and so accentuates its shadow. Before exposing the plates the excess of solution must be allowed to drain away. We owe the method to

Kümmel, and it is valuable in selected cases. In such cases it appears probable that the stone is enveloped in a membrane which absorbs and retains the opaque solution.

Execretion Urography (*see* Chapter XXVI) can play an important rôle in the diagnosis of ureteric calculi and is especially valuable when it is impossible to obtain an ascending ureterogram. Always given a sufficiency of excretory power on the part of the kidney, descending urography will exhibit :—

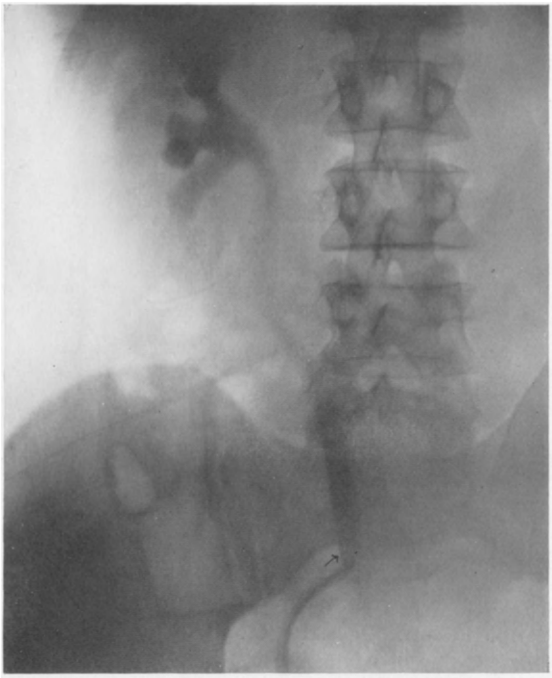


Fig. 195.—Case of persistent right-sided renal pain. Straight X-ray negative. Carmine test showed delayed excretion on the right side. Ureteric catheter refused to pass beyond sacro-iliac joint. Note the wide excursion of the catheter below and its immobility at the catheter tip, which suggests peri-ureteric adhesions (cf. mobility seen in many urograms, e.g., *Figs.* 237, 242, 248, 251, 268, etc.). Filling defect just above catheter tip due to stone of poor radiological density. Dilatation of the channels above this point.

1. The coincidence of the ureteric shadow with that of the stone. The shadow of the ureter is generally sufficiently strong to convince, especially when there is

2. A hold-up of the contrast solution above the stone. If this feature is well developed the shadow of the reagent becomes richer

and richer as time passes and more of the dye is secreted (cf. *Figs.* 294, 295, page 455).

3. The degree of dilatation proximal to the calculus.

4. By showing the line of the ureter and the absence of morbid change in that tube, excretion urography will rule out extramural shadows that were regarded as possible stones.

All these points are well shown in *Fig.* 196.

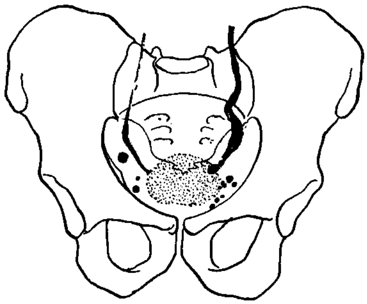


Fig. 196.—Stone in intramural part of left ureter. Tracing from an excretion urogram. *See* text above and also contrast the ureteric shadow on the two sides.

TREATMENT.

A ureteral calculus may be treated expectantly, by open operation, or by cystoscopic manipulation. Many stones, if left to themselves, will descend the ureter without assistance (different writers estimate them between 50 and 95 per cent), and though this is a painful process, some time should be allowed to elapse before active measures are undertaken to aid or to remove them. Ureteric and pelvic dilatation are important indications for interference, and as the onset of these is likely to occur within three or four months, expectant treatment should not be prolonged beyond this period.

Choice of Methods.—Unanimity has not yet been arrived at amongst surgeons as to the relative values of open and cystoscopic means of treating ureteric stones. Non-operative procedures are much more the vogue in America than in this country or on the European continent. It is true that a very high percentage of successes is claimed, but in some instances this is at the cost of prolonged and distressing treatment, and the ultimate result is uncertain right up to the time when the stone is finally shed into the bladder.* In

* In penning this section the writer has been anxious on the one hand to do justice to these modern and undoubtedly valuable means of perurethral treatment, whilst on the other hand he recognizes his responsibility in recommending procedures which are not entirely devoid of danger and which require considerable experience and judgement in their selection and execution.

contrast to this, operative methods have the advantage of certainty and a convalescence of known duration. The ureter heals well and fistulæ are, in my experience, unknown. The following factors will influence the choice : (1) The size of the stone ; (2) The radiographic appearance of the stone ; (3) The urographic evidence ; (4) The time the calculus has been impacted ; (5) Its position ; (6) The condition of the kidney ; (7) The tolerance of the patient to cystoscopic manipulation.

1. *The Size of the Stone.*—The vast majority of small stones can be relied on to descend of their own accord, or to be amenable to cystoscopic manipulation. The passage of an opaque catheter, used in diagnosis, has in many of my cases been sufficient to precipitate their discharge. Open operation should not be employed for little calculi, as the majority will come away under cystoscopic persuasion. It is difficult to fix an arbitrary line dividing those stones which are suitable for this form of treatment from those which should be subjected to open operation, but it may be said that calculi the size of a cherry stone will have a reasonable chance of success, whilst still larger ones have been evacuated under dilatation.

Some observers believe that a spinal anæsthetic itself stimulates the ureter to discharge a small stone in the same way that it sometimes acts magically in unloading a paralysed intestine; and indeed it is no uncommon thing to administer a spinal anæsthetic for cystoscopic dilatation or other operation only to find, on looking inside, that the stone is already in the bladder.

2. *Its Radiographic Appearance.*—Spiculated stones descend with greater difficulty than smooth ones and spiculation is often evident on the radiogram (*Fig.* 197). Surgeons experienced in open operations on such stones know well that they may be firmly embedded in the ureteric mucosa and that even when fully exposed they are dislodged with real difficulty, the mucosa having to be peeled off the stone in many cases. It would appear unreasonable to expect this type of stone to pass spontaneously, nor is it likely to be easily influenced by cystoscopic methods. An irregular dentated margin on the radiographic shadow signifies an oxalate stone which is probably adherent, and this fact must be taken into account when making a choice between open and closed methods of attack.

3. *Urographic Evidence.*—This will indicate what is happening above the obstructing stone. The presence or absence of symptoms is no safe guide to what is going on. Colic, of course, means that the ureter is making efforts at expulsion, and in view of this it should not be too actively combated by morphia, etc., lest its efforts be lost. At the same time it means that there is injurious back pressure on the kidney. After an attack of colic the practice of taking fresh

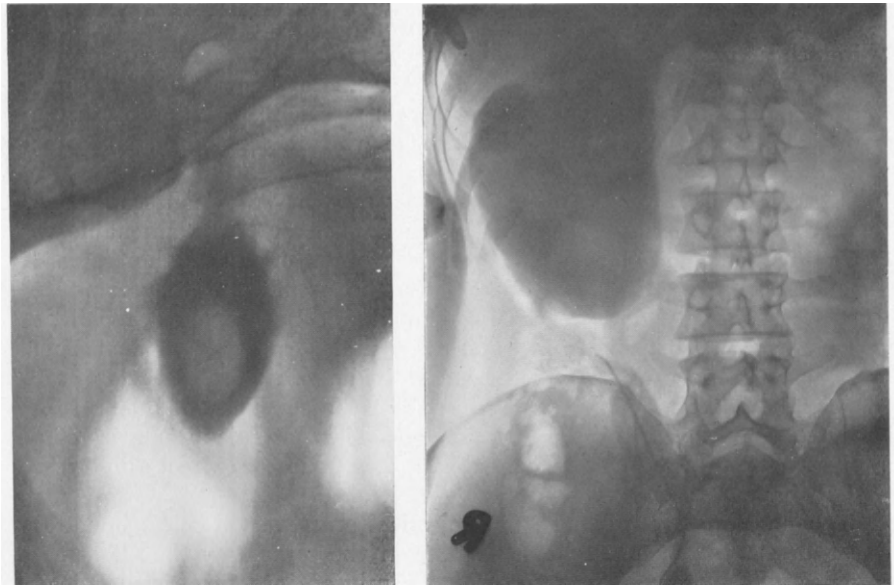
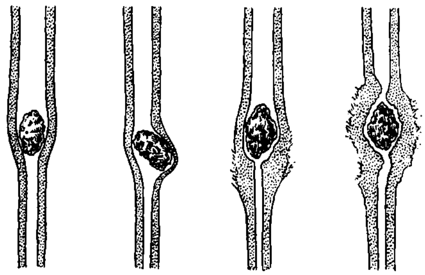


Fig. 197.—A ureteric stone of unusual size, particularly as most of it is of the primary variety. The straight radiogram shows that the nucleus lies near the lower end and is relatively transparent to the rays, probably chiefly uric acid. Other parts show greater density—lamination. The bosses seen on the operative specimen can be recognized on the radiogram. They consist of oxalates (mulberry calculus). Note channels on the stone. Such channels are often seen and help keep the passage for urine open. A triangular peak of triple phosphates caps the stone. It indicates the recent onset of infection with a urea-splitting organism, and suggests an increase of symptoms which possibly brought the patient for advice. The position of this cap and also the situation occupied by the original uric acid nucleus illustrate how a ureteric stone grows by addition to its upper end, i.e., against the stream of urine. Three kinds of salts are recognizable at different stages in the production of this stone: urates and oxalates (primary), triple phosphates (secondary—infective). Urogram shows a large pyonephrotic sac.

radiograms to see if the stone has moved is to be recommended, and in this way I have many times watched the steady or uneven progress of a stone. Similarly at an interval after ureteric catheterization or other perurethral manipulation it is well to take new skiagrams to check progress.

Yet a calculus which gives no symptoms cannot be trusted to be doing no damage. The silent stone is a proper object of suspicion, for its capacity to produce an equally silent destruction of the kidney is notorious. Not a few stones, indeed, are so completely symptomless that their presence is unknown, and when eventually, perhaps accidentally, discovered it is quite customary to find that the corresponding kidney is entirely destroyed and is represented by a functionless hydronephrotic sac. It will be seen, therefore, that neither with the silent nor with the pain-producing stone is it safe to leave well alone. Each must be carefully watched for evidences of pelvic or ureteric dilatation by periodic urography (ascending or descending, according to choice) and at the first sign of this they should be dealt with *secundum artem*.

4. *The Time the Stone has been Impacted.*—Calculi which have been impacted at one spot for a long time may be surrounded by peri-ureteral thickening and have a subjacent stricture, and this latter may be indicated by the ureterogram. It is often quite easily overcome by dilatation. A close inspection of the ureterogram may, on occasion, arouse a suspicion of diverticulation (*Fig.* 198 *b*) which should be an indication for open operation. Such stones occasionally perforate the ureter (Berry, Marion, etc.), and this would be rendered specially probable when that tube was undergoing dilatation. It may be again asserted that the medical adviser should not acquiesce in leaving a stone for more than a limited period of time, say a maximum of six months. After this, some form of removal must be advised to save the kidney from the results of back-pressure and possible infection. *Fig.* 198 illustrates various ureteric states associated with the presence of a stone in its lumen.



a *b* *c* *d*

Fig. 198.—Ureteric calculus. *a*, Recent impaction; *b*, Older impaction, with some local thinning and bulging of the wall of the ureter; *c*, Old impaction—stricture below the stone, peri-ureteritis and adhesion; *d*, Old impaction—additional stricture above the calculus. In all cases there is dilatation of the proximal ureter.

5. *The Position of the Stone.*—The higher the stone lies in the ureter, the more accessible it is to open operative treatment. A

calculus at the ureteropelvic junction should be submitted to pyelotomy, as it is, for all intents and purposes, a renal stone. But a stone lying at or anywhere above the pelvic brim is easily removed by operation and, in my opinion, should, unless quite small, be dealt with promptly before it passes over the brim, for every further advance renders it more inaccessible to open methods and at the same time puts it in that section of the ureter where permanent impaction is most frequently observed. To coax a calculus by transvesical manipulation down into that problematical zone, the juxtavesical ureter, seems to me unsound policy. It is taking an undesirable risk, even though, of course, practically all such stones are eventually either passed or recovered by some surgical means. If a stone when first seen has already reached this part of the ureter, it is in the position where, on the one hand, open operation is most difficult and, on the other, cystoscopic removal is most suitable and effective, and the latter should therefore be given a trial in the first place. Judd says that cystoscopic technique is here so successful that in the majority of cases of stones in the lower third of the ureter it must be considered the treatment of choice.

6. *The Condition of the Kidney.*—In old and advanced cases the kidney will often be reduced to a pyonephrotic sac, as evidenced by pyuria, fever, a swelling in the loin, the general urological investigation, etc., and on this or other account will require removal, when the two conditions will be best treated simultaneously by open operation.

7. *The Tolerance of the Patient to Cystoscopic Manipulation.*—Though it is possible in some cases to obtain a successful result with a single cystoscopy, several may be necessary, and some patients are unsuited temperamentally to tolerate such interference.

TECHNIQUE OF VARIOUS PROCEDURES.

Dilatation by Ureteric Catheterization.—As before stated, the passage of a single bougie or catheter for diagnosis is often enough to dislodge a small or recently impacted stone, and to cause its passage within a few hours or days. Catheters may, however, be left in the ureter indefinitely. Bugbee by catheterization alone claimed success in 326 patients out of a total of 347, and Crowell, by this method combined with the injection of antispasmodics and analgesics through the catheter, induced the descent in all but 7 of 140 consecutive cases. Failure to make the catheter pass the stone is very rare if the ureter is first anæsthetized with one of the derivatives of cocaine, which eliminates spasm and pain. The catheter is left *in situ* for twenty-four or forty-eight hours, the urine passing through its lumen.

Generally twelve hours will suffice to promote the expulsion of the stone, which, however, is then associated with severe colic. If the catheters remain in position for forty-eight hours or more, the descent is painless, or practically so. The present tendency is to shorten the duration of catheterization to about five hours and to increase the period between treatments. A catheter left *in situ* for some time may cause bleeding. Clots then block the catheter and there is ureteric obstruction and colic. The catheter should be immediately removed for it is not feasible to syringe away the clots without further distending the pelvis and thus making matters worse.

When the surgeon fails to get past the calculus, the catheter is allowed to remain with its tip in contact therewith. After a day or so the obstacle can then usually be negotiated. Once beyond the calculus, an ascendancy has been gained over it which will probably end in its natural expulsion. This also happens occasionally, though less frequently, when the catheter has failed to slip beyond the obstruction. Whilst the catheter is in position the separated urine can be collected and examined and the kidney's function be estimated.

If a small catheter has been employed to pass the stricture, it may be replaced periodically by larger ones until a No. 11 Charrière is passed, the Joly or Buerger instrument being necessary to accommodate this size. The ureter is a thin-walled tube and very distensible; it is more easily dilated than the urethra. Crowell increases his dilatation until two No. 11 catheters and one No. 6 have simultaneously been inserted into the canal. The No. 6 is introduced through a No. 15 child's catheterizing cystoscope because the male urethra will not admit two No. 11 catheters and a single catheterizing instrument. In the female, however, three No. 11's can be used. The ureter can thus be greatly dilated. The process is painless, and after the first dilatation the patient often states that his discomfort has vanished. A ureter thus widened will generally relax its grasp on the calculus, especially if various supplementary remedies (*see below*) are employed to assist it. The physical difficulties of introduction are, however, not always easily overcome, and the friction of the catheters against each other may be considerable. It is often impossible to pass the third or even the second instrument more than a few centimetres up the ureter. Sometimes the stone has been pushed back into the renal pelvis by the catheters, but it quickly re-engages in the dilated channel on their removal and is generally evacuated.

The Injection of Drugs through the Catheter.—This method has been much employed and is often very effective. The value of cocaine derivatives to overcome spasm in the neighbourhood of the stone when passing the catheter has already been referred to. After having surmounted this obstacle, drugs are still useful and fall into three categories :—

1. Those employed in quantity to irrigate the renal pelvis and help to mobilize the stone mechanically. They generally contain some antiseptic, as boric acid (sat. sol.), flavine (1–1000 in aqueous solution), or mercurochrome (1 per cent in normal saline). Oxycyanide of mercury (1–3000), has also been recommended, but the writer has on more than one occasion seen severe albuminuria result from its use.

2. Those having a lubricating action, of which paroleine (pure liquid paraffin), olive oil, and glycerin are the most used.

3. Drugs having an antispasmodic and anodyne action. Papaverine sulphate (4 per cent) had a vogue at first, but novocain (4 per cent) or procain (novocain-Metz) (5 per cent) are now held to be the most serviceable. They control pain, which is much appreciated by the patient, and they overcome spasm, which is very important in en-

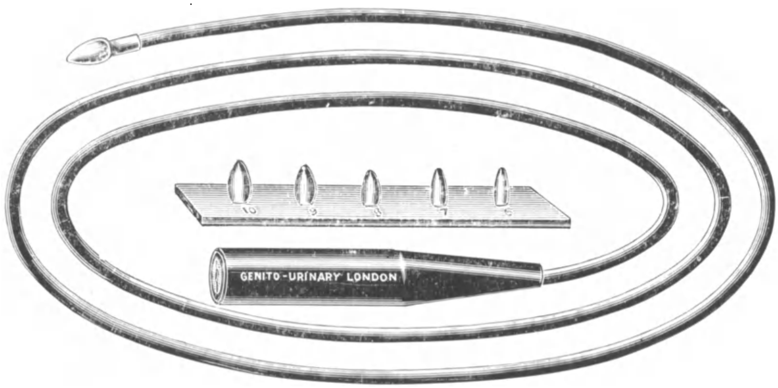


Fig. 199.—Buerger's dilating olives.

couraging the extrusion of the calculus. I find that a calculus rarely moves so long as the catheter is *in situ.* Before withdrawal the ureter should be re-anæsthetized and the pelvis distended with fluid in order to propel the stone along the canal. If sterile olive oil or paroleine is used for this purpose, its lubricating qualities will be valuable, whilst its viscosity will mechanically aid the progress of the calculus.

It is found in practice that there is difficulty in maintaining perfect asepsis of the external end of a ureteric catheter which has been *in situ* for long. Should any doubt exist as to its sterility, intra-ureteric medication must not be risked. I regard this as a principle, the importance of which can scarcely be overstated, but to which sufficient attention is not paid.

Graduated Metal Olives.—Buerger has introduced graduated metal olives for dilatation of the ureter (*Fig.* 199). They vary from

6 Fr. to 20 Fr. in size, and are used with the operating cystoscope. They screw on to the end of a No. 9 Fr. silk ureteral catheter which serves as insulation for a wire cable, the proximal end of which carries a coupling for connection to the diathermy machine. The largest olive is flattened to permit its exit through the fenestra of the cystoscope. The bipolar diathermy current in small doses has the effect of relaxing smooth muscle, and therefore dilates such a tube as the ureter. A small olive is first employed. It is passed up the ureter until obstructed, when 300 to 400 milliampères are brought into action, gentle pressure being maintained against the impediment. This usually yields, and the process is repeated with successive sizes of olives. In many cases the stone is expelled in a few days. The procedure is not without danger, and the utmost care must be exer-

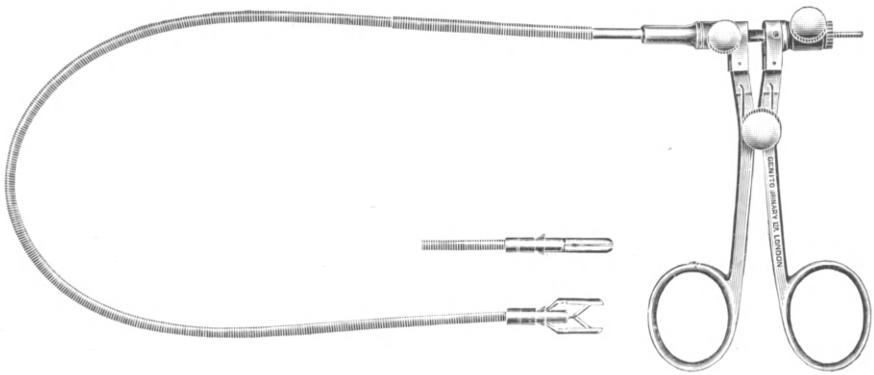


Fig. 200.—Bransford Lewis's ureteral dilator.

cised in the use of diathermy, as too strong a current will give a ureteral burn which may lead to perforation or a stricture.

Dilatation by Means of Special Instruments.—Historically this is the first group, for Simon, of Heidelberg, in 1865 suggested ureteric dilatation, and Nitze early invented a ureteric catheter having near its tip a membranous balloon capable of air distension through the lumen of the catheter. This instrument was improved upon by Jahr, but both are now obsolete.

Bransford Lewis has made a neat little dilator (*Fig.* 200) similar in principle to the straight Kollmann's urethral dilator and manipulated from the exterior by a cable. It is specially useful in the intramural ureter, but is also employed at greater heights—4 or 5 in.—whilst Crowell has used it up to the renal pelvis. The writer would hesitate to employ it except in the last inch and a half of the duct. By it dilatation can be effected up to 24 Charrière. It is the most serviceable of all the mechanical dilators.

Laminaria tents, oval in shape, 1 in. long and No. 10 Fr. in size, and having a central bore for the passage of urine from the kidney, have been employed by Canny Ryall in the lowest inch of the ureter, and have been left *in situ* by him for twenty-four hours. A ureteric probang similar in principle to that used in the œsophagus has been invented to withdraw calculi from the ureter. It does not seem to the writer to be a safe instrument to employ in this delicate tube.

Other instruments also have been invented and much ingenuity is shown in some of them. But whenever using any of these mechanical devices in the ureter the operator must ask himself whether he is satisfied that they will be safely and easily withdrawn (Yates Bell), for there are instances recorded in which they have jammed, and this, it goes without saying, is a serious accident.

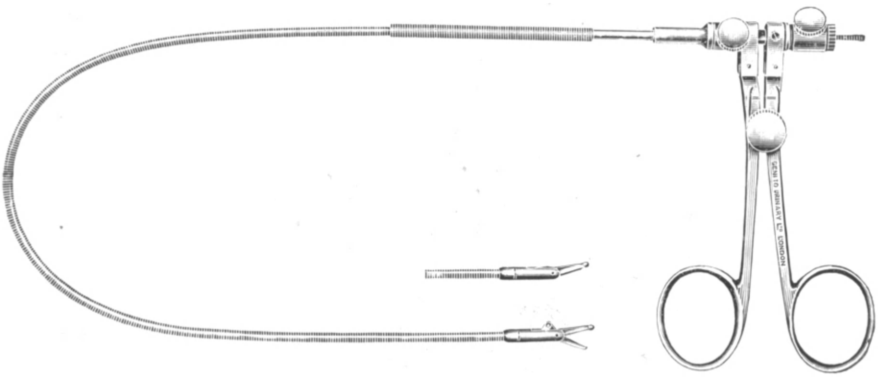


Fig. 201.—Buerger's scissors for use with operating cystoscope.

Ureteric Meatotomy.—Incision of the ureteric ostium with scissors or cautery is very valuable on occasion, and may be employed to liberate a stone in the lowest section of the canal or as a preliminary to instrumentation of the more distant ureter. This is the narrowest portion of the whole tube, being about $\frac{1}{10}$ in. broad as contrasted with the central portion, which is about $\frac{1}{4}$ in., and the renal outlet, which has a diameter of $\frac{1}{7}$ in. (Sinclair White). Jeanbrau in 204 cases found 51 per cent of stones in the pelvic ureter, whilst Bugbee found 86 out of 107 ureteral calculi in the lowest twelve centimetres and 65 in the lowest six centimetres. He states that few pass through the lowest three centimetres of the ureter without becoming impacted at least temporarily. Braasch and Moore have shown that stones arrested in the ureter do not lie immediately above the narrow section, but a short distance away.

The scissors illustrated in *Fig.* 201 is passed through one of the more capacious cystoscopes—Swift Joly or Buerger. One blade is introduced into the ostium, and the upper wall of the latter is slit up to an extent which appears through the cystoscope to be about one inch in length. It may be difficult to insert the blade if the stone is very close to the orifice. In practice these scissors prove to be fragile and the first or second incision is likely to be inadequate. Hæmorrhage then clouds the field and hinders further progress. Bleeding is occasionally very severe and distension of the bladder with clots is not unknown.

Diathermy, or better, endothermy (*Fig.* 202) of the anterior wall of the intravesical ureter is easy, and the extent of the incision is

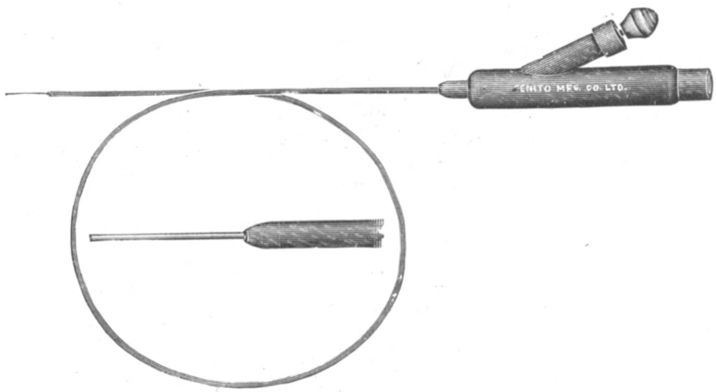


Fig. 202.—Electro-surgical meatotome with fine platinum cutting point which can be withdrawn into the insulating sheath.

under more accurate control than is the case when cold cutting instruments are employed. As hæmorrhage is absent the operation can be performed deliberately. When the stone actually presents at the opening (*Plate XIII* C, page 302, and *Fig.* 203), or when it is lodged immediately above, as evidenced by an oval swelling on the course of the ureter, the electrode may be employed directly over it. When it is an inch or so higher and the incision is a preliminary to subsequent instrumentation, a bougie should first be passed into the ureter in order to make a rigid salient against which the electrode can be applied and to guard the lower wall of the canal from injury. If diathermy is used, a week or more is required for the separation of sloughs, so that the stone is not so immediately liberated as when the cutting current or scissors are employed. For this reason, when

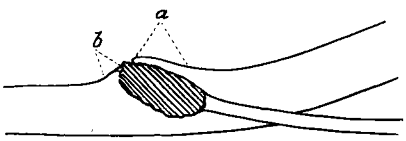


Fig. 203.—Sites for application of electrode when a stone impacted at the meatus is being released by diathermy. *a* is the usual and more important position.

dealing with urgent cases, especially with calculous anuria, diathermy is inferior to the cutting current or scissors.

Moore has devised a ureteral meatotome in which an electrical knife, shaped something like a rhinoceros's horn, projects upwards from a point near the tip. When passed into the ureter this projecting electric knife is made to cut the ureteral lip.

Extraction by Ureteral Forceps.—Forceps (*see Fig.* 129, page 205) are made on the same principle as the scissors, and by them a stone can sometimes be extracted from the ureteric orifice after incision, and then withdrawn from the bladder. However, if left to itself, the stone shortly falls free into the vesical cavity and is evacuated naturally. The forceps are really unnecessary, and perhaps a little meddlesome.

CALCULOUS ANURIA.

Albarran in 1901 originally suggested ureteric catheterization as a method of relief for calculous anuria, but Cimino in 1903 was the first to put it into practice successfully.

Diagnosis.—When confronted with a case of anuria, it is first of all necessary to satisfy oneself that the anuria results from a ureteric stone, and then to determine the respective part played by each kidney. The diagnosis and treatment should be undertaken promptly, for though several days may elapse during which the patient appears to suffer no inconvenience from the absence of his urinary secretion (period of tolerance), it has been shown by Huck that the operative mortality increases steadily with each day that is lost.

The diagnosis is made by symptomatology, by X rays, and by the cystoscope. In the commonest class of case where one kidney is destroyed by old-standing calculous disease, a lengthy history of unilateral renal ache, extending back over a number of years, can usually be elicited, and in addition to this there is a recent history of a sudden attack of pain on the opposite side. This latter, however, is by no means constant, as the recently plugged ureter may be silent or the pain so slight as not to excite comment apart from direct inquiry. The X rays and excretion urography should be employed at the earliest possible moment, and will generally show extensive calculous destruction of one kidney, and a shadow, usually small, in the opposite pelvis or ureter, whilst meatoscopy may reveal some of those changes already described as characterizing the presence of a stone freshly impacted in the ureter—ecchymoses, œdema, hæmaturia, etc. Where one ureter is plugged by a stone and the opposite kidney is congenitally absent, the corresponding meatus may also be missing (*see* page 352).

Object of the Catheterization.—The side to which catheterization must be applied is that one containing the newly impacted stone, as shown by the recent pain, by the X rays, and by the cystoscopic picture. It is hoped that the tip of the instrument will negotiate the stone, and thus be able to drain the renal pelvis. If this is successful, the anuria is immediately relieved. In some cases, however, it is impossible to get beyond the obstruction, but, even so, the stone may be displaced by the catheter and relief may thus be obtained, or the injection of paroleine may mobilize it, whilst novocain injected around it may overcome the ureteric spasm.

If the ureteric catheter reaches the kidney, it will tap a distended cavity, though occasionally it finds the pelvis empty. In the former case there is an immediate flow of urine from the catheter, but in either case as soon as the obstruction is relieved the kidney starts to secrete urine, and in a very short time a profuse polyuria occurs. It is wise to aid this polyuria by copious draughts of water or by intravenous infusion of salines.

Having obtained relief from the anuria, it must be decided how long the catheter shall be left in the ureter. By leaving it *in situ* for some time we guard against the danger of an early recurrence of the suppression—an occurrence which has been found very prone to take place when the catheter is removed. Moreover, if it remains in the ureter it will dilate that channel, thus preparing the way for the spontaneous evacuation of the stone. The rules already laid down for the management of ureteric stone will guide the surgeon, save that, in view of the greater dangers associated with anuria, he will adopt radical operative measures at an earlier period than would be necessary if the other kidney were functioning. Ureteric catheterization in calculous anuria may therefore be regarded as a temporary measure to gain relief before open operation is performed, or it may be looked upon as an end in itself, and as a means of obtaining the actual expulsion of the stone. It is a measure of less severity than open operation, but should not be persisted with unless it immediately meets with some degree of success.

RENAL COLIC.

The ureteric catheter has occasionally been used as a means of overcoming renal colic. As soon as the catheter is in position it evacuates the contents of the renal pelvis and the pain disappears. If it proves impossible to pass beyond the stone or other obstruction, the colic can nevertheless be controlled by injecting novocain (5 per cent) around it, and thus obtaining relief of the ureteric spasm. When the spasm is overcome the catheter may be able to continue its progress to the renal pelvis. Once in position, the catheter may be employed in the location of the obstruction by ureterography or as a shadow-casting instrument. It may also be retained *in situ* with the object of procuring ureteric dilatation and the spontaneous evacuation of the stone. In view of the exquisite pain of renal colic, of the fact that it is not always controlled by morphia or other drugs, and of the success which often attends catheterization, it would appear remarkable that this remedy has not been more extensively applied.

CHAPTER XXI.

DISEASES OF THE KIDNEY.

THE cystoscope is very important in the diagnosis of surgical disease originating in the kidney. It is at first called on to help in the location of the primary disease and subsequently to decide whether the other kidney is similarly or otherwise diseased, and especially whether it would be capable of doing the work of the body unaided. In undertaking these tasks, however, the cystoscope must not be relied upon exclusively; all the other clinical data which have been collected must be considered in conjunction with the cystoscopic findings.

In the present chapter we shall study the modifications met with at the ureteric orifices in disease of the upper urinary tract, and then the part played by ureteric catheterization in diagnosis. In Chapter XXIII methods of examining the renal function will be described. Urography, which is closely related to these subjects, will be dealt with in the final chapters.

URETERIC MEATOSCOPY IN RENAL DISEASE.

This section of the investigation aims at the localization of the primary focus of the disease. If the previous steps in the inquiry have failed to throw light on this question, meatoscopy may supply the only evidence available up to the present, but it also may fail, when ureteric catheterization and urography will be indicated. The description will consider: (I) *Changes in the meatus itself*; (II) *Changes in the efflux*

I. CHANGES IN THE MEATUS.

Congenital Abnormality.—Chapter XXII is devoted to a description of the congenital malformations of the urinary system, but attention will here be drawn to a few of their more important cystoscopic features. An indication of congenital abnormality in the urinary tract is sometimes supplied by meatoscopy. It may take the form of absence, displacement, or duplication of the orifice, or of congenital increase or diminution in its size.

Absence.—When the ureter is absent a careful search will prove fruitless. The cystoscopist must then decide whether it is indeed absent or is displaced, or whether he has failed to recognize an orifice which for some reason is not easily detected. After the usual site has been carefully examined, the ureteric and interureteric bars are closely scrutinized. Indigo-carmine (Chapter XXIII) may help to indicate the position of an orifice which might otherwise escape discovery. Rarely the ureter opens in the posterior urethra and may be recognized by urethroscopy.

Duplication.—Two orifices may be found on one or both sides (*Plate XIV* E). The relationship of a double orifice to duplication of the upper tract will be discussed in Chapter XXII. Without exception it indicates duplication of the whole of the corresponding ureter, and of the renal pelvis, and may or may not be associated with a double kidney.

Congenital Dilatation.—This is a well-recognized ureteric condition. A large gaping orifice is seen through the cystoscope, and the dilatation of the ureter and pelvis, which is generally excessive, can be demonstrated by uretero-pyelography (*Fig.* 257, page 413), or more simply by cystography, the opaque bladder fluid regurgitating past the incompetent valve (*Fig.* 258, page 413).

Congenital Diminution.—Orifices of less than usual size have been noted in the chapter on the normal bladder (*Plate II* A, page 72). They are quite common, but are almost invariably functionally adequate. Congenital inadequacy of the orifice is probably the cause of ureterocele (*see* Chapter XIII).

Inflammatory Changes.—Renal infection of mild degree may occur without there being any visible alteration at the meatus. If the ureter is also inflamed, its vesical extremity will show some evidence of the disease. It often happens, however, that the bladder too is involved in the process, and its redness and swelling mask that which results from the ureteric change, the redness of the meatus being then no greater than that of the remainder of the vesical wall. If the alterations are localized to the ureter and its immediate environs, or if they are greater there than would be accounted for by any neighbouring cystitis, they are evidence of uretero-pyelitis, and are important indications of the origin of the trouble. If the bladder mucosa is uniformly reddened, an abnormal efflux may throw light on the question, but otherwise meatoscopy will fail to locate its source.

The earliest indication of infection is a slight *redness* around the opening. This deepens in colour, extends, and becomes associated with œdema. *Œdema* occurs as a uniform swelling of the meatal margin, which may or may not extend to the surrounding bladder wall. The lips may become thickened, rigid, and immobile. It may also occur in the form of *bullous œdema.* This is very common and varies much in development. One or two minute 'water blisters' may be seen on the ureteral margin, or the whole area may be covered by clusters of diaphanous vesicles (*Plate III* C, page 80).

Ulceration is rare, except as a sign of tuberculous disease (*see* Chapter VI).

Epithelial Proliferation.—In long-standing chronic cases heaped-up masses of pale epithelium are occasionally seen on the margin of, and around, the orifice (*Plate XIV* C). In acute cases the red œdematous mucosa may encroach on the meatus, but this is rather a result of the associated cystitis than a ureteric change.

Miscellaneous Changes at the Ureteric Orifice.—

Ureteric Catheterization.—For several days after this procedure the meatus is slightly hyperæmic and swollen. Sometimes a few ecchymoses may also be seen. It soon reverts to the normal condition, however, but should the catheter have been long in position the changes are more pronounced and subside more slowly.

Operation.—After incision of the upper ureteral wall with scissors or diathermy some permanent deformity invariably remains, there often being some loss of tissue. Generally a gutter-shaped orifice with irregular margins results, the ureter debouching higher than usual. When a ureter has been resected and reimplanted in the bladder, it as a rule occupies an abnormal situation. It then appears as a pinkish, rigid orifice of small size and circular shape, and is surrounded by a paler area consisting of scar tissue.

Dilatation of the Orifice.—This occurs in cases where there has been back-pressure from prostatic hypertrophy or stricture, but in my experience it is often absent, and is generally not very obvious through the cystoscope, even when the valve mechanism is clinically incompetent and allows regurgitation of urine up the ureter. After the removal of the sac of a ureterocele by open operation or by diathermy the resulting orifice is patulous and the ureter and pelvis are dilated. When a tuberculous ureter has healed following nephrectomy it may remain gaping and rigid.

Tumours.—Growths arise frequently on the edge of the ureter. If of any size they may cover the opening. *Plate VII* E, page 150, shows a papilloma which actually originated in the ureter and mushroomed into the bladder cavity. Such a neoplasm is rare. It may be primary in the ureter itself or an implantation secondary from a similar papilloma of the renal pelvis (*see also* pages 166–170).

II. CHANGES IN THE EFFLUX.

Alterations from the normal in the frequency and copiousness of the efflux are not very easy to estimate, and do not generally give much information, because the normal speed and character are themselves so variable. In the ordinary way a movement occurs once in every ten or twenty seconds, but quite often one may watch an orifice for several minutes without noting such a movement. Nor is it always possible to be certain when a contraction does occur that there is an emission of urine, for unless the swirl is fairly vigorous it does not become visible. The kidney appears to have periods of rest from excretion during which the ureter does not receive the reflex stimulus to contract. If, however, it is stimulated by a copious draught of water, it will, when healthy, start to excrete this extra fluid within five or ten minutes. The stimulus of urea or a dye introduced into the circulation has similarly the power to awaken the activity of the kidney.

Absence of Contraction.—If, under prolonged inspection or under such artificial stimulation as I have mentioned, no contraction is observed, some explanation must be sought. The following possibilities must be considered :—

1. The kidney may be congenitally absent or atrophic.
2. It may have been completely destroyed by disease.
3. The urine may be retained in a hydronephrosis, or be dammed back by a stone impacted in the ureter.
4. The urine may be drained away by a ureteric fistula. Usually with a ureteric fistula, as also with a stone in the ureter, the peristaltic movement is propagated to the bladder and is visible there, though generally enfeebled and infrequent.

The absence of a satisfactory efflux should be confirmed by chromocystoscopy.

Increased Contraction.—Increase in the force and frequency of the contraction may be present :—

1. In the normal kidney during a period of special activity, such as occasionally occurs to counterbalance the period of inactivity above described.
2. In compensatory hypertrophy of one kidney when the other is absent, diseased, or destroyed.
3. In polyuria, from whatever cause—forced diuresis, high blood-pressure, interstitial nephritis, glycosuria, etc.
4. When the kidney or ureter is irritated by the presence of a stone, or from other irritating disease—the early stage of tuberculosis of the kidney, for instance.

Hæmorrhage.—Bleeding from the kidney may be slight or copious. Its recognition at the ureteric meatus is valuable information in the localization of disease.

Slight Hæmorrhage.—Hæmorrhage may be so slight that it cannot be detected cystoscopically, though even when inconsiderable it is often apparent. In doubtful cases ureteric catheterization does not help much, for traumatic hæmorrhage resulting from the passage of the catheter cannot be distinguished from that caused by renal disease. In these obscure cases the site of origin of the hæmaturia may be revealed by some other form of examination, of which X rays, renal function tests, and pyelography are the most likely to assist. Sometimes these cases are very difficult and disquieting. When the diagnosis is obscure it is better to await further developments rather than to operate or even express an opinion on insufficient evidence.

Not infrequently the question arises whether a hæmorrhage is unilateral or bilateral. In some such instances it may be possible to say that there is blood coming from one meatus, whilst it is impossible to be sure that it is absent from the other. This difficulty arises only when the hæmorrhage is small in amount. When copious and of the surgical type it is usually unilateral.

Copious Hæmorrhage.—Copious hæmorrhage from the upper tract is generally easy to detect if still active, but it should never be assumed that it will continue, and its investigation should be undertaken promptly (*see* Chapter X). It may occur :—

1. In the form of a bright-red efflux, the colour varying in intensity with the severity of the bleeding. Frequently, however, the efflux has a somewhat brownish tinge, owing to changes produced by contact with the urine.

2. When the blood has been retained for a time in the renal pelvis, either through clotting in a normal pelvis, or especially when due to hæmorrhage into a hydronephrosis, it may come away in small shreddy clots of brownish-red colour.

3. Clotting may take place in the ureter, producing the worm-like coagula sometimes found in the urine. Such a clot is occasionally seen in process of being extruded from the ureteric meatus (*Plate XIV* A). It is a deep purplish-red comma-shaped body hanging from the orifice, but if its expulsion is delayed it becomes decolorized and is then greyish in colour and appears granular and laminated in texture.

Pus.—Pus escaping from the ureteric meatus may be small in quantity or plentiful. It is less evident, quantity for quantity, than blood, owing to the difference in colour.

Small Amounts.—When finely particulate, for instance in *B. coli* infection of the kidney, there is generally not sufficient pus to be obvious through the cystoscope. When the origin of pus is being investigated a careful scrutiny of the meatus should nevertheless be made, and with the objective close to the orifice, a hazy efflux or actual pus flakes may be observed. Purulent débris is almost invariably present, in greater or less degree, on the bladder wall in these cases, and the cystoscopist should always be on his guard to avoid mistaking the movement of particles of débris disturbed by the ureteric efflux for the actual emission of pus. When in doubt, catheterization of the ureter will collect infected urine from the kidney, and the presence of pus and organisms can be demonstrated pathologically.

Moderate Amounts.—When it is more plentiful, pus renders the ureteric efflux definitely turbid. The muddy urine diffuses itself in the medium and temporarily renders it hazy. Marion has compared the effect with that of a snowstorm. The speed with which the medium clears again depends on the consistency of the pus. When finely divided it remains suspended for a time in the vesical fluid. Larger flocculi more quickly settle to the bladder base, whilst inspissated matter never rises off the vesical floor, but rolls along it lazily like a stream of lava.

Kidneys producing pus in small or moderate amounts are often valuable organs, playing a varying but generally considerable part in the excretory functions of the organism. They are usually not suitable objects for surgical activity, the more so as this type of infection is frequently bilateral. They often produce a normal or even more than normal quantity of urine, though this may be deficient in solids and the function of the organ actually reduced.

Copious Pus.—When pus originates in a pyonephrosis it constitutes a large proportion of the ureteric effluent; indeed, there may

PLATE XIV.

A, Worm-like clot of blood partially extruded from ureter. B, Lava-like stream of pus from right ureter flowing slowly into the retrotrigonal recess. C, Ureter in chronic pyelitis. Heaped-up masses of thickened epithelium are seen around the ureter and below it. D, Copious efflux of indigo-carmine from left ureter. Note the slight blue haze in the bladder medium above and to the left of the ureter. E. Double ureter (left side). The lower ureter is on the outer aspect of the ureteric bar. F, The same after catheterization. The modification in the position of the orifices is due to the drag of the catheters.

be little urine or none at all mixed with it. The consistency of the efflux will vary according to the proportions of these two fluids. Often it is grey, grumous, and almost jelly-like; at other times it is creamy and semi-solid, and then contains practically no urine. Even from a pyonephrosis it occasionally issues with fair force into the vesical cavity, but on other occasions it trickles feebly over the margin of the meatus and rolls away in a worm-like stream to the bladder sump. This appearance has been aptly compared with that of paint expressed from a squeezer tube (*Plate XIV* B).

In these advanced cases the emission of the pus is not continuous. Long intervals may occur between the delivery of two separate amounts into the bladder. I have watched the ureter mouth for as long as fifteen minutes in suspected cases, to be rewarded ultimately by seeing the creamy fluid emerge therefrom. If the cystoscopy is hurried in such circumstances, the picture may be missed. Gentle bimanual pressure over the affected kidney has often in my experience been very effective in dislodging the purulent contents of the pelvis and accelerating their appearance in the bladder. A kidney in this condition is valueless and probably takes no part in the excretory work of the body.

URETERIC CATHETERIZATION IN DIAGNOSIS OF RENAL DISEASE.

The indications for ureteric catheterization are: (1) *In order to search for the primary seat of disease*; (2) *To test the function of the remaining kidney*; (3) *As a preliminary to urography.*

1. **Search for the Primary Seat of Disease.**—The search for the primary seat of disease in the upper urinary tract has in most cases been successful before the stage of ureteric catheterization arrives; but if it has hitherto evaded discovery, it will fall to the lot of the ureteric catheter to trace it. This it will do in two ways: (*a*) By showing a kidney with a damaged function; and (*b*) By collecting urine containing pathological material. The examination under these circumstances must be a bilateral one, and, if the disease is one-sided, the urine from the second kidney will indicate the function of that gland.

2. **Testing the Function of the Remaining Kidney.**—When the location of the disease has been settled earlier in the investigation, probably all that remains is to decide the function of the remaining kidney. This may be done by chromocystoscopy or by ureteric catheterization. If the latter is selected, only one side need be catheterized, the other kidney being known to be diseased, though some surgeons prefer bilateral catheterization even in these circumstances.

Relative Advantages of Ureteric Catheterization and Chromocystoscopy.—Ureteric catheterization presents certain disadvantages and also certain advantages in renal function testing as compared with chromocystoscopy.

Disadvantages.—It is admitted that in some instances catheterization of the ureter has an inhibitory effect on renal activity. When this happens it may lead to an erroneous impression of a kidney's efficiency. It is generally of short duration, but even so may outlast the stay of the catheter in the ureter. Chromocystoscopy evades this disadvantage.

The catheter may occasionally fail to collect the urine from the kidney owing to its becoming blocked or to the urine escaping alongside the catheter. This is more likely to happen with small catheters than with larger ones. Blocking of the catheter is obviated by injecting through its lumen a drachm or so of sterile water after the instrument is *in situ*. The addition of even this amount of fluid to the renal secretions proper may make an appreciable difference to function tests in view of the small quantities usually collected. Urine escaping alongside the catheter finds its way into the bladder. Its recovery from that viscus, either by simultaneous vesical catheterization or by normal micturition immediately after the ureteral instruments have been removed, will show the quantity of fluid thus lost, but it will not tell from which kidney it has come. This, together with the undesirability of keeping catheters in the ureters for any length of time, is the reason why many surgeons have now discarded the attempt to estimate separate renal excretion *quantitatively*, there being obviously a large and incalculable error from this cause.

Many renal functional investigations are performed on out-patients. I avoid as far as possible catheterization of the ureters of those who have to travel and who may thus be exposed to chill. Chromocystoscopy is peculiarly suitable for this class of work owing to its simplicity, quickness, and avoidance of ureteric catheterization.

Advantages.—The signal advantage of ureteric catheterization is that, in addition to providing data for renal function estimations, it supplies material for pathological investigation, which throws more light on the condition of the kidney than can be obtained by simply observing its dye-excreting capacity. It is therefore the more searching test. Where, however, the surgeon is satisfied as to the freedom from serious disease of this second organ, the ease of application of the carmine test will determine its selection.

Pathological Examination of Specimens Collected by Ureteric Catheterization.—The urine sent to the laboratory is accompanied by a request for its chemical, microscopical, and bacteriological investigation. It is not proposed to enter fully into such reports, which do not strictly come within the scope of cystoscopy. The reports must be exhaustive, and when available will be correlated by the surgeon with other facts already in his possession. They need, however, interpretation with a knowledge of certain fallacies :—

a. Ureteric catheterization is frequently, almost invariably, accompanied by some hæmorrhage, which may be macroscopic or microscopic, and is due to friction occurring between the catheter and the wall of the ureter, or to bruising of a renal papilla. It is always remarked in the pathologist's report. As has been observed already, this traumatic blood cannot be differentiated from blood of pathological significance, and its occurrence unfortunately renders the ureteric catheter valueless in the localization of renal hæmorrhage.

b. The serum albumin of the blood is indistinguishable from other albumin of renal origin. If the traumatic bleeding of catheterization is copious, the resulting albumin may also be considerable ; when, however, the bleeding is slight, the albumin may be negligible. In considering small quantities of albumin occurring in ureteric catheter specimens, the possibility of its having this origin must be taken into account.

The difficulty is best illustrated in connection with the presumed healthy kidney in *serious* unilateral renal disease. In such disease it is well known that a low-grade inflammatory change occurs in the neighbouring gland, determining albuminuria therefrom. This change, which is most characteristically seen in renal stone and tuberculosis (though also in other diseases), is at first a subacute parenchymatous nephritis, whilst later there occurs in many instances an actual extension of the original disease to the second organ. The importance of disease in this second kidney does not require emphasis, especially when nephrectomy is contemplated. It is generally easy to discover the propagation of the original disease to the neighbouring gland—in the case of lithiasis by X rays, and in the case of tuberculosis by ureteric catheterization—but sympathetic nephritis is a phenomenon for which one must watch, particularly in these two diseases. It is not easy to detect. Its effects are not separately discernible in the general health of the patient. The resulting albuminuria is slight in quantity and is quite obscured by pyuria and albuminuria from other sources, whilst ureteric catheterization is subject to the fallacy that traumatic blood may be present in sufficient quantity to complicate the interpretation. It will thus be seen that the presence of a slight albuminuria from the second kidney in these cases of primary unilateral renal disease is difficult to detect, even though important. It should be said, however, that this sympathetic nephritis, which may also determine the presence of casts in the catheter specimen, is kept up by the irritation and toxæmia arising from its diseased neighbour, and after removal of the latter it tends as a rule to subside, the function of the gland simultaneously improving.

3. **Pyelography** (*See also* Chapter XXIV).—In renal function testing we have a means of showing the physiological state of the kidney, in pyelography a method of demonstrating its anatomical condition. The former will tell that a kidney is wholly or in part disabled but may fail to say why. The latter not infrequently makes good this omission. The two examinations are related and complementary, and their results must be reviewed together. Instrumental pyelography may be undertaken as a separate examination, or the pyelographic medium may be introduced into the kidney as soon as the separated urines have been obtained and the function tests completed. When feasible the latter is the better way, as it avoids a second cystoscopy and ureteric catheterization.

CHAPTER XXII.

CONGENITAL ABNORMALITIES OF THE KIDNEY AND URETER.

Malformations of the upper urinary tract are constantly cropping up. Probably no other visceral system is so frequently misformed or presents such a variety of deformities. All these abnormalities are of first-rate importance to the surgeon and of great academic interest. Modern methods show them to be far from uncommon, and it is evident that they have in the past been overlooked. They can be recognized and correctly diagnosed by cystoscopy and urography; but if the surgeon is unfamiliar with their embryology, variety, and their radiographic appearances, he must of necessity meet with surgical puzzles which are easily solved if the requisite knowledge is forthcoming but are insoluble in its absence. All the congenital abnormalities of the urinary apparatus predispose to disease, and therefore appear in any urological department with a frequency which is quite disproportionate to their incidence in the general population. Congenital abnormality is important rather by reason of its complications than on its own account, and where it is encountered care should be taken to exclude disease in all component parts of the upper urinary tract. A study of the pyelographic picture will play an important part in this exclusion. The following pages find a fitting inclusion in this book because, without a knowledge of the mechanism of production of these deformities, and of the cystoscopic and urographic pictures which result from them, correct interpretation is impossible.

The congenital abnormalities of the upper urinary tract will be considered under the following heads :—

I. Malformations of the Kidney—

1. Fused kidney
    - *a.* Central { Discoid / Shield / Horseshoe
    - *b.* Unilateral crossed ectopia { 'S-shaped' or 'sigmoid kidney' / 'Long' or 'long simple kidney'
2. Ectopic kidney
3. Renal hypoplasia
4. Solitary kidney
5. Absence of both kidneys
6. Supernumerary kidney

II. Malformations and Displacements of the Ureter—

1. Associated with a misplaced kidney
2. Duplication and bifid ureter
3. Errors of implantation.

GENERAL EMBRYOLOGY.

The renal bud appears early in the second month of fœtal life as an outgrowth from the dorsal aspect of the lower end of the mesonephric (Wolffian) duct (*see Fig.* 228, page 364). But it does not long retain its connection with this structure. Migrating along the duct till it reaches the cloaca, the ureteric insertion then severs its connection with the Wolffian elements and moves upwards to that part of the urogenital sinus which ultimately forms the bladder. This migration may in part or wholly fail when the ureter ends ectopically.

Early in fœtal life the developing kidneys lie close together in front of the sacrum. The pelves face anteriorly and short ureters emerge from them to descend in front of the respective lower poles to the bladder. In birds the caudal position of the kidney is retained, but amongst the higher animals this gland shortly ascends to the loin, possibly to clear the pelvis for pregnancy and parturition, as amongst the gravest dangers arising from a kidney retained in the pelvis are the complications caused by its presence during gestation and delivery. During the greater part of its journey the kidney pelvis retains its primitive forward aspect, but about the time the loin is reached a movement of rotation causes it to assume its adult outward direction. Ascent may be incomplete on one or both sides, with the result that either kidney may be found in the true pelvis, at the junction of the false and true pelves, in the iliac fossa, or in the lower lumbar region. The condition is then called 'ectopic kidney'. *Fig.* 204 shows a right kidney in the condition of lumbar ectopia, the original anterior disposition of the pelvis persisting. The left kidney has reached its correct level in the loin, but the final act of rotation has failed.

In the earliest stages nothing separates the two renal buds except the developing aorta. Sometimes they are in actual contact and fuse. The junction almost invariably takes place anterior to the aorta, but in a few instances it has been posterior. The organs then remain united in adult life (fused kidney). The degree of this fusion is variable. If it is complete a discoid organ results—'cake-like kidney' (*rein en galette, Kuchenniere*). The term 'shield-like kidney' indicates an organ of similar type but slightly notched at its upper pole. When the separation is further advanced a horseshoe kidney (*rein en fer à cheval, Hufeisenniere*) results. In any of the above-mentioned conditions two ureters emerge from the common anterior renal surface at a point slightly lateral to its centre and pass downwards to the bladder in front of the lower portion of the respective kidneys. Such deformities occupy a central, prevertebral, or presacral position in the body.

Certain other fusion deformities in which both organs occupy the same side of the body also occur (unilateral fused kidney). This

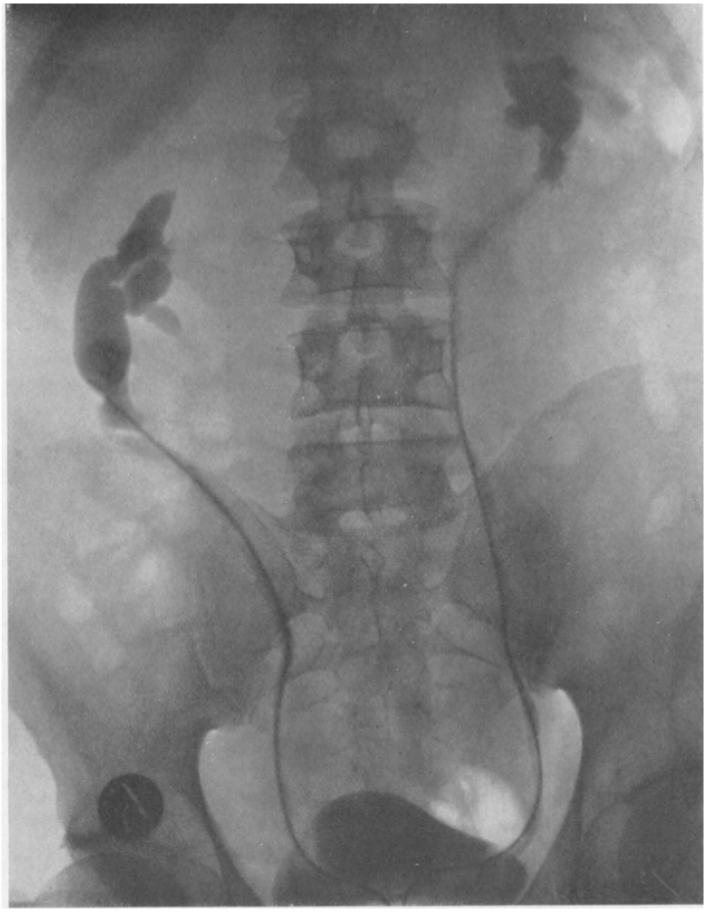


Fig. 204.—Bilateral renal deformity. The right kidney is incompletely ascended, and has not rotated properly. The pelvis lies well away from the spine and shows moderate pyelectasis. Left pelvis is fully ascended but unrotated. No dilatation. The condition is similar to that seen in horseshoe kidney, but the distance of the pelves from the spine seems to preclude this diagnosis. A lateral view, however, showed the catheters to lie anterior to the spine. Possibly an instance of a long fibrous union. Parenchyma not visible. Right pyelitis. No operation, but exploration of other kidneys giving similar urographic pictures has verified the origin of the pelvis from the front of the organ.

group differs from the centrally placed group in that, whilst the former are united by similar poles—that is, lower to lower or upper to upper

—the unilateral variety shows fusion between the upper pole of one kidney and the lower pole of the other. It appears probable that in this latter instance the two kidneys have individually migrated from the pelvis and that one has become displaced laterally so that it finds itself on the wrong side of the spine (crossed ectopia). The two kidneys lie in apposition, one above the other, generally united but not always so. This union therefore takes place subsequently to their migration from the pelvis, the fusion involving dissimilar poles. If the two pelves face in opposite directions, a kidney shaped like an S ('S-shaped' or 'sigmoid kidney') results. If they point in the same direction, the so-called 'long' or 'long simple kidney' is produced.

When the primitive kidney occupies the pelvis it is supplied by the common and internal iliac arteries, chiefly the former. As it ascends, a succession of branches derived from the iliacs and the aorta bud out to supply it, and the lower branches one by one disappear as they are replaced by others springing out at a higher level. Any of these earlier branches may persist as the main or as an accessory arterial supply. This evolution explains vessels arising from the internal, external, or common iliac trunks, from the mid-sacral artery or from the lower aorta. Such vessels not at all uncommonly run to properly formed and normally situated kidneys, but with ectopic and malformed organs supernumerary vessels and vessels arising below the usual site are almost invariably present.

An anomalous vascular supply is important from the operative standpoint, as accessory branches are much exposed to injury when the renal poles are being cleared. The majority are of small size and the resulting bleeding is of little moment, but when they happen to be large severe hæmorrhage occurs and may be difficult to control in the depths of the wound. The loss of small tributaries appears to be of little consequence to the vitality of the kidney, though when a large branch is severed necrosis of the portion supplied by it may occur. Accessory vessels crossing the ureter are frequently associated with pyelectasis.

I. MALFORMATIONS OF THE KIDNEY.

HORSESHOE KIDNEY.

In the deformity called horseshoe kidney the two kidneys are more or less intimately fused by similar poles, and the resulting structure assumes the shape from which it derives it name. It is the most important and frequent of the major malformations of the kidney. Its occurrence has been known since 1552, when a case was described by Béranger de Carpi.

Incidence.—During the last thirty years the post-mortem records of several large hospitals have been searched by various investigators and the incidence of this deformity in the general population has thereby been estimated. The following statistics may be cited :—

Observer	Year	Bodies	Horseshoe Kidneys
Morris	1901	18,244	19
Botez..	1912	50,504	72
Carlier and Gérard..	1912	68,000	80
Efremoff	1912	91,220	125
Stewart and Lodge	1923	6,500	14
Sokolow	1928	50,198	53

Totalling up the above figures we find that 363 instances of horseshoe kidney occurred in 284,666 cadavers, or 1 in 782·2.

In striking contrast to these figures are those supplied from the operating-theatre, where according to Israel 5 horseshoe kidneys were observed in 800 operations, according to Marion 1 in 100 kidney operations, whilst Federoff in 558 cases has encountered the condition 5 times. At the Mayo Clinic 17 horseshoe kidneys were found in 2424 renal operations (1 in 142). The disparity between the post-mortem and surgical figures is apparently to be accounted for by the susceptibility to disease which these dystopic organs exhibit.

Anatomy (*Fig.* 205).—

The Kidneys.—In the section on the development of the kidney (page 333) the process by which the two kidneys become fused in early fœtal life has been described. In 90 per cent of specimens (Robinson) the lower pole only is fused so that the concavity of the united glands points upwards. The condition found in many low vertebrates, e.g., the dogfish, is thus imitated (the kidney, however, in these is a mesonephros). In the remaining 10 per cent the upper poles are fused and the concavity faces downwards. The isthmus almost invariably lies in front of the great vessels.* It may consist of fibrous tissue (15 per cent of specimens, Robinson) or of parenchyma. Occasionally it is so well developed as to look like a centrally placed third kidney (Sutherland, Perregau, et al.), and instances are on record in which it has been served by an additional ureter.

The junction is sometimes stretched tightly across the great vessels, obstructing their circulation, or causing abdominal pain, severe enough to necessitate its division. The vertical development

* There is an exception in the Royal College of Surgeons Museum (No. 638) in which it lies posteriorly, and two other similar specimens (Nixon; Kelly and Burnham) are also known.

of the isthmus is variable. It may be so well formed that the kidneys are united almost as high as their upper poles, a circle being thus almost completed. The condition then approximates to the one known as 'cake-like' or 'shield' kidney.

The axes of kidneys united by their lower poles are so altered that instead of their upper extremities inclining inwards as in health,

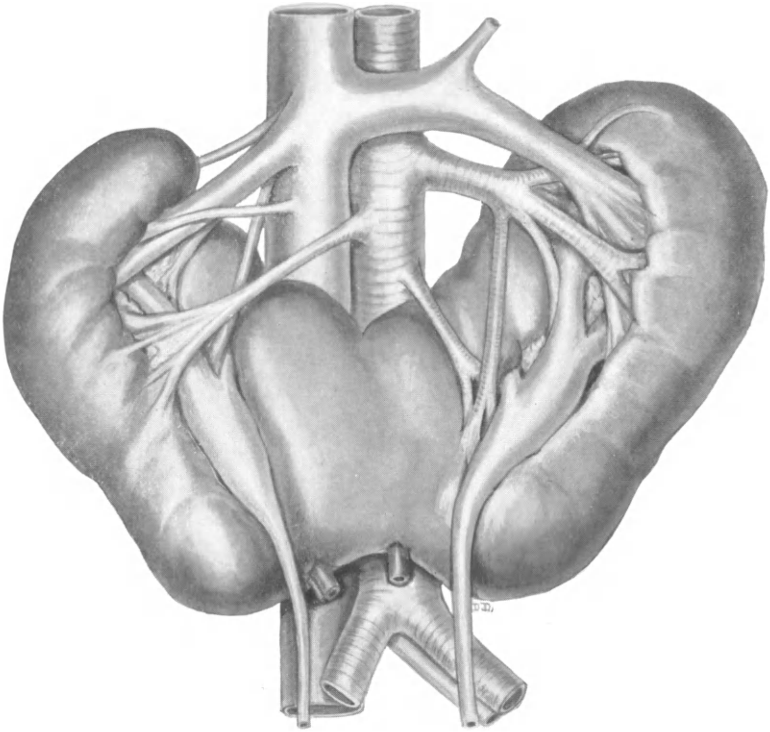
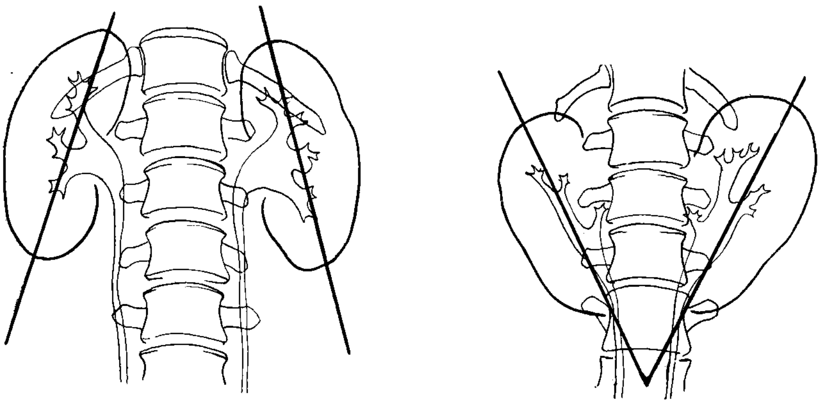


Fig. 205.—Horseshoe kidney showing the following features common to most examples : Isthmus lying in front of great vessels (here, large and fleshy). The ureters, lying anterior to the lower poles, occupy grooves (which sometimes cause back-pressure) and are very close to mid-line of body. The pelvis faces forwards, the lowest calix passing inwards to drain the isthmus. The kidneys are held close to the middle of the body by their union and they are incompletely ascended—just above the aortic bifurcation. Vascularization is very erratic. Note vessels to inferior margin of isthmus which joined up with the iliac blood-vessels.

they come to point outwards (*Fig.* 206). The two halves of the horseshoe kidney lie closer to the mid-line than do normally developed organs. The distance between them varies with the development of the isthmus, but on the average is about 6 cm. (Rubascheva). Legueu and Papin state that a horseshoe kidney is rarely symmetrical, one half being larger and more shapely than its fellow. The better favoured kidney adopts a more normal position in the body than its partner. It therefore lies at a higher level and is farther from the mid-line. Occasionally it appears to drag the other element transversely on to, or even across, the spine, the so-called L-shaped kidney resulting. A horseshoe kidney may lie at the normal level (7 times in 222 cases, Legueu and Papin), but the majority fall short of that position by the depth of one or two vertebræ, and the isthmus is situated about the level of the aortic bifurcation. A greater degree of displacement, as for instance on to the sacral promontory or into the true pelvis, is rare. Rokitansky states that the more developed the isthmus is, the lower the organs lie.



a *b*

Fig. 206.—Diagram showing the axes of the kidneys: (*a*) In the normal; (*b*) In a horseshoe kidney.

The horseshoe mass lies on a plane which is much anterior to that assumed by the normally situated organ. This is a fact which, though obvious enough, receives practically no notice in any descriptions. Instead of lying in the deepest recesses of the loins the kidneys are perched not only on the prominence of the lumbar spine, but in addition overlie the great vessels. The isthmus is the most anteriorly placed section, the lobes inclining slightly away. The usual inward rotation of the pelvis, almost a final movement in the process of ascent, is forbidden by the fusion of the two organs; the hilus therefore faces forwards, or forwards and inwards.

The Ureters.—In the common type of horseshoe kidney (caudal union) the ureters retain the relationship anterior to the united lower poles which characterized their early sacral form (*see* page 333), though an instance is known (Landouzy) in which they perforated the renal substance, and two (Perruchot, Rathbun) in which they passed posteriorly. In Rathbun's case the pelvis on the right side passed upwards and then the ureter arched over so as to be directed behind the kidney. The ureters below the isthmus are not as a rule dilated, and in this contrast with the pelvis, which commonly shows a greater or less degree of pyelectasis, caused either by an abnormally acute uretero-pelvic junction or by pressure exerted on the ureter where it crosses the isthmus. Evidence of such pressure exists in the fact that the ureter produces a furrow in the renal substance.

The *vascular supply* of a horseshoe kidney is erratic and very variable, a fact which gains considerable importance because of the danger to which the vessels are exposed at operation. For the most part the *arteries* spring from the common and internal iliac trunks, chiefly the former, and also from the lower aorta and the mid-sacral artery. Exceptionally a branch arises from the inferior mesenteric artery. The latter trunk is closely applied to the upper margin of the isthmus and actually leaves its imprint on the renal tissue (Legueu). This relationship is important when operations are undertaken upon the isthmus for its division, etc. The majority of the arteries enter the kidney by the hilus, but some perforate its surface. Frequently a special branch passes to the isthmus. Papin collected 139 cases of horseshoe kidney and found that the arteries varied in number from one to ten ; two to five were often observed, but three was the most customary supply. Robinson found one branch to each lateral mass in 10 out of 60 specimens, whilst in 4 more there was a single trunk to each lateral mass and a branch to the isthmus. In four-fifths of the cases the renal arteries originated distal to the normal situation.

The *veins* are less irregular in their distribution, and as a rule unite into two main branches which pass to the vena cava, but which may empty themselves into the iliac veins.

Every variety of renal lesion has been found in the horseshoe kidney. Rathbun collected 108 cases from the literature and has tabulated the diseases which complicated them. The following is his table :—

Calculi	32	Trauma	2
Hydronephrosis	18	Pyelitis	1
Pyonephrosis	11	Ureteric calculus	1
Tuberculosis (one double) ..	12	Adhesions about ureter ..	1
Neoplasm	4	Fistula	1
Polycystic	3	Uncomplicated	13
Nephritis	2	No details	7

In contrast to this, Stewart and Lodge in 14 autopsy specimens found gross kidney disease in 1 case only—chronic nephritis in a woman of 27. The average age of these 14 patients was 47, one patient being

82 and two more between 60 and 70, whilst five were between 50 and 60. The authors conclude from this that the possession of a horseshoe kidney is no bar to long life.

Symptoms.—Patients come under observation :—

1. Because the deformity itself is occasioning symptoms: (*a*) Pain due to the pressure of the isthmus on the great vessels. Usually located in the umbilical region, this is stated to be aggravated by increasing the anterior prominence of the lumbar spine and to be relieved by recumbency (Rovsing). (*b*) Evidence of pressure on the great vessels : œdema of the lower extremities due to the compression of the vena cava, and cardiac hypertrophy from obstruction to the abdominal aorta (Rovsing, Davidsohn).

2. For any of the diseases which supervene on the abnormality.

In a majority of all cases the symptoms are those arising from the complication, and a diagnosis limited to this, and failing to take account of the malformed kidney has in the past been the rule. The diagnosis of a horseshoe kidney has been facilitated by the advent of urography. In Rathbun's 108 collected cases only 24 (22 per cent) had been diagnosed prior to operation. Judd, Braasch, and Scholl, however, reported 16 cases, of which 8 (50 per cent) were correctly diagnosed before operation. Even to-day many cases are encountered unexpectedly during operations for hydronephrosis, stone, tuberculosis, etc.

Diagnosis.—The diagnosis may be suggested by the pain described above. A centrally placed abdominal tumour, especially if associated with urinary symptoms, may arouse suspicion. The isthmus is rendered prominent by the aorta and in a thin subject may be very evident and may receive transmitted pulsation. X-rays should be of assistance in showing renal outlines which are abnormally close to the mid-line, converge at the caudal instead of the cephalic end, and are low in position. The position and shape of a stone shadow has led the writer to a correct pre-operative diagnosis in two cases.

Urography.—This is nowadays the most useful means of diagnosis at our disposal and will probably in the future lead to a much higher proportion of correct diagnoses. The pyelographic picture is complementary to the anatomical arrangements. The pelvis is low-lying, abnormally close to the median line, and the axes of the two pelves diverge as they pass upwards. The lowest calix reaches across towards the isthmus to drain this unusual area. It therefore lies to the inner side of the pelvis and ureter (*Figs.* 207, 208). Some of the other calices (middle and upper groups) may also be inwardly directed owing to the anteriorly rotated renal hilus, but this is not constant. Calices lying to the inner aspect of the ureter always suggest a malformed kidney. For confirmation a double pyelogram should be made.

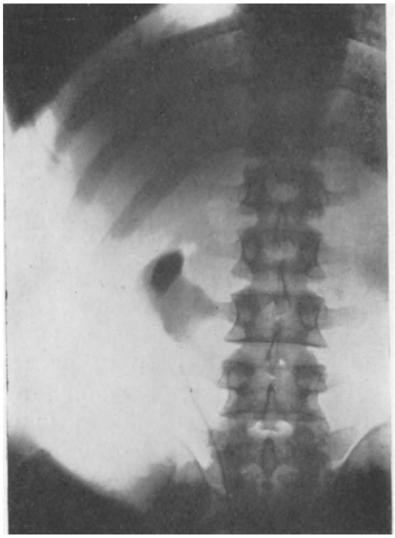


Fig. 207.—Stone in a horseshoe kidney.

Fig. 208.—Horseshoe kidney. Pelves close to mid-line, somewhat low, definitely dilated. Note presence of calices on inner side of ureter. (*Mr. Jocelyn Swan.*)

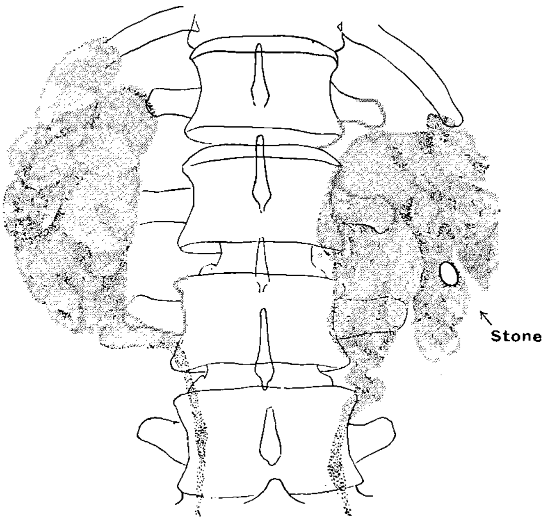


Fig. 209.—Horseshoe kidney. Tracing of bilateral pyelogram. Both sides severely dilated. Small stone in left pelvis. Note inward position of the ureters and absence of ureteric dilatation. The organ lies fairly high for a horseshoe kidney.

The pelvis frequently shows a greater or less degree of dilatation, (*Figs.* 208, 209) together, perhaps, with evidence of concomitant disease—stone, (*Figs.* 207, 209) tuberculosis, etc. Lateral pyelography will show that the pelvis is displaced forwards so that its shadow lies in front of the spine. The ureters in their upper extent lie close to the mid-line and generally overlap the spine (*Fig.* 209). At the point where they arise from the pelvis they are situated in front of the spine and great vessels and are therefore relatively close to the anterior abdominal wall. To reach their customary position in the pelvis they have to pursue a markedly rearward course. These facts are not recognized in an antero-posterior skiagram, but the course of opaque catheters in the ureters when seen in a lateral view brings out this feature.

Excretion pyelography is a valuable aid, not only in so far as it demonstrates the condition of both pelves, but in that by rendering the renal parenchyma more evident it may help to decide, prior to operation, the type of isthmus likely to be encountered.

Treatment.—As horseshoe kidneys have so often been overlooked until revealed at operation, the approach has generally been by the customary incision. The surgeon then becomes aware that, whereas the upper end of the organ is mobilized even more readily than usual, the lower refuses to come into the wound, and indeed no true pole can be identified. If the condition is not quickly recognized, injury may occur to various structures, especially accessory vessels and the ureter, during the attempt to deliver the kidney. As soon as the abnormality is recognized the incision should be enlarged anteriorly. Operations on horseshoe kidneys are fraught with more risk than those on the normally placed organ owing to the immobility of the gland and to its rich and variable vascular supply. Stones are most easily reached by nephrolithotomy, but if pyelolithotomy is preferred the pelvis will be found more accessible on its anterior surface. The peritoneum is in almost direct contact with the front aspect of the kidney and should be gently elevated by gauze dissection till the pelvis is identified. Moreover, contrary to the normal arrangements the vascular supply of the kidney passes behind the pelvis, making pyelotomy safer from the front. Ureteric stones not infrequently lodge at the point where the ureter crosses the isthmus and are then best reached by working along the anterior surface of the kidney.

In nephrectomy the main difference from an ordinary operation is the treatment of the isthmus, which always lies deep and is approached with difficulty from the loin. If it consists of fibrous tissue it may be snipped across, if of parenchyma its division may occasion free hæmorrhage in an inaccessible position. To obviate bleeding the isthmus may be crushed by a large clamp, and Judd has recommended that this be left in position for several days. Another method is that of making an angled section of the isthmus combined with the use of interlocking sutures. Division of the isthmus for the relief of abdominal pain or of vascular compression has been practised. Rovsing has described an operation for its performance. The approach is a transperitoneal one, the abdominal contents being displaced to right or left as most convenient. The posterior layer of the peritoneum is incised and the renal isthmus exposed, mobilized, crushed with large forceps, and its capsule sutured. There is an element of danger from urinary leakage in all divisions of the isthmus, and a renal fistula may declare itself and may resist treatment. Lumbar drainage should therefore invariably be employed.

UNILATERAL FUSED KIDNEY.

(*Crossed Ectopia.*)

In this condition the two kidneys are united* into a single mass which lies on one or other side of the spine. It is a rare deformity, of which Papin and Palazzoli, in 1910, were able to collect only 70 examples.

Anatomy.—The fusion is almost invariably in the vertical direction, so that one kidney lies higher than the other. In 87 per cent of cases the upper kidney has belonged to the side on which it has been found and its ureter has passed down directly to the same side of the bladder to be inserted in the normal position. The lower of the two organs belongs to the opposite side, and its ureter invariably crosses the mid-line to obtain insertion in its own side of the bladder, in the normal situation. The upper kidney is larger than its fellow. The two together form a mass of greater length than that of a single kidney. The size of the two may be equal to, but is often less than, the combined size of two healthy and normally situated kidneys. It is never greater unless they are hydronephrotic or otherwise diseased. In the majority of specimens the junction is easily discerned, but in a few there is no evident dividing line. The lower kidney is occasionally enveloped by the upper in such a manner as to disguise the true condition. In two cases (Houzel, Dennis) this has led inadvertently to pannephrectomy.

The *pelves* are separate and distinct. Cases have been reported in which they communicated, but these should be discredited. The

* Gottlieb calls attention to the fact that the primary condition is the renal ectopia. One kidney is displaced from its usual situation and comes to lie on the opposite side of the body, where it finds itself in close apposition with the other kidney. Fusion results but is secondary. Pagel, in examining 55 records, showed that in 14·5 per cent there was no fusion.

upper pelvis faces more or less in the usual direction, though there is a tendency for it to be rotated forwards. In some instances it lies externally. The lower pelvis is more erratic and may look inwards, outwards, downwards, or forwards. Backward-looking pelves have been described by Albarran and Wehn. When both pelves are directed inwards the condition has been called the 'long simple kidney'. When they face in opposite directions it is called the 'S-shaped' or 'sigmoid kidney'. With any of these arrangements, but particularly when the lower pelvis is directed away from the spine, the corresponding ureter may have to cross the ureter of the upper organ to gain the mid-line of the body. The combined mass rarely attains the proper kidney position. In many instances it occupies the iliac fossa.

This malformation must be carefully distinguished from that in which a solitary kidney is provided with two ureters. The two conditions are genetically distinct. The term 'unilateral horseshoe kidney' has sometimes been erroneously applied to unilateral fusion of the kidney, the distinguishing point being that in the latter condition dissimilar poles are fused—that is, the upper pole of one kidney is united to the lower of the other, whereas in a horseshoe kidney similar poles are joined to each other—lower to lower, or upper to upper.

The *vascular supply* is erratic, but often rich, additional arteries being frequently observed. The supply for the upper segment generally springs from the aorta at or below the customary site, whilst that for the lower portion is more capricious and may take origin from the aorta low down—perhaps from the bifurcation—or from the iliacs of the opposite side. In two-thirds of all cases the whole blood-supply comes from the aorta.

Complications.—Malformations of the *genital* apparatus, which are so commonly found associated with a true solitary kidney, are much less frequent in the fused kidney, but are nevertheless fairly numerous. In the male, absence of vas and atrophy of the left lobe of the prostate (Tandler), and hypospadias (Sutherland) have been observed; in the female, uterus unicornis and absence of corresponding tube and ovary (Turner) and atrophy of one horn of the uterus (Stolz). General malformations have also been reported such as transposition of viscera (Wehn), etc.

Concomitant disease has been observed in the kidneys, as, for example, nephritis, hydronephrosis, pyonephrosis, and stone. A stricture of the ureter of congenital origin complicated a case reported by Krause.

Diagnosis.—There are no symptoms which would suggest a fused kidney, but the presence of a tumour in the iliac region has been observed in many cases. Cystoscopy does not help, as the ureters are normally situated. The sheet-anchor in diagnosis is urography (*Fig.* 210), which brings to light not only the crossed ectopia but also any malformation of the renal pelves and perhaps evidence of associated disease.

ECTOPIC KIDNEY.

Embryology. — The embryology of this condition is not difficult to understand. The kidney has failed to carry out its customary ascent from the pelvis to the loin, as also the rotation of its pelvis from the anterior to the median aspect. It is, therefore, to be distinguished from a movable kidney, an organ which having reached its normal position has wandered again therefrom. In contradistinction to this failure of ascent a few cases are on record in which the kidney is known to have overshot its mark, the condition being then called 'high lumbar ectopia'. In one instance such a kidney passed into the chest through a congenital orifice in the diaphragm (Campbell).

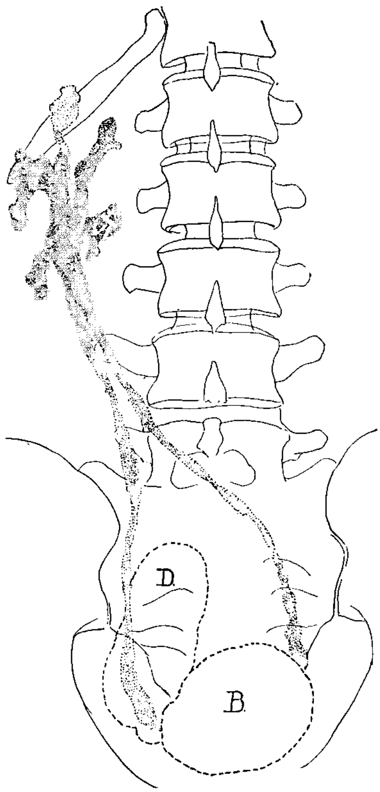


Fig. 210.—Crossed renal ectopia. The kidneys appear to be at the same level, which is unusual, and they may constitute a fused mass. The ureter of the ectopic kidney crosses the mid-line to reach its proper insertion in the bladder (B). D is an appendage to the bladder, a diverticulum of unusual shape, which proved at operation to be urachal in origin.
(*Mr. McCrea's case.*)

Incidence.—Ectopia is a moderately common malformation ; there are several hundred records of such cases and these have multiplied rapidly since the routine adoption of urography. Guizetti and Pariset found 18 examples in 20,000 necropsies in 1910, that is, 1 in 1100 bodies; but in 1930 Campbell discovered 27 in 13,000 necropsies, or about 1 in 500. Up to the last decade females appeared to preponderate because ectopia was chiefly discovered when it complicated pregnancy or labour, but the last ten years have seen an excess of males in the published cases, presumably brought to light by the more precise means of diagnosis now available.

The left side is affected in 65 per cent of cases according to Straeter (Orth gives 80 per cent), and when the displacement is bilateral the left kidney is usually the more severely involved. Bilateral ectopia is rare. Darner was unable to find more than 16 instances in 1924, to which McCown added 8 collected cases in 1929.

Anatomy.—

Position.—The kidney may lie at any point between its site of development opposite the second sacral vertebra and its normal position in the loin. We speak, therefore, of a pelvic (*Fig.* 211), low lumbar (*Fig.* 212), or iliac (*Fig.* 213) ectopia. The other kidney is, for the most part, normally placed, but if both organs are ectopic they may lie at the same level or at different levels, the latter being

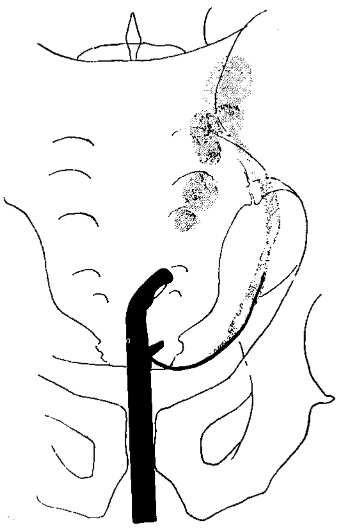


Fig. 211.—Pelvic ectopia. The ureter pursues a curved course and approaches the pelvis from the outer side. The pelvis is dilated. Symptoms: renal colic referred to the corresponding loin, and pyuria.

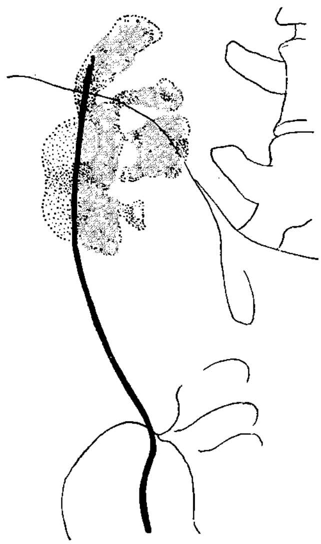


Fig. 212.—Right, low lumbar ectopia. Pyelectasis. All calices face inwardly.

more usual. The left is the lower in a preponderance of cases. When both occupy the pelvis they may be closely approximated to each other, but the rectum usually separates them. A kidney has been observed posterior to the rectum and through its pressure has been responsible for obstruction to the gut. Lemberger found a kidney lying behind the aorta. Crossed ectopia occurs, but is rare and has already been considered.

Shape.—The more extreme the degree of its displacement, the more the kidney deviates anatomically from the normal. The lower it lies, the closer it is to the mid-line. The ectopic kidney is smaller than usual. Its hilus faces anteriorly with the more severe grades of displacement, but approaches the inner border more and more as the kidney nears its proper position. The anterior surface is smooth, but may be lobulated ; the posterior is smooth and flat, or may be moulded to the structures against which it rests. The shape of the kidney is very variable, but it is generally elongated and may be oval or quadrilateral. Its original form may be much modified by disease. There is little or no perirenal fat, the organ being in close contact with the parietal peritoneum. In one case (Boyd) perirenal fat was found in the correct situation.

The *ureter* arises anteriorly. Shorter than the normal structure, it takes an approximately direct course to the bladder. It is distinguished from the ureter in nephroptosis by not being redundant. When the kidney lies in the pelvis the ureter is not more than a few inches in length. Occasionally, however, the ureter pursues an upward course in the first instance and then loops over and runs to the bladder (Campbell, Dreyfuss, Israel, et al.).

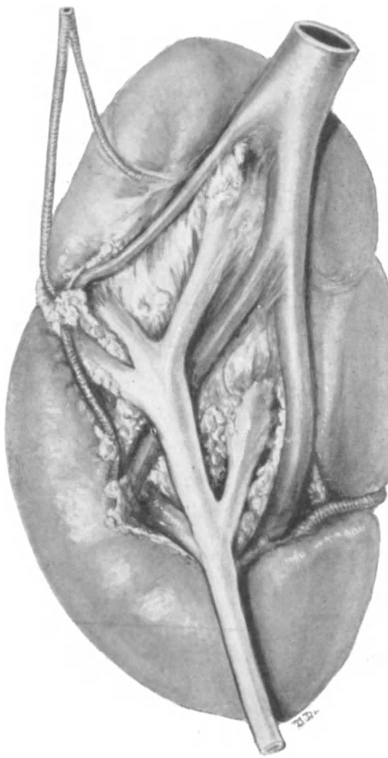


Fig. 213.—Imperfect ascent. Kidney found in the iliac fossa. The drawing depicts the anterior surface. The hilus faces forwards. Note irregular vascular supply and the calices, some of which point internally and some externally. Internally-facing calices are found only in congenital defect of the kidney—imperfect ascent, horseshoe kidney, etc. (cf. *Figs*. 205–208, and 212).

The *arteries* are extremely irregular in number, origin, and disposition. They vary in number from one to ten to each organ and may enter the hilus, surfaces, or borders. According to the position of the kidney they arise from the mid-sacral, inferior mesenteric, or iliac arteries or from the lower reaches of the aorta. The *venous distribution* corresponds roughly to that of the arterial. The *suprarenal gland* is invariably found in its correct position.

Complications.—There are numerous records of concomitant malformation in the genital organs, particularly in the female, the uterus, vagina, and tubes being partially or completely undeveloped. The Müllerian duct is differentiated about the time that the kidney starts its migration cranialwards (fifth week), and this is thought to account for the frequency with which deformities affect that channel. In the male the testicle may be atrophic, undescended, or absent. The two deformities are invariably homolateral. Stephan estimated this incidence at 38 per cent.

Complications in the kidney itself are very common. Straeter places them at 51 per cent of all pelvic kidneys, but Bugbee and Loser found 23 ectopic kidneys, 21 of which were infected. Hydronephrosis, pyonephrosis, and stone are common, whilst a neoplasm has several times been seen.

A misplaced kidney is a serious complication in pregnancy and labour. It may obstruct delivery and necessitate Cæsarean section. Pressure exerted on the kidney may cause severe damage to that organ, and necrosis has been recorded (McCown). Rupture of the uterus or kidney has also been noted (Albers Schönberg). There is a high incidence of spontaneous abortion at an early stage amongst all varieties of low-lying ectopia. The danger of pregnancy should be explained to women affected with this malformation.

Symptoms.—The symptoms are anomalous. Pain may be felt at the site of the misplaced kidney, but is more often referred to the loin, in the situation customary for renal pain. Pelvic ectopia may give rise in women to dysmenorrhœa and dyspareunia. The kidney has frequently been palpated low in the loin, in the iliac fossa, or by vaginal or rectal palpation, and may be immediately and easily recognized, as was the case with the kidney shown in *Fig.* 211. Its identification is, however, not always easy. In the female pelvis the swelling is liable to be regarded as having a gynæcological origin.

Pyelography (*see Figs.* 211, 212) should supply the key to the diagnosis. Thereby the position of the kidney, the congenital malformation of the pelvis, as well as any acquired lesions, are rendered evident. Gottlieb showed that up to 1911 this examination had been employed in 12 per cent of cases; in a further series running up to 1924 it was used in 30 per cent; and of 50 fresh cases up to 1927 48 per cent were correctly diagnosed by this means.

Treatment.—This will be dictated by the symptoms, the presence of concurrent disease, and the state of the other organ. The extra-peritoneal approach to the iliac or sacral kidney is the best, but the transperitoneal is recommended when the kidney is very adherent. Stones are very accessible in the anteriorly placed pelvis, but a sharp lookout must be maintained both in this operation and in nephrectomy if the rich and irregular vascular supply is to be safeguarded. The deeply placed pelvic organ is not easy to treat because of its short ureter and its fixity.

RENAL HYPOPLASIA.

In this condition an under-developed organ represents the kidney. It is a variation of the congenital absence of a kidney, though from the practical and functional point of view the organ might as well not exist. The kidney in some cases is represented by a small mass of fibrous or fibro-fatty tissue which may contain some epithelial

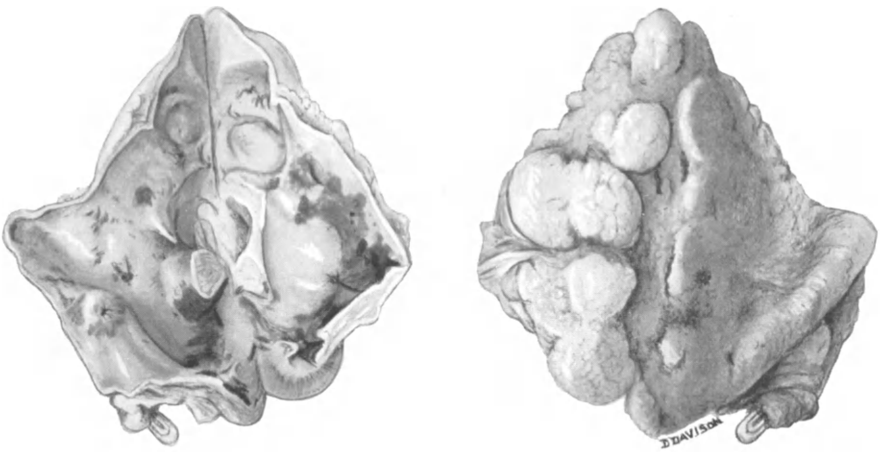


Fig. 214.—Renal hypoplasia. Operation specimen from a patient whose urogram is shown in *Fig.* 215. A thin fibrotic shell containing practically no true renal tissue. The whole organ was only $2\frac{1}{4}$ in. long.

elements or a few cysts, and is sometimes firmly adherent to surrounding parts. Other examples of hypoplastic kidney consist of a thin-walled functionless sac (*Fig.* 214). The ureter and pelvis may be well formed and patent, may be impervious in a part or the whole of their course, or may be partially or entirely absent.

In the production of this defect it appears possible either for the Wolffian bud (*see Fig.* 228, page 364)—which produces ureter, pelvis, and collecting tubules—or for the metanephros itself, to be faulty. In the former case the ureter and pelvis would fail and the metanephric parts would abort. In the latter event the ureter and pelvis would be well formed, but the renal structures proper would be missing.

The opposite kidney is hypertrophied to take over a double share of work, but is very susceptible to disease—infection, stone, etc.—

and Anders has shown that 42 per cent of such organs are the seat of advanced chronic nephritis. The hypoplastic kidney may be found accidentally when investigating disease in its fellow, but, as pointed out by Mackenzie, and as observed in two cases in the writer's experience, it is a cause of pain referred to the corresponding loin, the pain being relieved by removal of the deformed kidney.

The diagnosis can be very difficult, and this congenital anomaly may well be mistaken for some acquired renal condition. When the ureter is present at cystoscopy the lack of secretion of urine and the deficient function will be easily ascertained. Urography generally shows a shapeless rudimentary sac representing the pelvis and having no calices (*Fig.* 215). The condition requires to be distinguished from a small hydronephrosis, for which it is very likely to be mistaken. The pyelogram mimics closely the appearance seen sometimes when a catheter is passed into the dilated upper segment of a bifid ureter. Failure to outline the lower pelvis by withdrawing the catheter to the lowest section of the ureter and refilling will exclude this condition. Excretion urography is, of course, useless in the presence of a functionless organ.

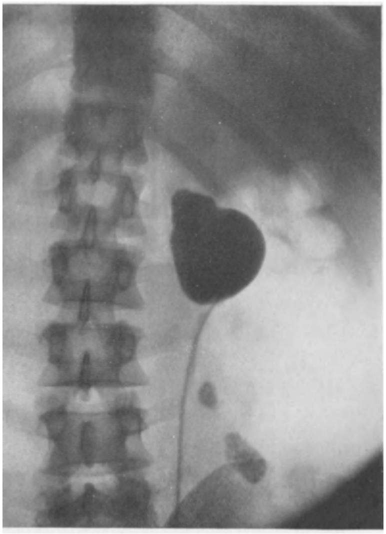


Fig. 215.—Hypoplasia renalis. A dilated shapeless pelvis with complete absence of calices (*see Fig.* 214).

SOLITARY KIDNEY.

The subject of solitary kidney is an extremely important one to the surgeon who is continually on the outlook for inefficient kidneys, whether the reason be congenital or acquired. A solitary kidney restricts surgical activity and increases its dangers, whilst, of course, it precludes nephrectomy. When disease attacks a single organ it gains additional importance because of the greater danger of uræmia or anuria. The condition is not very rare. Its incidence has been variously estimated at 1 in 1500, but Guizzetti and Pariset place it at 1 in 500, which is probably too high. In 1895 Ballowitz wrote a classical monograph in which he collected 213 cases. Various additions to the literature were reviewed by Goldstein in 1925, when

349 cases were aggregated, and to these Hennessey in 1929 added a further 24, making 373. The disability is about equally common in the two sexes, and in females the two sides are equally affected. In the male the deficiency shows a curious and unexplained preponderance on the left side.

Anatomy (*Fig.* 216).—

Kidney.—The solitary kidney is generally of normal appearance except for its materially larger size. Only in a few instances has it

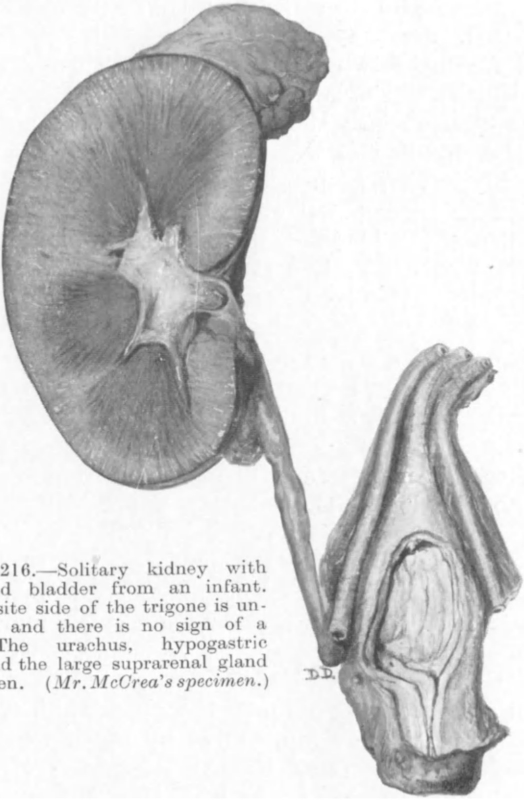


Fig. 216.—Solitary kidney with ureter and bladder from an infant. The opposite side of the trigone is undeveloped and there is no sign of a ureter. The urachus, hypogastric vessels, and the large suprarenal gland are well seen. (*Mr. McCrea's specimen.*)

been lobulated, lost its characteristic kidney shape, or become rounded or shapeless. Its size is usually increased to compensate for the absence of its fellow, though this increase is variable in extent and may not occur. In 5 per cent of cases the organ is very small (Winter). The kidney as a rule occupies its correct situation in the loin, but it may be ectopic and lie in the iliac fossa or in the pelvis. Failure to ascend occurred in 24 out of 373 cases, of which 4 occupied the mid-line, 6 the iliac fossa, and 14 the pelvis (Hennessey). The renal *pelvis* is increased in size, as may be recognised on a pyelogram. Enlargement of the pelvis does not occur when hypertrophy supervenes in later life.

Ureter.—The ureter is single, of ordinary calibre, and descends to the corresponding side of the bladder. Exceptions to these statements occur occasionally, however, and Papin collected 5 instances of double pelvis and ureter. In this event the tubes are both inserted in the same side of the trigone, one above the other, and on the same side of the body as that on which the solitary kidney is situated. By these facts duplication is distinguished from the unilateral fusion of two kidneys. Five authentic examples are on record in which the single ureter of a solitary kidney crossed the mid-line to be inserted into the opposite side of the bladder. Insertion into the mid-line of the bladder is more common, sundry instances of this having been recorded. The ureter of a solitary kidney reported by Girling Ball was enormously distended down to a point one inch from the bladder and required implantation afresh in that organ. In Kreise's patient the ureter was strictured and the kidney hydronephrotic. The ureter and kidney each contained a stone.

In 90 per cent of subjects no sign of the ureter corresponding to a *missing* kidney can be discovered. In the remaining 10 per cent some indication of a ureter exists in a fibrous cord, completely impervious in many instances, but in others patent for a varying distance. It may terminate immediately above the bladder or extend into the loin. Occasionally a properly formed ureter occurs which may be short or reach its full length to end in a bulbous dilatation representing the renal pelvis. In several cases the ureteric implantation has been ectopic, the corresponding vesicula seminalis or vas being the most favourite site in the male, the vagina in the female. The embryology of the Wolffian duct explains these abnormal insertions (*see* page 364).

The renal *vessels* on the side of the absent kidney are usually missing, but are occasionally represented by impervious cords which end in a clump of fibro-fatty tissue. Both *adrenals* are almost invariably present in their customary situation.

Bladder.—The bladder findings are highly important to the clinician and may supply the first intimation of abnormality. The ureter of the solitary kidney is discovered most commonly at its correct site and the corresponding half of the trigone is fully developed. The opposite half of the trigone may be normally shaped, or more or less atrophic, the interureteric bar then disappearing at or about the mid-line (*Fig.* 216). It requires emphasis that although the ureteric orifice of the missing kidney is usually absent, in 10 per cent of cases it is present. The discovery of an opening does not, therefore, justify the assumption that a kidney is present. The bladder is occasionally deformed or absent, the ureter in the latter case ending ectopically.

Genital Malformations.—In view of the embryology of the urinary and genital apparatus it is not surprising that malformations should be shared in common. Malformations of the genital tract both in the male and in the female are more common in association with the unilateral absence of a kidney than with any of the other dysplasias of the urinary organs. Winter estimates that they occur in about one-third of all cases. The importance of this fact to the surgeon was not appreciated until Ballowitz's important paper (1895). From the literature this writer collected 213 cases of congenital unilateral absence of the kidney. In 110 of these no mention was made of the condition of the genitalia. In the remaining 103 cases a malformation of the genital apparatus was remarked in 73, 28 being males and 41 females, whilst the sex was left unstated in 4. These figures appear to indicate a preponderance of deformities amongst women, which, however, Papin questions, since genital abnormality assumes more importance in the female than in the male.

Recent work appears to point to a greater proportion of associated genital malformations in men, which might be expected on embryological grounds, for the primitive ureter is more closely connected with the Wolffian duct (vas deferens) than with the Müllerian duct (vagina, uterus, Fallopian tube, etc.). In the male the chief defects concern the epididymis, vas deferens, common ejaculatory duct, and the seminal vesicles, any or all of which may be absent or atrophic. The corresponding side of the prostate likewise fails to evolve whenever the efferent channels are undeveloped. Testicular atrophy invariably accompanies these hypoplasias. In the female the principal defects are small size or absence of the corresponding uterine horn and its Fallopian tube, double uterus, double vagina, and non-development of the uterus or vagina, or both. Genital malformation is therefore important corroborative evidence of congenital renal anomaly.

Severe general malformations have been frequently reported and include anencephaly, hydrocephaly, spina bifida, imperforate anus, malformations of the heart and great vessels, the transposition of viscera, etc.

Symptomatology and Diagnosis.—Disease is frequent in solitary kidneys and practically all known renal lesions have, at some time or other, been seen in them. The malformation as such rarely causes trouble. The patient presents himself for a symptom or group of symptoms which does not suggest any anomaly but which characterizes the particular disease. If the latter leads to lowered renal function, uræmia shows itself early ; if to ureteric obstruction, anuria occurs forthwith. External examination is rarely helpful, though a large renal swelling associated with an empty opposite loin may arouse suspicion. The anomaly has usually in the past been overlooked. Out of 374 collected cases only 55 were recognized during life. Correct diagnoses should, however, nowadays be possible by the following methods :—

1. Cystoscopy, showing absence of one ureteric orifice, or of one half of the trigone, evidence which, as above stated, may be absent.

2. Absence of an efflux or other signs (chromo-cystoscopy, catheterization, instrumental pyelography, etc.) of a functioning kidney corresponding to a normally placed meatus.

3. Catheterization of the existing kidney may be undertaken to obviate the possibility of having overlooked a misplaced or concealed ureter. A control catheter in the bladder may confirm the lack of any further supply of urine. This test is of value only when positive, that is, when no urine comes from the control catheter, as urine coming from the bladder may represent leakage down the ureter around the ureteric catheter.

4. Radiographic absence of one renal shadow.

5. Excretion urography is of outstanding importance when a ureteric orifice cannot be discovered, as, if a kidney exists, it may reveal its presence, whereabouts, and condition. It will, of course, fail if the kidney is functionless, though a functionless kidney may be regarded, for practical purposes, as absent.

6. Search for concomitant malformation—especially genital.

7. Pneumoradiography on the defective side, though this is now superseded by excretion urography.

8. Exploration.

Treatment.—The treatment of disease occurring in a solitary kidney calls for discretion and ingenuity. Many operations have been practised on these organs with success. On not a few occasions they have been unwittingly removed.

ABSENCE OF BOTH KIDNEYS.

The absence of both kidneys constitutes an abnormality of no surgical interest, as the individual survives but a few hours or days. Coen collected 33 cases from the literature in 1884. The deficiency is, as a rule, not confined to the kidneys. The ureters are generally absent, and in most cases the bladder also. Multiple deformities are usually observed. The condition also occurs in the lower animals (Garcia).

SUPERNUMERARY KIDNEY.

This is the rarest type of renal anomaly. In 1930 Parin reviewed the literature, and, after excluding many doubtful records and others falsely described as supernumerary, he collected 25 apparently authentic examples. In the same year Kretschmer added a personal case and increased the list to 30, whilst in 1934 Saccone and Hendler brought it up to 36.

By the term 'supernumerary kidney' is understood an independent organ provided with separate fibrous and fatty capsules, pelvis, and blood-supply, and having no connection with the other kidney of the same side. The latter occupies its customary position in the loin, and is approximately normal in size (4 cases are reported where it was notably diminished). The size of the supernumerary organ varies from that of a bean to that of a fully developed kidney. The shape is reniform, though it may show lobulation. In Parin's collection 13 supernumerary kidneys lay to the left, 8 to the right, of the spine, and 4 in the mid-line. Only 3 occupied a position in the body higher than the normal organ. The pelves of the two kidneys were separate in all examples. In less than half the cases separate ureters ran to the bladder; in the remainder the ureters combined before reaching that viscus, but in 2 cases an extravesical insertion into the vagina was observed. Some additional pathological complication has been observed in about three-fifths of the reported cases, and may in many instances be suitably met by removal of the supplementary kidney. Kretschmer, however, showed that disease was also present in the other kidney on the same side in about a third of the cases.

Supernumerary kidneys have been observed in the cow (Pieth) and pig (von Hansemann).

II. CONGENITAL MALFORMATIONS AND DISPLACEMENTS OF THE URETER.

ASSOCIATED WITH A MISPLACED KIDNEY.

When a kidney is misplaced its ureter must of necessity follow an unusual course. Thus with unilateral renal ectopia the ureter has to cross the mid-line, in pelvic ectopia it is short, and with horseshoe kidney the upper ends of both ureters are displaced forwards and lie unduly close to the spine. These and other congenital displacements resulting from renal mal-development have already been described.

DUPLICATION AND BIFIDITY OF THE URETER.

Duplication and bifidity of a ureter are both very common. In duplication two distinct channels are present from a single kidney to the bladder, whilst in bifurcation the channels are separate above but

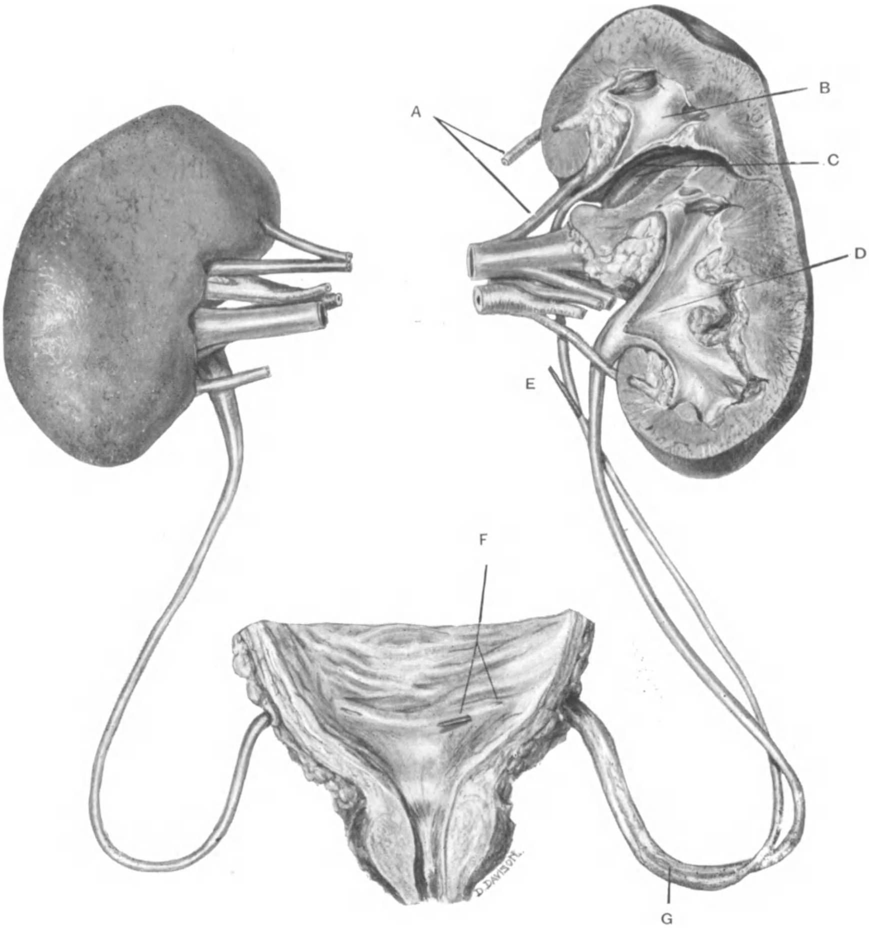


Fig. 217.—Duplication of left pelvis and ureter.—Note : (1) Relative length of the two kidneys ; (2) Sizes of respective pelves and ureters ; (3) The deep sulcus between the two sections of the duplicated kidney each of which has its own capsule ; (4) Separate blood-supply to the upper elements ; (5) Crossings of the two ureters and the insertion of the ureter from the upper pelvis below and internal to its fellow. A catheter has been introduced into the lower ureteric orifice and has been made to emerge through the wall of the ureter in its upper part. The lower orifice drains the upper portion of the kidney. (6) Connective-tissue sheath enclosing ureters which has been retained below but removed above ; (7) The upper portion of the kidney is moulded over its fellow so that its under surface is concave and its general outline semilunar. The lower portion is reniform. A, Separate vessels to upper segment; B, Upper pelvis; C, Dividing sulcus; D, Lower pelvis; E, Catheter; F, Two orifices (note emergence of catheter); G, Two ureters in common sheath.

unite at some point between the renal pelvis and the bladder. Double and bifid ureters without exception are found to drain a duplicated pelvis. A ureter bifid in its lower portion and single above is practically unknown, though Rihmer has reported an authentic instance. In each condition the two ureters run their courses in close proximity, bound together in a common connective-tissue sheath. It is important to differentiate between duplication of a ureter to a solitary kidney and the condition of unilateral fused kidney served by two ureters. In the latter the fused organ represents the glands of the two different sides which have ascended on the same side of the body and united (*see* page 343). It is presumed that duplication of the ureter results from a splitting of the original ureteric bud into two parts, each of which forms its own pelvis and collecting tubules, and claims its own quota of metanephric tissue.

DUPLICATION OF THE URETER.

Unilateral duplication of the ureter is frequently encountered as it occurs in about 2 or 3 per cent of bodies (Bostroem, Pohlman, et al.). The sexes are equally prone to the anomaly, and the right and left sides are affected in like proportions. Bilateral duplication is much less frequent, but is not uncommon. Though only 86 cases appear to have been reported in the literature (Day), many must have gone unreported. The author personally has seen 6 examples. In one man the lower right ureter ended in the posterior urethra (*see* page 364).

There is much constancy in the anatomical arrangements. Starting above, there are two pelves which serve independent portions of the kidney (*Figs.* 217–220). They are placed one above the other, never one in front of the other. The upper pelvis is the smaller and drains approximately a third of the kidney; the lower, obviously the larger, serving the remainder. These proportions are singularly constant. Exceptions have nevertheless been known, the two divisions having been equal in size, whilst in one instance the upper was the larger. The ureters are proportionate in size to their pelves. Usually the upper pelvis shows two or three minor calices only, and it appears to represent the upper major calix and associated minor calices of a kidney supplied with a single ureter, whilst the lower pelvis, which is larger and better fashioned, corresponds to the middle and lower groups of calices. The pelves never communicate. The contrary has been affirmed by several writers, almost certainly incorrectly, and on embryological grounds it would appear improbable that they could communicate.

Passing downwards we find that the ureters bear definite relations to each other. The superior ureter at the upper end starts internal to its fellow, but soon passes behind it so as to become external. In

Fig. 218.

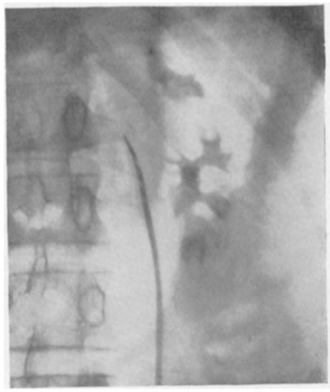


Fig. 219.

Figs. 218, 219.—Duplication of ureter and pelvis. The catheter in the ureter draining lower pelvis did not enter area of pyelogram. This pelvis was distended first (*Fig.* 218), and later the upper pelvis was filled through catheter which appears in the pyelogram (*Fig.* 219). Note small size and rudimentary appearance of upper pelvis.

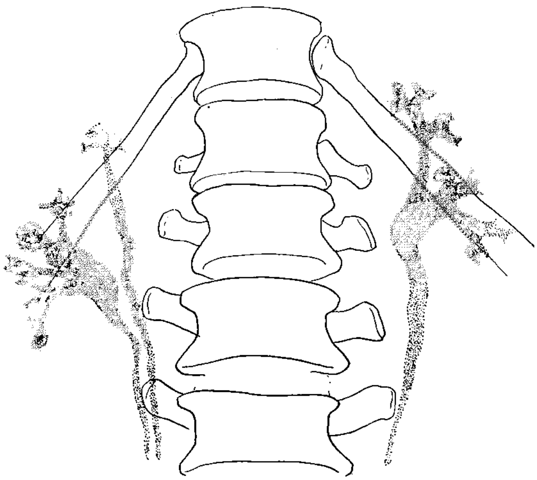


Fig. 220.—Right pelvis duplicated. Upper segment very small. Lower segment might pass for a complete, normal pelvis, though the upper calix is unduly short. No concomitant disease or dilatation. Normal left pelvis, but showing a tendency to bifidity, as is often the case when the other side is double.

the lower third of its course to the bladder it again crosses posteriorly so as to regain the inner side. This is true for the majority of ureters, but does not cover all cases. A pyelogram is shown in *Fig.* 221 in which the ureters run parallel courses without crossing, and Papin has illustrated a specimen in which the upper tube wound spirally round the lower.

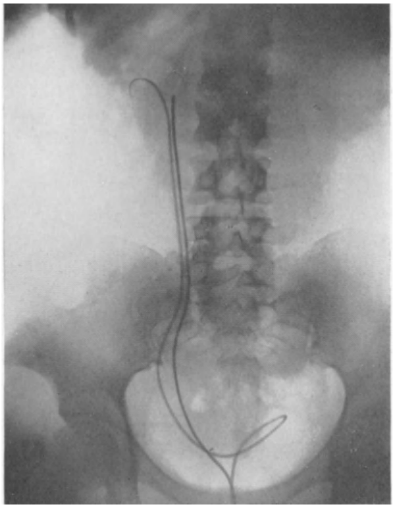


Fig. 221.—Double ureter. Note the absence of crossings.

When the bladder is reached it is found that "the ureter of the upper half of a double organ opens (within or without the bladder) caudally and mesially to the ureter of the lower half". This law was formulated by Weigert in 1877 and was re-stated by Meyer in 1906. It is known on the Continent as the Weigert-Meyer Law. It may be supplemented by the statement that the ureter of the lower pelvis opens at the site which is correct for the normal single ureter. The explanation of this relationship is given in *Fig.* 222, where it will be

Fig. 222.—To expialn why the upper renal element receives the lower insertion at the bladder. The origin from the Wolffian duct (*see* page 364) is seen, and, in the migration along that channel to reach that part of the cloaca which ultimately forms the bladder, the ureter which was originally the lower one precedes its partner and thus eventually becomes the upper.

seen that the lower ureter on the vas precedes its fellow during their migration towards their final insertion and that this precedence continues till the leading ureter wins home, when progress by the second ureter ceases. This law likewise is not without its exceptions (Perlmann, Bostroem, Nicolich, et al.). At their point of implantation I have known the two orifices to be so closely approximated that they appeared cystoscopically as a single opening and were only distinguishable by the double efflux rendered evident through chromocystoscopy. For the most part, however, they will be found sufficiently far apart to be easily recognized. The lower opening may indeed be far removed in the direction of the bladder outlet or may open into the urethra or elsewhere. Extravesical implantations will be described later.

Fig. 223.—Bifid ureters. High junctions. No other pathological condition.

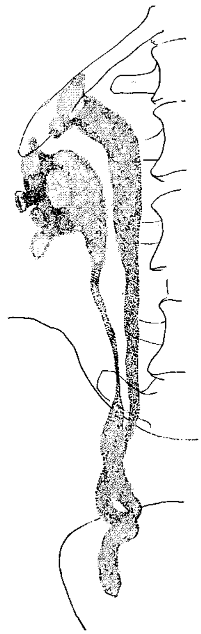


Fig. 224.—Bifid ureter. Low junction. All segments dilated.

BIFID URETER.

A bifid ureter (*Figs.* 223, 224) is one which, when traced upwards from the bladder, is found to divide at some point above the meatus and below the renal pelvis into two separate channels. The point of this division is very variable. It may be situated actually within the vesical wall or, on the other hand, so high up as to appear merely as an exaggeration of the bifid pelvis (Chapter XXIV). Bifidity is said to be at least as common as duplication, though precise figures are lacking. In the writer's experience it is certainly not so much in evidence. It escapes notice at cystoscopy, and at instrumental urography the catheter may pass up one branch which alone receives the opaque medium, though frequently there is an overflow to the other channel. Excretion urography is now showing up additional examples. Bifidity on one side may be associated with duplication on the other. Bifidity on both sides is extremely rare, for Papin could find but 12 reported cases up to the year 1927. When the bifurcation takes place near the bladder the anatomical course and relationships of the two ureters, as also the formation of the two pelves, are identical with those described for duplication. When the division is higher one or both of the ureteral crossings may be wanting, according to its position.

If the ureteric orifice is duplicated one tube may fail to reach the kidney and so ends as a cul-de-sac at a greater or less distance above the bladder. This is a suggested origin for a vesical diverticulum. Similarly with ureteric bifurcation one of the channels may abort and it is then termed a *ureteric diverticulum.* Such a diverticulum may house a calculus, and by this or other means may be a cause of obstruction to the functioning channel.

The outward appearance of the kidneys associated with duplication and bifidity of the ureter does not differ much from the normal, except that they tend to be somewhat longer. Often no alteration is observable externally. Sometimes a furrow is present indicating the boundaries of renal substance drained by the respective pelves. This furrow is stated to be most evident when the bifurcation is near to the kidney (Papin). On longitudinal section (*see Fig.* 217, page 356) the division is more apparent, each pelvis obviously having its own parenchyma. The two areas of parenchyma are, in many examples, partly separated by a double layer of capsule which insinuates itself between them like the pleura between two lobes of the lung. The position of the kidney is not affected by these structural variations. It almost invariably occupies its correct situation in the loin and its two pelves have rotated correctly so as to face the mid-line.

The blood-vessels associated with these anomalies have not been carefully described but appear not to be grossly abnormal.

Diagnosis.—The diagnosis of duplication is self-evident at cystoscopy in most cases, for the second meatus lies somewhere near its fellow. When, however, the opening is far displaced, and especially when it is extravesical, it will be more easily overlooked. Both ureters must be catheterized and the urine examined. Urography will exhibit the contour of their respective pelves, displaying all the various features which have been above described. When the condition is bilateral excretion urography offers advantages, especially in the male, as four catheterizations are difficult to manage and may prove distressing to the patient.

A bifid ureter cannot be recognized apart from urography, which may be either of the instrumental or intravenous variety. With the latter it may be necessary to examine several plates before the picture can be pieced together owing to the fragmentary nature of the shadows. With instrumental urography the following possibilities are presented :—

1. The catheter tip lies distal to the bifurcation and contrast fluid flows up each ureter.

2. The catheter passes beyond the bifurcation up one or other channel, generally selecting the larger one. The fluid regurgitates down the occupied ureter and up the other one. The presence of a catheter obstructing the lower ureter encourages regurgitation into the unoccupied tube, the distension of which, however, is often found to be poor.

3. Pyelography outlines a small and obviously incomplete pelvis and attempts are made by withdrawal, or by withdrawal and re-insertion of the catheter to demonstrate another pelvis.

Kidneys with duplicated outlets are very susceptible to disease. Robinson discovered hydro-ureter of one ureter in 24 per cent of 50 specimens of duplication, while Braasch and Scholl, reviewing 144 cases at the Mayo Clinic, showed that 54 per cent had definite pathological complications, including hydronephrosis, pyonephrosis, pyelonephritis, tubercle, and lithiasis. Mertz, examining 300 reports, found disease in 80 cases (27 per cent). These included: Obstruction with or without infection, renal tuberculosis, renal and ureteric lithiasis, and atrophic pyelonephritis. One section of the kidney may be infected or otherwise diseased whilst the other escapes. The two different parts will then be dissimilar in respect of : (1) Normal urinary constituents; (2) Pathological contents of the urine (albumin, blood, organisms, etc.) ; and (3) Functional capacity.

Treatment.—Disease in these organs may be treated on general surgical principles. The existence, however, of a double outlet encourages an attempt at resection of the kidney when the disease is limited to one part, and a growing number of case reports of such procedures is available. The kidney shown in *Fig.* 227 has a double pelvis and ureter. The lower portion is dilated, and contains a stone (*Figs.* 225–227). Several large cysts are to be observed in the renal tissue. It was resected. In performing a division of the two portions care must be taken : (1) To keep to the natural line of separation between the two portions ; (2) To seal the tubules with a cautery ; (3) To leave abundant capsule for overstitching ; (4) To suture carefully, otherwise a urinary fistula will form. The kidney pouch must be drained.

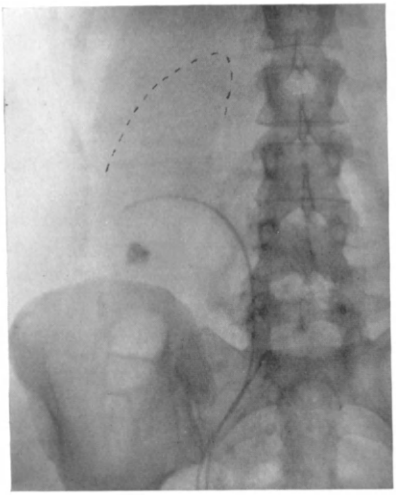


Fig. 225.

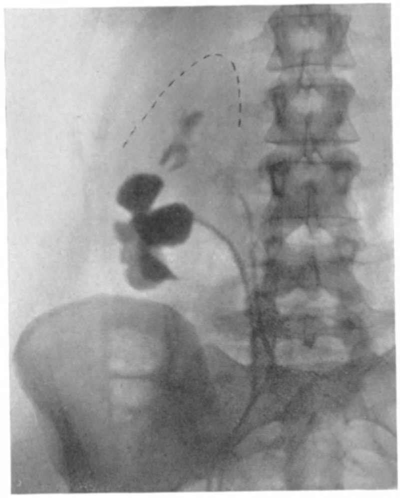


Fig. 226.

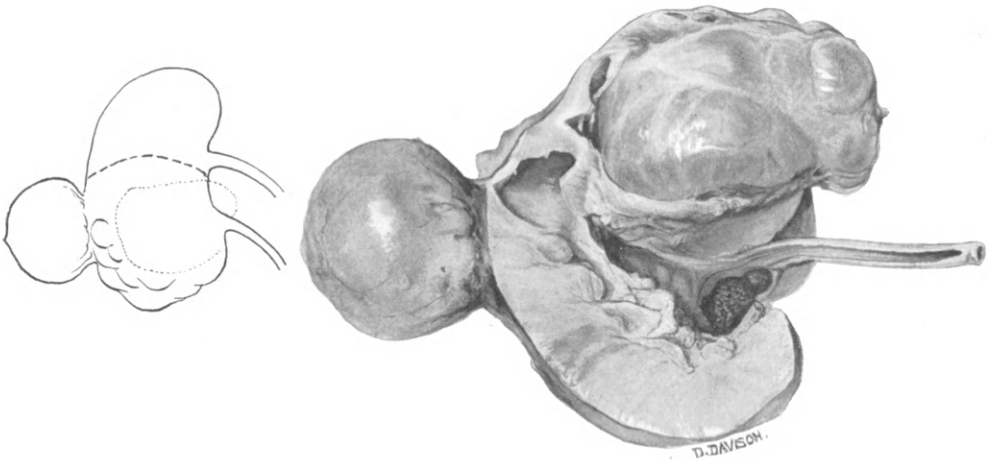


Fig. 227.

Figs. 225–227.—Showing straight X-ray, urogram, and operation specimen, and illustrating procedure in diagnosis. Straight radiogram showed a single shadow very low down and externally placed. Cystoscopy revealed two ureteric orifices on right side. Both were catheterized. Note the course of the catheter to lower pelvis. The urogram shows the double pelvis, the distension of the lower segment, and the blotting out of the stone shadow. The whole kidney lies low. At operation the lower component was removed as it was severely cystic, the line followed being that of the natural cleavage (see line drawing and *Fig.* 217, page 356). The specimen is drawn from above (cut surface).

ERRORS OF IMPLANTATION OF THE URETER.

The orifices of the ureter may be faultily inserted within or without the bladder. Faulty insertions *within the bladder* have already been discussed. They are associated: (1) With malformations of the kidney, a good example being when the single ureter of a solitary kidney opens in the mid-line ; and (2) With duplication of the ureter, when, one of the orifices being normally situated, the other is displaced towards the vesical neck. The majority of intravesical displacements are symptom-free and are, therefore, found unexpectedly at cystoscopy or in the cadaver.

Extravesical implantations are more important. They are much commoner with double than with single ureters. Hartmann (Leipzig) collected 16 cases of positive and 12 of doubtful supernumerary

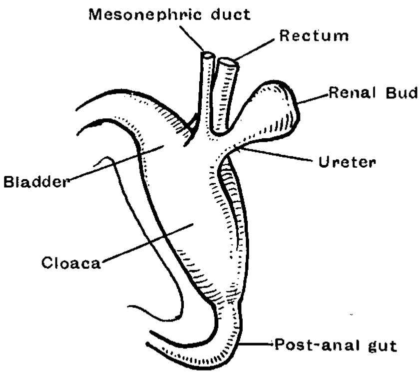


Fig. 228.—To show the origin of the ureter from the mesonephric (Wolffian) duct. (*After Keibel.*)

displacements as against 7 in which a single ureter was ectopic. With double ureters it is always the channel which originates from the upper pelvis (lower insertion at the vesical end—Weigert-Meyer's Law) that is ectopic.

It will be recalled that the ureter originates as an offshoot (*Fig.* 228) from the lower end of the Wolffian (mesonephric) duct (seminal duct, duct of Gärtner in the female) and that from this it migrates to the urogenital sinus (sixth week). The two ducts then part company, the ureter passing forwards and upwards to that area which will ultimately form the trigonum vesicæ, and the vas continuing downwards in the genital cord side by side with the Müllerian duct, the two opening near each other (*Figs.* 229, 231). All the various degrees of ectopia result from the ureter retaining its association with the parts from which it originated or along which it should migrate to reach its correct insertion—therefore:—

1. In the *male* (*Fig.* 229) it may open into the common ejaculatory duct, the seminal vesicle (*Fig.* 230), and occasionally into the last section of the vas deferens. It may also open at the verumontanum.

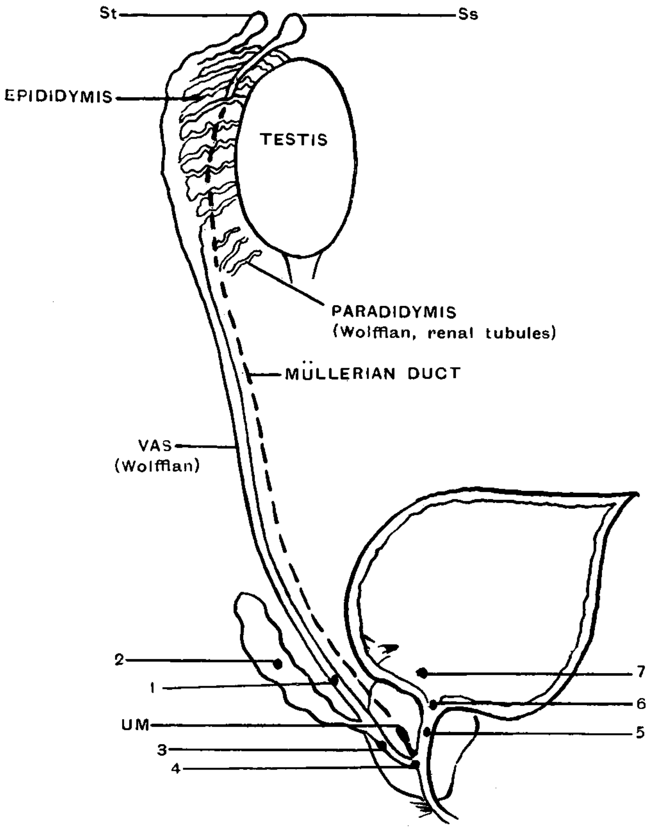


Fig. 229.—Diagram explaining faulty insertions of ureter in the male. Arising from the lower end of the Wolffian duct (*see Fig.* 228) it may remain attached to 1. The vas; 2, The seminal vesicle; 3, The common ejaculatory duct; 4, The junction of common ejaculatory duct and urethra at verumontanum; 5, The floor of the posterior urethra above verumontanum; 6, The internal meatus; 7, The bar of Bell. St, Stalked hydatid of Morgagni—remnant of pronephros. The Müllerian duct is represented by the utriculus masculinus (UM), and the sessile hydatid of Morgagni (Ss). The intermediate portion disappears and is indicated by a dotted line. Compare *Fig.* 231.

If after its separation from the Wolffian duct it has failed to move sufficiently ventralwards towards the bladder, its outlet will be found in the posterior urethra—always at or above the level of the verumontanum, never below it, and always on the floor. In reaching this situation its course may pass between the bladder and prostate or may traverse the latter. In any of these abnormal situations, but

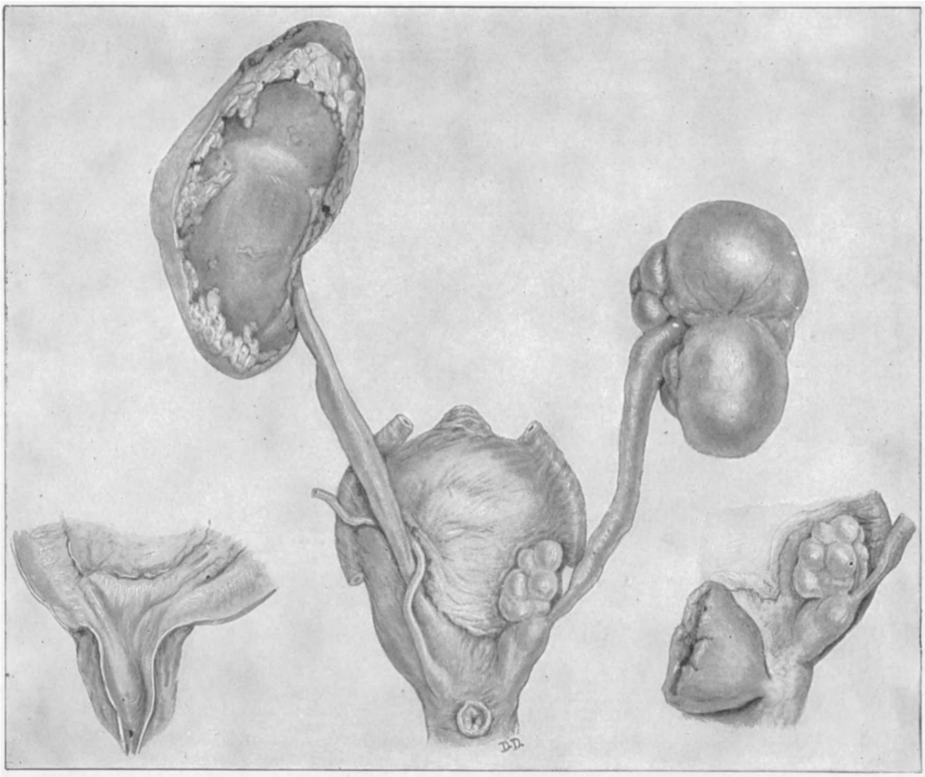


Fig. 230.—Three views of parts removed from an infant who was the subject of several deformities.

1. *Posterior aspect* (centre), note: (*a*) Below—a rosette with a central depression where the rectum opened into the posterior urethra. (*b*) The right ureter opens into the right seminal vesicle, which is dilated. The corresponding kidney is hydronephrotic and cystic. (*c*) There was no vas deferens on this side. (*d*) The left ureter and vas deferens are inserted normally. The vesicula seminalis of this side is not visible (? accidentally removed).

2. *Anterior view.* Asymmetrical trigone showing normal insertion of the left ureter and an undeveloped right ala. The dimple in the posterior urethra is the opening of the rectum.

3. *Lateral view* before removal of funnel of rectum showing its attachment to the prostate, etc. (*From specimen lent by Mr. McCrea.*)

particularly when it opens into the seminal channels, its orifice is prone to stricture formation. The result then varies with the anatomical conditions. If the ureter is a single one, the whole of the urinary channels on that side are dilated. If, on the other hand, it is one of duplicate ureters the upper and smaller pelvis alone is involved.

2. In the *female* (*Fig.* 231) the structures which are homologous to those affected in the male may receive an ectopic ureter. These are

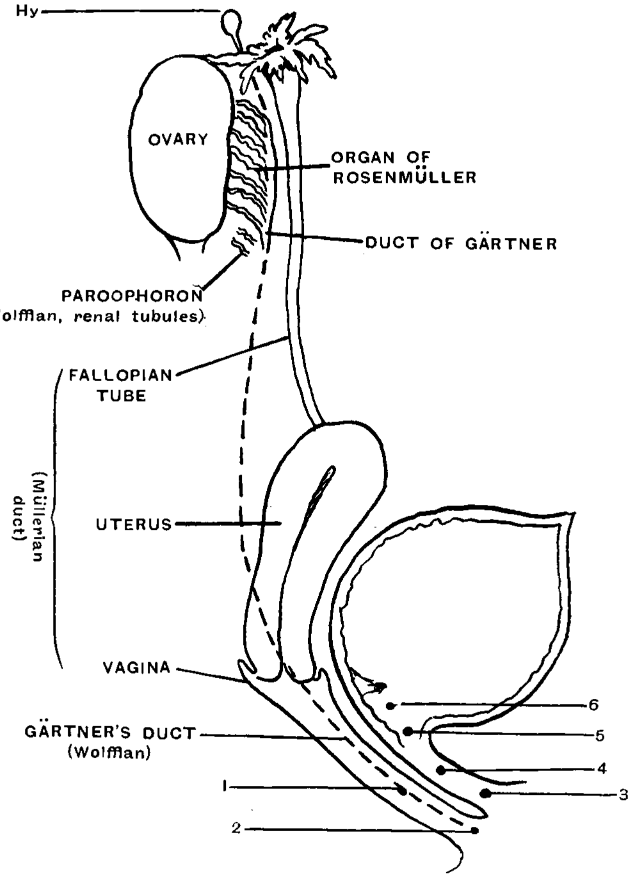


Fig. 231.—Faulty insertions of ureter in the female. The Müllerian duct is seen in this sex to develop into the Fallopian tube, uterus, and vagina. The Wolffian duct, from which the ureter originates, becomes rudimentary. Its remainders are the hydatid of Morgagni (Hy), found near the fimbriated end of the Fallopian tube and the vertical limb of the organ of Rosenmüller (in broad ligament). Portions below this disappear in the human—*see* dotted line. Remnants are sometimes found in the lateral wall of the vagina, where it is called the duct of Gärtner. The embryonic association of the ureter with this duct may persist, and it is then found in the wall of the vagina (1, 2). The line along which the ureter travels in its journey to the bladder is represented by the posterior wall of the urethra and the bar of Bell. The opening may therefore be found at the external or internal urethral meatus (3, 5), in the wall of the urethra (4), or on the bar of Bell (6). Compare *Fig.* 229.

the duct of Gärtner, the vagina, vulva, or the urethra. Hartmann (Copenhagen) states that the ureteric opening was found in the vestibule in 21 cases, in the vagina in 8, in the duct of Gärtner in 2. Obstruction may affect the ureter in this sex also, whilst the situation of the orifice exposes it to infection. In one instance the ureter in reaching the urethra traversed the fibres of the internal sphincter. By this muscle it was compressed except during micturition. In this way the accessory ureter was turned into an additional receptacle and underwent dilatation.

Opening of the ureter into the rectum is a very rare phenomenon. It occurs when the Wolffian duct and ureter have failed to move before the rectum is split off from the urogenital sinus. It is invariably associated with other gross developmental defects.

Symptoms.—In the *female* the symptoms are characteristic. There is diurnal and nocturnal incontinence of urine to the extent of one-half or less of the total urinary output, whilst the remainder is periodically and normally evacuated. The condition originates at birth but is not evident until bladder control has become established. The underlying cause may go long unsuspected. The supernumerary orifice requires a diligent search as it is invariably small and hidden by folds of mucosa. When it lies in the vagina a vaginal tampon and the intravenous injection of indigo-carmine will assist in its identification. When at the vulva close and prolonged inspection is necessary or it will be overlooked. The periodical appearance of a few drops of urine brought down by ureteric peristalsis will eventually betray its whereabouts. In either position an attempt at catheterization should be made with a view to renal function tests and pyelography. Catheterization may prove difficult or impossible owing to stenosis of the orifice. Simultaneous or independent pictures of the other pelvis or pelves are also desirable. Excretion urography is helpful in disclosing the presence of a renal pelvis not accounted for by the orifices hitherto recognized. Continual urinary leakage causes excoriation of the skin of the vulva and thighs. The patients are keenly alive to the severe social disadvantages from which they suffer.

In the *male* urinary incontinence does not occur, as the ureter opens behind the external vesical sphincter, the urine returning to the bladder through the weaker internal sphincter. The condition therefore escapes observation more readily than in the female. The ureter has been catheterized through a posterior urethroscope.

In both sexes disease induced in the kidney and ureter as the result of obstruction or infection will produce supplemental symptoms. Many observers remark a severe dilatation of the lowest section of the ureter. In some cases this has been cyst-like, and in a few has been operated upon in the pelvis without the nature of the condition being recognized.

It is evident that whilst in the male the diagnosis is rarely made, all cases in the female will present symptoms which will be characteristic for the initiated, but the significance of which is frequently overlooked. This fact is revealed in *Fig.* 232. Here the large number of cases which have been observed clinically in the female contrasts strikingly with those in the male. It is interesting also to observe that the total number of reported cases in men is about half that in women, but that the autopsy findings almost exactly reverse these figures. Of the few cases diagnosed clinically in men all sought relief from resulting renal or ureteric disease.

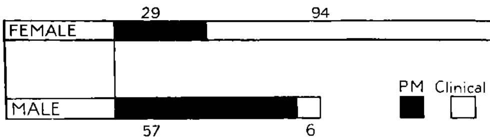


Fig. 232.—Diagram showing incidence of ectopic ureter. (*Redrawn from Sargent.*)

Treatment.—Treatment is imperative in the female because of incontinence. In the male complications in the upper urinary tract alone call for attention. Operation may be directed to the kidney or to the ureter. The choice will depend partly on whether a single or double ureter is concerned. If the former, and the kidney is healthy, neo-implantation of the ureter may be undertaken, though when the kidney is severely diseased nephrectomy comes into consideration. If the latter, a resection of the upper segment together with its pelvis and as much of the ureter as convenient should be attempted.

The literature of this condition abounds with the records of remarkable operations mostly for the implantation of the accessory ureter into the bladder. In many cases the vaginal and 'infrapubic' routes have been chosen. The fact that many of these cases fall into the hands of gynæcologists serves to explain the choice of this route. In all neo-implantations it is true that even if the implantation is successful the bladder now receives urine from an infected source, and the operation drains an area of renal tissue small in extent and injured by back-pressure. Its loss would have been unimportant. The ureter, moreover, is dilated, tortuous, and may be strictured. The risk of contaminating the remainder of the urinary tract by the introduction of septic urine is considerable and should not be accepted. With duplicate ureters the best operation is a partial nephrectomy together with a removal of a part or the whole of the ureter. When the ureter is a single one the condition of the kidney will indicate whether neo-implantation or nephrectomy is preferable. The results of implanation as reviewed in the literature have not on the whole been satisfactory (Herbst and Polkey), and nephrectomy is generally to be preferred if the other kidney is sound.

Other operations requiring brief dismissal are :—

1. Ligature of the ureter, which has the disadvantage of leaving behind dilated and possibly infected passages.

2. Anastomosis between two pelves together with ligature of the ectopic ureter. This has the disadvantage of introducing septic urine into an aseptic pelvis.

3. Interureteric anastomosis, which suffers from the same disadvantage as (2), whilst in addition the insertion of a large tube into a smaller one offers practical difficulties.

4. In three instances a glove-finger has been introduced into a ureter which opened in the vagina. It has been inflated with air and the prominence thus produced in the bladder has been incised with per-urethral diathermy until the glove-finger was perforated. This exploit does not commend itself. It must be uncertain and hazardous, makes a communication between septic and aseptic channels, provides a new orifice which will tend to close, and requires the shutting off of the original opening into the vagina.

CHAPTER XXIII.

RENAL FUNCTION TESTS.

THOUGH renal function tests do not strictly constitute a part of the subject of cystoscopy, they are so closely related thereto that it is proposed to include a description of them in this work. Such tests may be applied to the function of the two kidneys taken together (total renal function) or to that of each of the kidneys individually (separate renal function). Save in rare instances, which will be referred to later, the cystoscopist is not concerned with total renal function. His inquiries are limited to disease primary in one kidney, and having discovered which is the affected organ, he next wishes to know the condition of its fellow, in view of the possibility of surgical intervention.

Separate renal function always requires the cystoscope, either in the form of chromocystoscopy—watching the outflow of dyestuffs at the ureteric orifices—or with the aid of ureteric catheterization—collecting the secretions from the kidneys individually. It will be seen, therefore, that in one way or another the estimation of separate renal function is a cystoscopic problem.

Selection of Tests for Renal Function.—A considerable number of tests have at one time or another been used, but most of them, after careful investigation in the past, have become obsolete. The selection of a test will depend on its reliability and on its simplicity. Reliability is the more important of these, but no test is reliable under all circumstances and in all cases, and the urologist should not confine himself to any one. He should select two or three and not forsake them until he has acquired a mastery over their possibilities and failings and the methods of circumventing the latter. Simplicity in the working of a test, though obviously second in importance to reliability, is nevertheless of much moment. Complicated physical, chemical, and colorimetric tests are time-consuming, and cannot be carried out alongside the cystoscopic examination. An unfortunate interval therefore occurs between the cystoscopy and the decision on a line of action, during which specimens collected are put aside for personal examination or are sent to the laboratory for this purpose. It is a great advantage if the test is so simple that its result can be made known at the time of the cystoscopy, and if its technique is not too laborious to be undertaken by the surgeon or his assistants whilst conducting a cystoscopic clinic.

When employed to estimate separate renal function most tests depend on the power of the kidney to excrete certain substances introduced into the body for the purpose of the test (excretion tests). This constitutes an artificial stimulus to renal activity, and the vigour of the response thereto is the measure of the kidney's capacity.

EXCRETION TESTS.

Significance of Excretion Tests.—Any substance used in excretion tests must be dealt with by the kidney in a manner similar to that which it employs in eliminating the waste products of the body. The work of the kidney in dealing with such substances will then be representative of its excretory capacity in its ordinary work, and will thus provide a true criterion of its function. There are three sets of excretion tests in common use at the present time : (1) Those depending on the elimination of substances occurring in our normal metabolism ; (2) The 'dye tests' ; and (3) Tests resulting from the excretion of contrast media (uroselectan-B, perabrodil, etc.). Of the first I shall describe one, the urea-concentration test ; of the second two, the indigo-carmine and the phenolsulphonephthalein tests ; and the contrast media will be dealt with when describing their use in urography (Chapter XXVI).

Taking the dye tests first : Heidenhain's work on renal excretion, and much of that of his successors, concerns the elimination of indigo-carmine by the kidney, and is based on the visible demonstration of that dye in the renal cells. It is assumed in his work that the kidney adopts the same mechanism for eliminating indigo-carmine as it does for excreting certain of the urinary constituents, and the same assumption is made when we use indigo-carmine and other dyes in renal function testing. It is almost certain that this working hypothesis is sound, and in practice the dye tests give reliable information concerning the renal function.

Nevertheless, some workers prefer the urea-excretion tests, partly on the grounds that this substance occurs in the normal excretory activity of the kidney. Again, in the urea-concentration test, it is assumed that the speed and facility with which this substance is eliminated is characteristic of the kidney's capacity to eliminate the whole of that group of waste products of which urea is so important a member. If this were not so, the test would be useless, for urea alone is not the cause of the chronic uræmic symptoms so often witnessed in urology ; indeed, by itself it appears to have very little harmful effect, as shown by the fact that the blood-urea may be reduced by dietetic means to the normal, and yet the patient die of uræmia (MacLean). It is only one of a number of toxic bodies which accumulate in the blood, but the ability or inability of the kidney to get rid of it is believed to represent the renal efficiency in dealing also with other members of this toxic group. It is selected for a test because its presence is easily recognized and its quantity easily measured.

THE UREA-CONCENTRATION TEST.

The urea-concentration test was reintroduced and popularized by MacLean and de Wesselow during the war, its original purpose being the estimation of renal function in nephritis. Its use has been extended to the surgical field, including separate renal function.

Technique of the Test.—All fluid is withheld from the patient for eight or ten hours prior to the examination. After this he receives by mouth 15 grm. of urea dissolved in 100 c.c. of water. The head of blood-urea thus artificially created is eliminated in health by the kidney within a few hours, during which time the urea in the urine is found to be in the neighbourhood of 2 to 2·5 per cent. Inefficient organs are incapable of eliminating urea in such quantities. If 2 per cent or more of urea is discovered in the urine, the kidney may be regarded as functioning well. When the figure is decidedly below 2 per cent the kidneys are not likely to be efficient, and when the result is between 1·5 and 1 per cent or lower, it is certain that a considerable defect exists. Urea is a diuretic, and one of the first effects of the artificial head of urea is a marked diuresis. In the first and perhaps in the second hour this is so considerable as materially to affect the percentage reading for all urinary solids. The quantity of urea may therefore be well below 2 per cent in spite of a satisfactory elimination. The first hour's readings are therefore ignored, either the second or the third hour being found to provide the highest figure.

When separate renal function is being estimated the ureters are catheterized during the second or third hours after the administration of the draught of urea. Only a sufficient quantity of fluid is collected for the estimation of the percentage of urea, and the catheters are then removed. Meanwhile the total quantity of fluid excreted by the kidney during the separate hours is observed, and if this exceeds 130 c.c. to the hour, allowance must be made for the dilution, or the test must be repeated.

Diuresis is a weak point in this test. The urea percentage obviously depends on two factors, the quantity of the salt and the quantity of the solvent. To obtain satisfactory results from the percentage estimation, the latter of these should remain constant.

Unfortunately it exhibits considerable variations, which cannot be controlled and for which compensatory corrections cannot be made. This factor has been taken into account by Swift-Joly in work on total renal function. He considers that if the hourly response is 10 per cent of the administered dose the condition is satisfactory, even though a copious diuresis brings down the percentage of urea. If one-tenth (1·5 grm.) is eliminated in each hour the patient appears to be safe so far as the kidney is concerned, whereas a 2 per cent urea excretion combined with a small elimination of water may occur in spite of renal inadequacy. Swift-Joly considers that the following figures represent a perfectly satisfactory test :—

		Quantity of Urine	Percentage of Urea	Quantity of Urea
2nd hour	..	165 c.c.	1·3	2·1 grm.
3rd hour	..	125 c.c.	1·6	1·9 ,,

Whereas the following is distinctly bad :—

		Quantity of Urine	Percentage of Urea	Quantity of Urea
2nd hour	..	75 c.c.	1·7	1·27 grm.
3rd hour	..	65 c.c.	2·0	1·3 ,,

The application of the principle to separated catheter specimens is liable to fallacy because of the loss of fluid around the catheters, and it is time-consuming and requires prolonged ureteric catheterization.

When the urea-concentration examinations are used for total renal function in prostatic surgery the highest readings are sometimes noted in the second and sometimes in the third hour of elimination. The same factors must obtain in separate renal estimations, and when the catheters have been in position for only a limited time there is no guarantee that this corresponds with the period of most copious elimination. If it happened to be a period in which excretion was poor, a faulty impression of the kidney's capabilities would be produced.

When one kidney is diseased or destroyed and the work of the body is being carried on unaided by the second organ, the writer has found a greater concentration of urea to be produced by this organ than occurs from either of two healthy kidneys when they are sharing the work.

The test is quite simple to work, the urea percentage being easily arrived at by any of the recognized variations of the hypobromite method, and it has become very popular in this country. In spite of the disadvantages of diuresis to which reference has been made, it is a delicate test. It should be routinely checked by blood-urea estimation, the sample of the blood being best taken for this purpose immediately before the administration of the dose of urea. This additional examination is done in order to obviate the fallacy arising when a high 'pressure head' of blood-urea, itself due to advanced renal disease, causes a normal or even more than normal quantity of urea to escape through the damaged kidney from the accumulation in the blood. The high percentage of urea registered by the concentration test under these circumstances would be regarded as evidence of good renal efficiency, had not its true cause been revealed by examination of the blood-urea.

DYE OR COLOUR TESTS.

Of these a number have been employed, but only two hold the field to-day; these are: (1) *The indigo-carmine*; and (2) *The phenol-sulphonephthalein tests*. The former is the more popular in this country, the latter in America.

I. THE INDIGO-CARMINE TEST.

Indigo-carmine was used by Heidenhain in his classical work on the physiology of the kidney as long ago as 1874, and was adopted for renal function testing by Voelcker and Joseph in 1903. The dye was at first administered intramuscularly, but not until it was used intravenously did the test become popular.

Physical and Chemical Properties.—Indigo-carmine is the sodium salt of indigodisulphonic acid ($H_2C_{16}H_8N_2O_2(SO_3)_2$). It is a stable body and resists sterilization by boiling. Its reaction is neutral, and on the addition of an alkali it turns to a pale yellow, its characteristic colour being restored on the addition of acetic acid. A urine of marked alkalinity may occasionally decolorize the indigo in its passage through an infected kidney (Kidd), but this is very uncommon. Decolorization might be a source of error, and the reason for the absence of blue is likely to be overlooked. The colour could be restored by the addition of acetic acid if the cause were recognized. Indigo-carmine deteriorates if exposed to the air, taking on a greenish coloration, and should then be discarded, as it is valueless.

Technique of the Test.—Indigo-carmine is generally used as a 0·4 per cent solution. It is soluble up to 0·8 per cent. Above this strength it is no longer a solution, but forms a suspension, and when given intravenously is dangerous, because the suspended particles act as minute emboli. Shock, dizziness, and pallor have been recorded as resulting from its use at too great strengths. In two patients of mine a 4 per cent solution was used by mistake. In addition to some slight vomiting, the skin—especially around the eyes and over the scrotum—became a bright indigo blue. One of the patients also suffered from transitory convulsions, due doubtless to minute emboli of undissolved dye lodging in the cerebral capillaries. Though no ultimate harm ensued, these cases illustrate the importance of using a solution of the proper strength.

Method of Injection.—A 10-c.c. syringe, preferably with an eccentric nipple, is filled with the solution. It must contain no air, as this might have serious results if it entered the venous circulation. The median basilic or other convenient vein at the bend of the elbow (*Fig.* 233) is usually selected to receive the dye, the skin being sterilized with iodine. In order to make the veins prominent the arm is held in a dependent position and a light rubber tourniquet—a rubber catheter answers the purpose very well—encircles the upper arm. The patient is also instructed to clench his fist tightly. The needle first perforates the skin to one side of the vein and then by a second movement the vein is entered. 7 c.c. are used for adults, and lesser quantities for younger subjects.

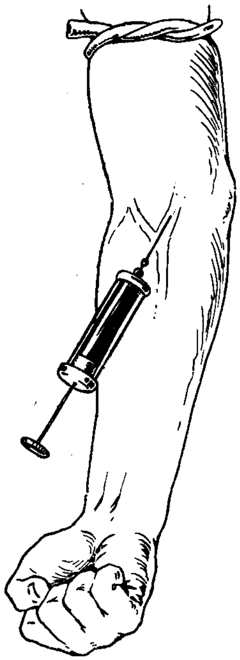


Fig. 233.—Injection of indigo-carmine into a vein.

When the vessel is of good size its lumen is easily found, but when small or deeply situated it may be difficult to strike. If the indigo-carmine escapes into the subcutaneous tissues, a small painful swelling appears around the tip of the needle. A fresh point on the vein, or another vein, must then be selected, and the manœuvre repeated. Sometimes a suitable vessel cannot be found, even though both arms are inspected. This difficulty occurs most frequently in women, owing to the greater development of subcutaneous fat. Other veins may then be sought for in the thigh, leg, or neck, but are usually even less suitable than that at the bend of the elbow. Recourse must then be had to intramuscular injection. When used intramuscularly a larger quantity of dye (20 c.c.) must be employed in order to get comparable results. The excretion then commences late (ten minutes), reaches its zenith in twenty minutes to half an hour, and continues for several hours (up to ten).

Fate of Indigo-carmine in the Body.—About 25 to 30 per cent of indigo-carmine can be discovered in the urine by colorimetric methods. Of the remainder, some is excreted by the liver and is found in the fæces as a leuco-derivative, which becomes blue on exposure to the air. The fate of the remainder is unknown.

In the urine the dye is observed in about 3½ to 6 minutes in health, 4 minutes being the usual time. Three-fifths of the total quantity eliminated by the kidneys is excreted in the first 15 minutes following its appearance in the urine, the depth of coloration increasing rapidly—almost suddenly—after its first onset. During the next half-hour the greater part of the remaining two-fifths is excreted, though traces are still visible at the end of the second hour, and occasionally also at the end of the third. There are two ways of noting the appearance of the blue, the one by inspection of the ureteric meatus (chromocystoscopy), the other by obtaining ureteric catheter specimens. The latter, however, is little used.

Chromocystoscopy is a very simple yet striking examination (*Plate XIV* D, page 328). The first sign of blue generally occurs as a faint puff from the ureteric orifice, but almost immediately the quantity increases, a copious and richly coloured efflux being shot into the bladder medium, and quickly diffusing itself there. The cystoscopic field is momentarily clouded and then slowly clears again. When this has been repeated several times the vesical fluid becomes so deeply stained with the dye that visibility is impaired.

The meatus first inspected should be that one corresponding to the supposed healthy kidney, and as soon as one or two jets of blue have been watched and it has been decided that the work of that organ is satisfactory, the cystoscope should be turned to examine the other meatus. If this kidney is seriously damaged, the excretion will be late and feeble. Often it happens that before any blue arrives at this orifice the transparency of the vesical fluid has been interfered with by the dye pouring from the healthy side, and the lotion has to be changed. This may happen several times during the cystoscopy, and at the end of twelve or fifteen minutes the investigation is abandoned with the note: "No dye seen from the . . . side in fifteen minutes". Frequently when watching an inactive meatus a swirl of blue from the opposite healthy kidney crosses the field. It is of no importance, except that the beginner may be in doubt whether he has overlooked an emission of indigo from the meatus that is under observation.

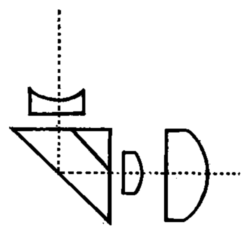


Fig. 234—Wide-angle objective by means of which the two ureters may be simultaneously watched.

To include both ureters in a single cystoscopic field, so that they may be simultaneously under observation, a wide-angle objective (*Fig.* 234) has been designed and is incorporated in the Bernard Ward catheterizing cystoscope. With this instrument the two ureters may be kept in view at a standard focal distance of one inch, and the watch for blue is simplified.

The points to be noted with the indigo-carmine test are the time of onset of the elimination and the depth of the coloration when the dye is being actively excreted. Should the first excretion occur early, say in 4 minutes, the kidney may be regarded as of good capacity. A $3\frac{1}{2}$-minute onset is by no means rare. If the interval exceeds 7 minutes, suspicion is cast on the kidney. If it is over 5 minutes, this delay should be counterbalanced by deep coloration when the peak elimination is reached, otherwise the kidney should be regarded with distrust. It is said that a copious diuresis may weaken the coloration of the dye, but I have not found this to be so, and do not think that even extreme excess in the output of water could be sufficient to affect its coloration materially. If, as sometimes happens, only a part of the indigo has been introduced into the vein, allowance for this circumstance must be made, as the dye may appear late. This may produce uncertainty in the mind of the surgeon, in which event it is incumbent on him to repeat the investigation.

This test is very simple and can be undertaken at a moment's notice during an examination cystoscopy. It is the quickest and least troublesome of all the tests, the results being available as soon as the dye is excreted, and that without the assistance of ureteral catheterization or chemical or colorimetric tests. In avoiding ureteric catheterization it saves time and also eliminates such accidents as occur from leakage around the catheter or blocking of its lumen, whilst it circumvents the secreto-inhibitory action of the ureteric catheter which has already been discussed.

The writer has employed the test extensively, and in his experience it is one of the most delicate of all the tests. It has been found to indicate minor disturbances of renal function very faithfully. On one occasion only has the writer been deceived by it, a tuberculous kidney being removed when the neighbouring gland had shown a satisfactory elimination of indigo-carmine. The patient died at the end of ten days from renal insufficiency, the second organ being found at post-mortem to be the subject of parenchymatous and amyloid changes. Thomson-Walker, however, says that he has not found it reliable for minor degrees of inefficiency. The test is a purely qualitative one and makes no pretensions to being quantitative. Its popularity is high in this country. In Germany, Rehn sent a questionnaire to 33 clinics inquiring their preference in the matter of renal function tests. He found that indigo-carmine was used routinely in 32 out of the 33 clinics and that no other test was used more than half as often. The next in popularity were cryoscopy of the blood and the experimental polyuria tests.

II. THE PHENOLSULPHONEPHTHALEIN TEST.

This test was introduced by Rowntree and Geraghty in 1910 and is much used in America Phenolsulphonephthalein is a bright-red crystalline powder first introduced by Remsen and soluble in water and more so in alcohol. It is very stable and is not decomposed by boiling. An alkaline solution has a brilliant red colour and its recognition in the urine depends on this fact.

Technique of the Test.—Twenty minutes prior to administering the drug, the patient receives 300 c.c. of water in order to procure an active diuresis; otherwise delay in the excretion of the phthalein may be due to lack of renal secretion. One or both ureters are catheterized according to the requirements of the case, and then 6 mgrm. of the drug are administered in 2 c.c. of solution by intramuscular or intravenous injection.*

The secretion from the two kidneys is separately collected in two test-tubes labelled 'right' and 'left' respectively. Each of these contains one or two drops of a 25 per cent solution of sodium hydroxide. As soon as the phthalein appears, a pinkish tinge is observed in this solution, and the time is noted. In an acid solution the colour displayed is yellow or orange, in a strongly alkaline solution it is a brilliant purple-red. When the quantity of urine in the test-tube increases, fresh sodium hydroxide is added to render it markedly alkaline in order that the colour may be maintained. It is claimed that the dye is absolutely non-toxic to the body, that, though it occurs in the bile in high concentration after one or two hours, it is entirely reabsorbed, and is ultimately completely excreted by the kidney unchanged. It is non-injurious to the kidney. It takes about ten minutes on the average for the dye to appear in the test-tube when the kidneys are healthy, though sometimes this interval is considerably reduced. If given intravenously it generally appears much sooner—$1\frac{3}{4}$ to 4 minutes.

When phenolsulphonephthalein is used in the estimation of total renal function the test is a quantitative one. The urines excreted to the end of the first and second hours are diluted up to one litre and compared colorimetrically with a standard solution of phthalein in a Duboscq colorimeter. The total quantity of fluid excreted by the kidneys in this test does not matter, as the specimen has to be further diluted before examination. The quantity of dye excreted in the first hour in health is between 40 and 60 per cent of the quantity injected, and in the second hour 20 to 25 per cent, making a total of 60 to 85 per cent for the two hours. When the urine is separately collected from each kidney the proportion of work done by each

* The solution is made as follows: 0·6 grm. of phthalein and 0·84 c.c. of 2N NaOH are made up to 100 c.c. by the addition of 0·75 per cent solution of NaCl. A few drops of 2N NaOH are added until the maximum red coloration is developed. The drug is nowadays obtainable ready put up in ampoules of 1-c.c. capacity, each ampoule containing the requisite dose—6 mgrm. of the dye.

individually may, under favourable conditions, be arrived at (*see*, however, below). It may, under these circumstances, be advisable to adopt a lesser dilution of the urine in the colorimeter, water being added up to a half instead of one litre. Absence of leakage along the side of the ureteric catheters must be proved by catheterization of the bladder.

The test is not an easy one in practice, and it has not achieved much popularity in this country, partly owing to the difficulty in ensuring that the drug is of good quality. Prior to the discussion on renal function tests at the Royal Society of Medicine in 1921, the writer used this dye extensively for a period of eighteen months, and at that meeting reported that "it had given fair results". Its chief disadvantages were: " The delicacy of the colouring and therefore the ease with which it can be vitiated by the presence of blood and pus, particularly the former, a very small quantity of which will make a considerable difference in reading off on the colorimeter. In many cases it is impossible to avoid a little hæmorrhage from ureteric catheterization. When this has occurred I have resorted to the use of indigo-carmine on a subsequent occasion, the difference in colour of this dye appearing to me to give greater security against a repetition of the failure.*

" The second difficulty is that of obtaining a true reading on the colorimeter. I occasionally take several observations, only to find that they vary, and have seen readings by several different observers in which there has been a considerable discrepancy."

Though the phthalein test aims at being a quantitative one when applied to total renal function, a similar claim cannot be made for separate renal function unless the catheters are kept in position for a sufficiently long time to collect all the dye, which is undesirable, and also because a quantity of urine is generally lost alongside the catheter and finds its way into the bladder. A further disadvantage is that one solution used in the colorimeter contains urinary pigments, whilst the other is made up with water. An attempt to get over this by diluting the standard solution with urine is only partially successful owing to the wide variations in the coloration of that fluid.

Petersen has employed the indigo-carmine and phthalein tests consecutively in the same patients. After catheterization of the ureters he injects the standard dose of carmine and watches its onset and peak period. At the end of about half an hour only a small quantity of the dye is being excreted. He now injects a standard

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* Marrack, however, states that blood can be removed by precipitation with zinc chloride.

dose of phthalein and this is received as usual into a test-tube containing sodium hydroxide. The alkali simultaneously develops the coloration of the phthalein and decolorizes the remnants of the carmine. The behaviour of the two drugs can thus be separately observed.

EXCRETION UROGRAPHY.

There are several ways of employing excretion urography to determine the function of the kidney, and those are described in Chapter XXVI, page 450.

RETENTION TEST: THE BLOOD-UREA TEST.

This test is really one of total renal function, but it has two uses in the examination of the individual functions of the kidney: (1) In the eliminating of fallacies associated with the urea-concentration test, which use has already been described; (2) In cases of tuberculosis of the urinary tract where the state of the bladder is such as to preclude cystoscopy I have occasionally used the blood-urea test. In such cases it is necessary to prove, as the result of clinical examination, radiologically or otherwise, that one kidney is totally disorganized. We may then regard the blood-urea test as a criterion of the work of the only remaining kidney, and if found satisfactory we may safely proceed to nephrectomy, though it may with advantage be supplemented by excretion pyelography whereby the level of renal excretion will be shown and the anatomy and dynamics of pelvis and ureter will be rendered evident (*see* Chapters XXVI, XXVII). Though it is obvious that a proper examination by the accepted cystoscopic methods gives superior results, especially with regard to the cytology of the urine from the supposed healthy kidney, these tests will afford such evidence as the circumstances allow, and almost invariably prove sufficient.

VALUE OF SEPARATE RENAL FUNCTION TESTS.

General points to be taken into account in estimating the value of separate renal function tests are: (1) *The variation in the amount of the excretion*; (2) *The reserve power of the kidney*; (3) *Sepsis.*

1. **Variation in the Amount of Excretion.**—The quantity of dye or urea excreted by a *sound* kidney varies *inversely* with :—

a. The amount of work which is being performed by the opposite kidney. This point has already been brought out in discussing the urea-concentration test. A kidney which is doing the whole excretory work of the body eliminates urea or dye in greater concentration than would be the case if the other organ were sharing the excretion.

b. The amount of reflex and toxic depression which has been caused by disease in the primarily affected kidney. In the section on albuminuria (page 330) it was shown that serious disease of one kidney may cause parenchymatous nephritis in the other. This is probably of threefold origin. It arises owing to increased strain being thrown on to it, to the necessity for excreting toxins produced by the neighbouring gland, and is possibly also partly reflex in origin. As a result of this sympathetic nephritis casts and albumin are discoverable in the catheter urine from this otherwise healthy kidney. In suppurative conditions waxy disease may be superadded. As a rule this kidney improves following the removal of its diseased fellow, as is shown by the disappearance of the albumin and casts from the urine. But on occasion it proves insufficient by itself for the work of the body, the work of its fellow, though perhaps inconsiderable, having previously augmented it sufficiently to ward off uræmia.

Excretion will vary *directly* with the extent to which compensatory hypertrophy has taken place in the sound kidney. This constitutes a difficult problem in urinary surgery. As shown by Rose Bradford, man is supplied with approximately three times as much renal parenchyma as would meet his minimum requirements. The extra two-thirds constitute a safety margin of tissue. When one kidney is partly destroyed the organism attempts to make good the loss by hypertrophy. This occurs chiefly in the opposite kidney, but it also occurs under favourable circumstances in the diseased one. Thus Guyon and Albarran showed compensatory hypertrophy in the wall of hydronephrotic sacs, and the latter in a pyonephrosis and also in the remaining portion of a kidney containing a malignant growth. An attempt appears to be made by nature to restore the previous standards, but it may fall short, especially where the supposed healthy organ is diseased prior to, or as a consequence of, the disease in its fellow. The extent to which nature has already made this reserve good is difficult to assess.

2. **Reserve Power of the Kidney.**—No tests are available to indicate the reserve power of the kidney, though Albarran, by means of his experimental polyuria test, comes the nearest to furnishing us with such a guide. The test is briefly as follows :—

The ureters are catheterized and the urine is collected from each kidney for half an hour in order to find the measure of their normal output. Three large glasses of plain water or Evian water are now administered, and the collection of urine is continued for a further one and a half hours. The receivers for the urine are changed at equal intervals, and the quantity of urine is measured for each unit of time. A comparison is thus possible between the output of the kidney when resting and under conditions of forced diuresis. A healthy kidney can react with great vigour, eliminating during forced diuresis as much as six times the amount of its previous output during rest. A comparatively inefficient kidney, prior to the draught of water, may be producing a greater quantity of urine than the healthy one, but when the extra appeal is made it is incapable of responding. It continues to plod along with little or no augmentation of output. When plotted out as graphs the differences between the reaction of an inefficient and an efficient kidney are very striking.

Together with Guyon, Albarran formulated the following two laws: "A diseased kidney has a more constant function than a healthy one, and the greater the destruction of its parenchyma, the less does its function vary from one minute to another." The second law is a corollary to the first: "As the result of any passing stimulus whatsoever to the renal function, the increased renal activity which results therefrom is always more marked on the healthy than on the diseased side." According to these laws we see that the function of the kidneys should not be estimated only when they are working under ordinary circumstances, for then a diseased organ may hide its deficiency by the constancy of its output. But if they are examined under provocation by means of forced intake of fluids, the healthy kidney can react energetically whilst the kidney which is without reserve responds feebly or not at all, as it is already working to its fullest capacity. This test applied to the supposed healthy kidney comes nearer to indicating its reserve of power than any other.

Another problem is the extent to which further hypertrophy will occur. If a kidney has been totally destroyed for some considerable time, it is a reasonable presumption that the opposite organ has had a sufficient time to produce as much hypertrophy as it is capable of. It may have been hampered, however, by the incubus of its diseased neighbour, and when freed from the latter it may recover from the parenchymatous nephritis from which we know that it generally suffers. Tuffier states that in parenchymatous nephritis no hypertrophy occurs. We have seen that the evidences of this lesion generally disappear when its diseased fellow is removed, and it is reasonable to hope that the kidney may then undergo hypertrophy. Some degree of interstitial change may, however, have taken place and will prevent recovery.

3. **Sepsis.**—Sepsis, if existing in a kidney at the time of the test, will be recognizable and will impoverish its function. On the other hand, it may be implanted subsequently. When a kidney which has given good tests, later appears by its behaviour not to

bear out those tests, the possibility of sepsis being the cause should be remembered.

Valuable as are these tests, they must not be allowed to usurp too important a position. The clinical features of the case must always be given their full weight, and the renal function tests must be considered alongside them. All the evidence must be carefully assessed, preferably by one accustomed to its interpretation and conversant with the scope and limitations of the tests.

UROGRAPHY

THE term 'urography' is used for the radiographical demonstration of any part of the urinary tract after opaque media have been used to render those parts more opaque. Pyelography and ureterography indicate the same process when limited to the pelvis and ureter respectively, though the former word is often loosely applied to both these procedures. Cystography and urethrography refer to similar studies of the bladder and urethra. Various uses of cystography have been described in preceding chapters of this book. The following chapters are concerned with pyelography and ureterography only—that is, with the urography of the upper urinary tract. Up to the year 1929, when excretion urography became a practical proposition, urography was possible only by filling the tract from below with a solution opaque to the X rays. In 1929 the advent of descending, intravenous, or excretion urography provided an alternative method. Separate chapters will be devoted to these two processes which, though they have much in common, yet present many points of difference.

CHAPTER XXIV.

INSTRUMENTAL PYELOGRAPHY AND URETEROGRAPHY.*

INSTRUMENTAL pyelography and ureterography are names given to the radiographic demonstration of the renal pelvis and ureter respectively, after filling them through a ureteric catheter with a solution opaque to the X rays. This examination has many uses, giving information about the shape and position of the pelvis and ureter which is invaluable in diagnosis. The first pyelogram was accidentally made by Voelcker and von Lichtenberg in 1906, who when practising cystography with collargol found that the fluid had regurgitated up the ureter, and outlined that structure together with the pelvis of the kidney. Klose, however, had attempted pyelography in 1904, using a bismuth solution. He failed because his solution, in virtue of its viscidity, was unsuitable. The value of the method was not recognized until about 1910, from which time it has received increasing attention. Its use to-day is universal, and it may be stated that in the absence of proper facilities for urography the standards demanded by modern urology cannot be attained.

DATA SUPPLIED BY PYELOGRAPHY.

The data derivable from pyelography may be classified under the following headings : (1) Demonstration that the pelvic outline is normal in shape and position ; (2) Detection of congenital abnormality in the upper urinary tract ; (3) Detection of alteration in the shape of the pelvis ; (4) Detection of alteration in the position of the pelvis ; (5) Demonstration of the relationship of the urinary tract to shadows seen on a previous radiogram.

1. Very frequently patients consult a surgeon complaining of symptoms the anatomical origin of which is difficult to locate, but in whom the urinary tract is regarded as the probable site of origin. The general examination, together with radiography and urinalysis, however, show no indication of urinary trouble. There remains the

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* *Synonyms :* Cystoscopic, retrograde, ascending, distension, or infusion } urography / pyelography

possibility of pelvic distension or displacement as an explanation for the symptoms. These can be excluded by pyelography, and this will be the final link in the chain of evidence absolving the urinary tract.

2. Congenital abnormality is often discovered quite unexpectedly by urography. Its features and importance have been discussed in Chapter XXII.

3. Alterations in the shape of the pelvis may be due to :—

a. Mechanical distension of the pelvis due to obstruction at the ureteropelvic junction or at a lower level. The cause may be intrinsic or extrinsic.

b. An *atonic dilatasion* of the pelvis and/or ureter. This may result from inflammatory causes (simple or tuberculous infections), or may be an expression of neuro-muscular dysfunction.

c. Cavitation of the renal parenchyma, whether due to simple or tuberculous inflammatory processes, or to necrosis occurring in a neoplasm. (The cavities in all cases must communicate with the pelvis in order that the solution may reach them.)

d. Encroachment on the pelvis by tumours and cysts of renal or pelvic origin, or by foreign substances, particularly stones, blood-clot, or pus occupying the cavity.

e. Pressure on, or *invasion* of, the cavity by neighbouring tumours or other swellings.

4. The position of the pelvis may be altered when it is congenitally displaced, when it is abnormally mobile, or when it is pushed aside by growths or other swellings arising within or without the kidney. If the differential diagnosis between these various conditions cannot be made apart from pyelography, it is generally possible with the aid of that examination.

5. A shadow in the neighbourhood of the kidney may be due to some extramural condition, such as a calcified tuberculous gland, gall-stone, etc. It may be shown by pyelography to be separate from the urinary tract, or, if at first its shadow coincides, it may be divorced from the pyelographic shadow by altering the angle of the X-ray tube. Shadows arising from opacities within the pelvis or ureter become partially or completely obliterated by the superimposed shadow of fluid contained in those channels, whilst if in the parenchyma they will have their relationship to the pelvic shadow exhibited.

TECHNIQUE OF PYELOGRAPHY.

It is highly desirable that the whole operation should be carried out on the X-ray table in order to avoid unnecessary movement of the patient and loss of time. The operation, which is time-consuming, requires the willing co-operation of surgeon and radiologist if good results are to be obtained. The patient comes prepared for X-ray examination in the usual way. The preparation of the bowel is, however, not of very great importance, for the strong shadows thrown by the shadow-casting media can generally be easily distinguished from gas in the bowel. The details of the ureteric catheterization are performed as described in Chapter XIX. It is customary to employ a small ureteric catheter, one not larger than a No. 5, as an additional precaution against over-distension of the renal pelvis, so that the fluid may easily regurgitate along the side of the catheter and escape. (*See*, however, page 462.) In doing this the fluid outlines the ureter, producing a ureterogram. In all instances the catheter should be an opaque one so that its position can be observed.

The instrument is passed up to the pelvis of the kidney when possible. If, however, some obstruction prevents this, the pyelogram can still be obtained, especially if the buttocks are raised to encourage gravitation of the solution towards the kidney. In order to eliminate delay the radiographic apparatus is in absolute readiness before the injection is made. The solution will thus remain in the kidney for a short time only. The surgeon himself should make the injection; it must not be left in the hands of a junior, as too often occurs. He should also await the development of the plates to decide whether or not they are satisfactory and whether it is necessary to increase the distension of the pelvis. Only by personal attention will proper distension and reliable data be obtained. A belt for abdominal pressure is usually employed in renal radiography, but is dispensed with in pyelography, first, because it tends to empty the kidney of pyelographic solution, and, secondly, because it increases the intrarenal pressure. The patient lies flat on his back, but in cases where the catheter has failed to reach the pelvis the end of the table or the buttocks are raised. In cases of mobile kidney a subsequent plate may be exposed with the patient in the upright posture. When feasible this should be done by means of an adjustable table so that movement on the part of the patient is unnecessary.

Instrumental urography is to-day routinely performed on out-patients with no important ill-effects, but provision is made for the patient to rest a while in the event of there being any reaction. Such reactions are observed occasionally, but are usually transitory and of no lasting consequence.

Anæsthesia.—As the sensations of the patient are the best guide to when the danger-point has been reached, it is obvious that general anæsthesia must not be employed, though sacral, spinal, or local anæsthesia may be used for the bladder and urethra. A further reason for not employing general anæsthesia is that the patient must hold his breath during the taking of the radiogram, as otherwise the images will be blurred. In children anæsthesia may occasionally be necessary. It will then be best to employ the gravity method for pelvic distension (*see* page 392) and to expose films frequently. Pain should be inconsiderable, but if it is complained of, a hypodermic injection of morphia may be administered.

Solutions Employed.—The ideal solution for pyelography has yet to be discovered. A large variety has at one time or another been tried, most of which have now been given up as unsuitable. Colloidal silver was the first to be used, and continued in favour for some time. Silver oxide, nargol, and other silver salts were then tried, and silver iodide became popular for a period. At the present time sodium bromide and sodium iodide between them hold the field, though the latter is deservedly the more popular.

An ideal medium must be innocuous, non-irritating, non-viscid, of osmotic pressure similar to that of the urine, easily sterilized, and of good opacity. Sodium iodide is used at a strength of 13·5 per cent, sodium bromide at 15 to 25 per cent, 20 per cent being generally adopted. Sodium bromide was introduced by Weld as a pyelographic medium in 1918, and sodium iodide was employed by Cameron about the same time. The potassium salts were at first used interchangeably with the sodium salts, until it was demonstrated by Weld that pyelographic solutions are absorbed freely from the renal pelvis (*see also* Chapter XXV), especially when the ureter is obstructed. The non-toxicity of the sodium salts is therefore a great advantage, and the potassium salts are now discarded. Following the use of the sodium salts no renal damage can be detected by blood-urea, creatine, or nitrogen estimations or by the indigo-carmine or phenolsulphonephthalein output tests. If, however, operation is undertaken within the first two or three days after pyelography, some œdema of the pelvis is occasionally discernible.

Cameron has shown that the molar 13·5 per cent solution of sodium iodide is as opaque to the rays as a three-molar 25·2 per cent solution of sodium bromide, that the osmotic pressure of the former is fairly close to that of a concentrated urine, whilst the osmotic pressure of a bromide solution is over three times as great. This is important because, other things being constant, the injury produced by hypertonic solutions on living tissues increases with their hypertonicity. Further, the bromide solution is more irritating to the kidney than is the iodide, and its viscosity is also slightly the greater of the two. On the whole, sodium iodide 13·5 per cent solution is the most serviceable medium we possess at the present time. It is neutral in reaction, sterilizable by boiling, and does not form precipitates with blood or urine. Symptoms of iodism are, however, occasionally observed after its use in susceptible persons. The solution can be made by dissolving 15 grm. of the salt in a sufficient amount of water to make 100 grm.

Though these solutions are easily sterilized none of them possesses any appreciable antiseptic value, a quality which, in view of the possibility of carrying infection to the kidney from the lower parts, would be desirable. Attempts to combine them with oxycyanide of mercury or with silver nitrate result in the production of highly irritating bodies, as, for instance, silver iodide, and in several instances (Praetorius, Rafin) kidneys have had to be removed following such a procedure. Mercuric iodide (1–4000) may, however, be combined with the sodium iodide solution if desired.

Lithium iodide was introduced as a urographic solution by E. Joseph somewhat after the drugs described above appeared and is marketed under the trade name of 'Umbrenal' by Messrs. Kahlbaum. It is put up in sealed ampoules which are filled under hydrogen gas to prevent splitting off of iodine. Joseph claims that a 25 per cent solution gives a more intense shadow than previously used substances, that it is unirritating, and is possessed of a certain antiseptic value.

Since the introduction of uroselectan and abrodil for intravenous urography, solutions of these drugs have been employed also for instrumental pyelography. They appear to be the least irritating of all the solutions thus far discovered, but their costliness is for the present prohibitive. They give excellent shadows when the solutions used for intravenous injections are diluted with an equal quantity of water. The shadow-casting properties of these drugs depends largely on their iodine content. Sodium iodide contains 84·7 per cent, lithium iodide 94·8 per cent, and the older uroselectan 42 per cent of iodine. A 30 per cent solution of uroselectan should therefore give a shadow approximately corresponding to a 13 per cent lithium iodide or a 15 per cent sodium bromide solution.

Various gas media have been recommended but have never become popular. Oxygen is the most suitable and was first used by Burkhard. Braasch says that with them there is difficulty in keeping the pelvis filled with the gas, and also that the shadow of the renal pelvis is easily confused with that of gas in the bowel. The method therefore is of little practical value, and in view of the possibility of embolism, which can be easily produced in animal experiment and has in clinical work proved fatal, gas media cannot be too strongly condemned (*see also* page 426).

Method of Injection.—In the early days a number of accidents, including some fatalities, were reported, due to over-distension of the renal pelvis and to the forcing of fluid up the uriniferous tubules of the kidney. In cases where nephrectomy was subsequently performed the colloidal silver then in vogue was found deep in the renal parenchyma, under the capsule, and even in the perirenal tissue. Its presence had caused extensive renal destruction, whilst in some instances infarcts, foci of suppuration, and in at least one case areas of gangrene were discovered. It was soon realized that these accidents were due to over-distension, the injection being forced, according to various observers, up tubules, through interstitial tissue, or along the lymph spaces. At necropsy in animals which died within five minutes of the injection of silver under high pressure the metal was found in distant organs as emboli. A factor contributing previously to renal injury was that in the presence of electrolytes such as are found in the urine many colloid solutions of silver are precipitated, which accounted for the discovery of deposits of the precipitated metal in the renal tissue after pyelography.

All observers are now agreed that pyelography with modern drugs is a safe operation if the pressure of the injection is kept within strict limits (*see*, however, Chapter XXV). So long as the pelvic pressure lies well below the level at which the kidney ceases to secrete urine no danger need be feared. In normal conditions the pressure in the pelvis is negligible, but when the ureter is obstructed it reaches a maximum of 40 to 60 mm. of mercury in about ten to fourteen hours, though much higher pressures have been registered. It should be safe, therefore, to keep the pressure of injection below 40 mm. of mercury. There are three methods of making the injection :—

1. *By Means of Gravity.*—A graduated tube or burette is filled with the solution and is raised a short distance above the level of the kidney pelvis. It may be arranged so that it is supported upon an adjustable stand capable of being raised or lowered as required. An elevation of a foot to eighteen inches should be sufficient to distend the average pelvis. If fluid in any quantity has been previously drained from the kidney, an equivalent amount, as shown on the graduated burette, may be forthwith replaced. If there is no evidence of dilatation, the injection should be stopped as soon as the capacity of the normal renal pelvis—say 5 c.c.—has been reached. The tube is now lowered to a few inches above the level of the pelvis, and a plate is exposed. The continued flow of solution under low pressure thus obtained is serviceable in replacing any solution which escapes from the pelvis down the ureter. Whilst the plate is being developed as much as possible of the solution is withdrawn from the kidney by a hand syringe. The plate is examined when ready, and it is decided whether the pelvis is adequately distended or requires further fluid to display its contour. If a satisfactory negative and a filled pelvis have been obtained, the examination is concluded. If the distension is inadequate, more fluid is employed. Over-distension is guarded

against by using a small catheter, by slow filling, by keeping a look-out for pain, and also by exposing a plate at successive stages to observe the requirements of the particular pelvis. As much of this fluid as possible is removed by suction with a syringe before removing the ureteric catheter. This is especially important when there is a stricture at any point in the ureter.

2. *A Hand Syringe.*—This is employed by many surgeons, and, if used with care and a knowledge of possible danger, is a simple and safe method. The syringe shown in *Fig.* 182, page 286, may be employed in conjunction with the conical nozzle (*Fig.* 235) or the universal fitting (*Fig.* 181, page 286). Syringes made with tapering nozzles are also obtainable. After the first barrelful has been injected a plate is exposed. The remainder of the technique is similar to that described above.

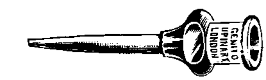


Fig. 235.—Andrews' pyelography nozzle, with 'Record' fitting.

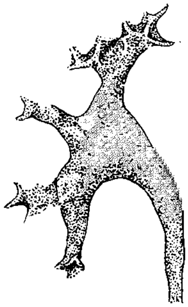
3. *Complicated Burettes.*—Burettes with manometers attached have been adopted by various writers (Papin, Pannett, and others), but are not necessary.

THE NORMAL RENAL PELVIS.

There is much variety in the shapes assumed by the normal pelvis. A knowledge of the normal is essential before abnormality can be detected and its significance correctly assessed.

The renal pelvis presents a funnel- or trumpet-shaped outline continuous at its outer margin with the renal calyces and at its inner and lower angle with the ureter. Its junction with the ureter shows a slight constriction anatomically and in casts taken from the pelvis and upper ureter, but this constriction is only occasionally discernible in a pyelogram. The mesial border of the pelvis may continue the line of the ureter vertically into the upper calix with little deviation (*Fig.* 236, *d*, *k*, *l*, *p*, *t*), but more commonly this line is broken by a double curve first outwards and then upwards, so that the calix, though more or less parallel to the ureteric line, is more externally placed (*Fig.* 236, *a*, *c*, *g*, *h*, *o*, *s*, etc.). The lower border of the pelvis diverges rapidly from the mesial, sweeping over with a regular and shapely curve into the lowest calix. The outer margin receives the middle calices.

Variations in the Normal Pelvic Contour.—These depend chiefly upon the respective extent to which the calices and the pelvis proper are developed. The range of appearances within the normal is a very wide one, and for this reason tracings of twenty normal pelves, selected because of their diversity, are illustrated. Three principal types may be described :—



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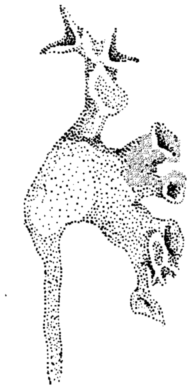

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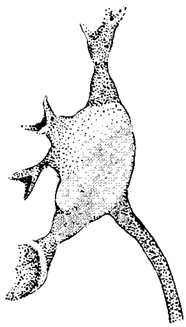

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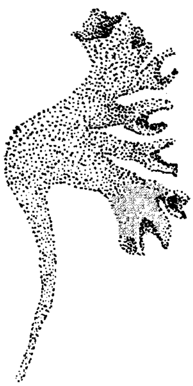

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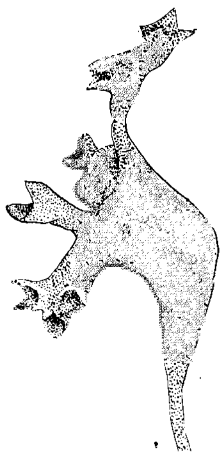

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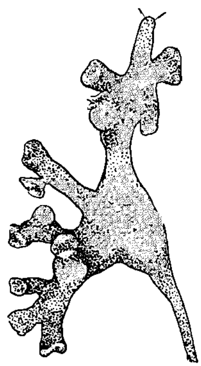

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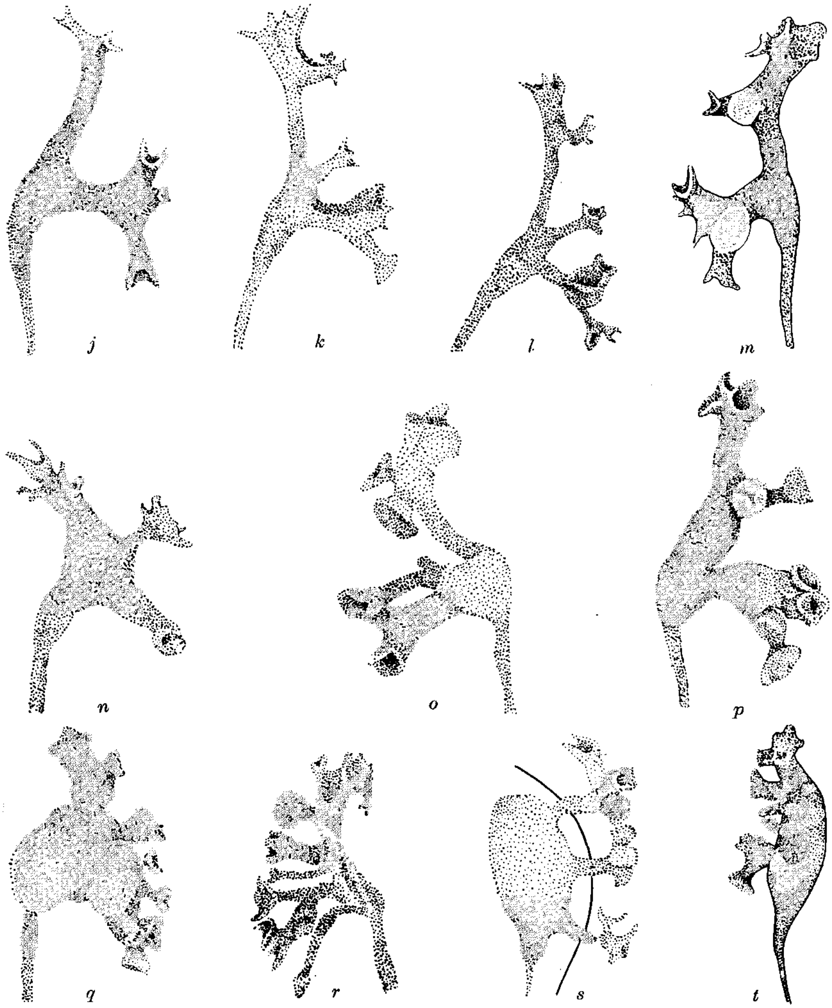


Fig. 236.—All figures are tracings from pyelograms and are reduced by one-half. They are therefore true in relation to each other and the variation in size of the normal is evident.

a, b, c, are characteristic of *Type A*, the triangular pelvis (*see also Fig.* 252, page 410, left pelvis).

j, k, l, m, illustrate *Type B*, the pelvis proper being small and the major calices, especially the upper one, large. The minor calices are few in this variety (cf. *e, g, i, r*).

Type C is represented by *q* and *t*.

Examine the different ways in which the ureteric line is continued upwards, contrasting *j, k, l, m, p,* with *a, c, g, h, s*. *f* shows the effect of mechanical distortion of the ureter and pelvis by the catheter.

The middle group of calices is very variable. It may be absent (*j*), single (*a, k, l, n, s*), double (*b, d, f, g*), multiple (*q, r, t*), or spring from one or both (cf. *Fig.* 237, left pelvis), of the other major calices.

One minor calix of the upper group often faces the spine (*a, b, c, f, j, m, p,* etc.). No other calix faces internally unless the kidney is congenitally abnormal or is displaced. Minor calices facing towards or away from the observer are seen as circles—best seen in *d, e, f, m, p*. The size of the minor calix is variable—contrast *c, e, g,* with *d, j,* and *t*.

r, s, t are somewhat bizarre types.

1. *Type A.*—In the first and most usual type (*Fig.* 236, *a*, *b*, *c*, *i*, etc., also *Fig.* 252, left pelvis, page 410) the triangular outline of the pelvis is well marked, receiving above the upper calix; below, the lower; and at a point near its centre, one or more shorter calices.

It is convenient at this point to describe the appearance of the calices. These are divided into major and minor. The *major* or primary calices are usually three in number, an upper, which is roughly perpendicular in direction, and is frequently long—over one inch; a middle one—sometimes double—which passes outwards; and a lower calix which curves outwards and downwards. When long these calices are seen to be slightly constricted at their middle, but when short they are generally stout and have parallel margins.

Two, three, or more *minor* or secondary calices cap the extremity of each primary calix, and in the pyelogram they appear as a fimbriated termination to the latter. Their extremities are cup-shaped and embrace the apices of the papillæ. When favourably placed their concave form may be suggested on the pyelogram, but more commonly they are seen in profile and appear pyramoid. When seen end-on they appear circular. In the middle area of the kidney the minor calices face anteriorly, posteriorly, or externally, according to the portions of the organ which they drain. The shadows of the anterior and posterior groups often overlap on the plate. At the two poles the calices face as above, but additional cups are present looking inwards and upwards in the case of the upper pole, downwards (rarely inwards) in the case of the lower, to drain the extremities of the gland. The minor calices are therefore more closely grouped at the two poles.

The delicate contour displayed by these cups is one of the first things to undergo change as the result of mechanical distension. Owing to their small size their shadow also suffers more readily from movements during the exposure of the film than does that of the coarser elements.

2. *Type B.*—In the second type (*Figs.* 236, *j*, *k*, *l*, *m*, and 237) the familiar funnel-shaped pelvis has been encroached upon by an unwonted development of the major calices, and in well-marked instances the pelvis proper ceases to exist. There is then an upper and a lower calix, and the condition differs only in degree from that known as bifidity of the renal pelvis. The pelvis is Y- or T-shaped, the middle calix opening into the upper or lower branch, or occasionally at the angle between the two (*Fig.* 236, *k*, *l*). Papin prefers to describe this as the typical form and regards the other varieties as modifications resulting from effacement of the angle of bifurcation.

3. *Type C.*—In the third type (*Fig.* 236, *q*, *t*) the pelvis proper is more developed and absorbs the major calices so that the minor calices open directly into the pelvis itself.

These three types are selected in order to facilitate description, but that intermediate varieties are constantly observed is obvious from a study of *Fig.* 236.

In interpreting a pyelogram it should be borne in mind that the shadow is only a silhouette of the renal pelvis and it must be interpreted accordingly. Parts of the tube may be foreshortened, and unless care is exercised this may lead to erroneous deductions. Thus the ureter often approaches the pelvis on a plane which is not quite perpendicular, so that it appears to be implanted above the lowest point. This appearance may be artificially produced when the catheter has been pushed so far that its tip is arrested in a calix, and the ureter becomes bowed in an antero-posterior direction. Implantation of the ureter above the lowest point of the pelvis is a sign of commencing hydronephrosis, and its artificial production must not be confounded with that pathological condition. The upper and lower major calices as a rule present their full length to the rays, but frequently the middle one is foreshortened (*Fig.* 236, *f*, *h*, *m*). The middle calix is normally shorter than the other two, and by such foreshortening this feature is accentuated. Occasionally the extremities of the calices overlap, and in so doing present the appearance of inosculating. This, however, is artificial, as may be demonstrated by taking a fresh radiogram from a different angle.

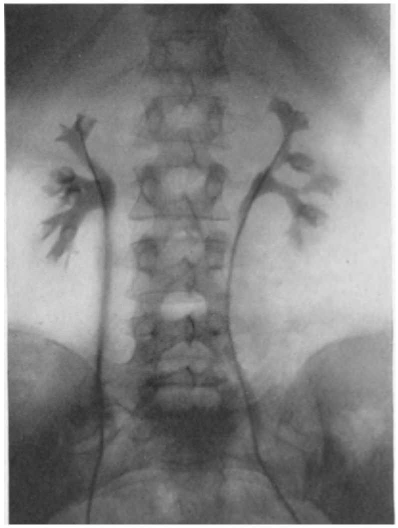


Fig. 237.—Bilatera normal pelves. Minor calices beautifully cupped. The left pelvis is a characteristic *Type B*. Note that the middle section of the kidney drains equally into the upper and lower major calices. The right pelvis is a form intermediate between *Types A* and *B*. The catheter enters the upper calix on each side, and on the left the ureter has been deflected so that it overlies the spine.

Position of the Normal Pelvis.—When the X-ray tube is centred just above the umbilical line the ureteropelvic junction is situated on a level with the transverse process of the 2nd lumbar vertebra, being slightly higher on the left than on the right side. This relationship is very constant with the normally situated and non-mobile kidney, and if altered, displacement or mobility can be diagnosed. It offers a better criterion of the position of the kidney than does the situation of the calices, whose development is very variable. These latter may reach in the upward direction as high as the 11th rib. The extremity of the lowest calix rarely descends below the transverse process of the 3rd lumbar vertebra in health.

CONGENITAL ABNORMALITIES OF THE KIDNEY.

(*See* Chapter XXII.)

MOVABLE KIDNEY.

Movable kidney can as a rule be diagnosed by palpation, and pyelography is only indicated for the investigation of concomitant disease or to establish the presence of pelvic dilatation. Plates should be exposed both in the upright and in the recumbent position in order to show the excursion of the kidney, the tube and plate as far as possible retaining the same relationship to the kidney. A mobile organ may retain its upright position when dropped, but more commonly it swings on its vascular pedicle, so that when it is under the costal margin it assumes its usual upright attitude, but as it descends its lower pole approaches the mid-line, and its hilum, which normally looks directly inwards, now faces upwards. Occasionally the kidney may reach, or even cross, the mid-line. In pronounced prolapse the shadow lies opposite the 4th or 5th lumbar vertebra, but it may actually overlap the iliac crest. Sometimes even in this position the pyelogram shows that the kidney is upright. When its axis tends to the horizontal the line of the calices as seen on the radiogram will undergo modification, so that the upper and lower calices come to lie in the horizontal plane, whilst the middle one is directed downwards. The hilum now faces upwards, and the ureter approaches it from above.

The ureter becomes redundant in length owing to the diminished distance between the kidney and bladder. It therefore presents a certain degree of tortuosity. It may be normal in calibre, but is frequently slightly dilated and atonic. Owing to its flaccidity and tortuosity it often happens that the point of the catheter picks up a fold of mucosa and is checked. An artificial kink is thereby produced on the pyelogram. This is particularly prone to occur at the point where the ureter is approaching the kidney, for it has here to negotiate a sharp curve to reach the upward facing pelvis. A stiff catheter will markedly displace the ureter, bowing it inwards so that it may even overlap the bodies of the vertebræ. These kinks and artificial curves disappear if the catheter is withdrawn after injection of the medium, but it is technically sounder not to pass the catheter in the first instance beyond the lower reaches of the ureter. Then the actual course and dilatations of the tube will be demonstrated and artificial kinking will be excluded. Some kinks of the ureter are seen only when the patient is in the upright position.

The pelvis itself may be normal in form, but it usually shows some slight degree of dilatation. This is sometimes due to atony comparable with that already shown to occur in the ureter. At others it is definitely due to back-pressure, varying degrees of actual hydronephrosis being observed (*see Fig.* 246, page 407). Kinks near the ureteropelvic junction may then be ascribed to adhesion between the ureter and the dilated hydronephrotic sac. Definite distension of the pelvis is an indication for operative interference ; it also constitutes an objective explanation for some of the symptoms which are usually regarded as purely subjective.

HYDRONEPHROSIS.

Small Hydronephroses.—The detection of early pelvic distension was the first field to which pyelography was applied, and it is still its most important province. Pyelography is the only available method of diagnosing the minor degrees of pyelectasis, and as a great deal of renal pain is attributable to this cause, its importance is obvious. It must be remembered that the operative demonstration of early renal distension is far from easy, and the importance of an accurate diagnosis prior to operation is thus greatly increased. Pyelography therefore fills in a serious gap in our diagnostic armamentarium.

Many surgeons still think of hydronephrosis in terms of a tumour which can be palpated in the loin; yet experience in the diagnosis of renal pain soon teaches that such gross instances of pelvic dilatation are rare in comparison with the minor degrees to the detection of which pyelography is so usefully applied. Renal pain is probably more severe at the onset, when distension is actually increasing and renal secretion is copious, than when the hydronephrosis is large and the parenchyma reduced in quantity, so that the patient is more likely to request treatment at this period than later. In a great many of these early cases the diagnosis is missed both clinically and even at operation.

In the absence of pyelography the pain of an incipient hydronephrosis may be erroneously attributed to some other organ (appendix, gall-bladder, etc.) and faulty surgical treatment adopted.

Complete absence of other symptoms or signs pointing to the urinary tract is characteristic of this complaint, and tends to put the surgeon off the correct diagnosis. On the other hand, there are instances in which the urinary tract is unjustly suspected of being the seat of pain. Even after the urine has been proved healthy, X-ray evidence has been negative, and satisfactory renal elimination has been established, doubt may still remain in difficult cases, and the demonstration of a normal pelvic outline will be valuable evidence in exonerating the kidney.

Large Hydronephroses.—It is only with large hydronephroses that the condition can be diagnosed satisfactorily by symptomatology and abdominal palpation, but the cystoscopist should then consider whether any fresh information is obtainable by pyelography. If not, the examination should be omitted : first, because it is a general cystoscopic principle that diagnoses which can be made with certainty by simple means should not be supplemented by complicated ones, and, secondly, because in many cases, as will be shown later, the injected fluid cannot be drawn off by the catheter from the kidney as has been recommended, whilst the pelvis itself, being obstructed, is unable to discharge its contents freely in the natural way. The pyelographic solution is therefore liable to be retained in the renal pelvis, or absorbed by the kidney (*see* Chapter XXV), neither of which is desirable.

Excretion urography has much to recommend it in this class of case, and in spite of the great loss of renal function it generally gives at least a sufficient shadow, the density being increased by the great depth of the fluid and by the retention of the dye.

It will generally be possible to tell by a study of the history and symptoms whether a renal enlargement is a hydronephrosis or a neoplasm, but in cases of doubt a pyelogram will show whether the pelvis is distended to form a sac, or has undergone such changes as are seen in renal neoplasm or congenital cystic disease of the kidney (*see* page 414). If the ureteric catheter can reach the renal pelvis, the evacuation of the retained urine and the disappearance of the swelling will itself be evidence of the hydronephrotic nature of the enlargement ; but where the catheter sticks and the sac cannot be drained, pyelography will be required.

When a hydronephrosis conforms to that type which shows a congenital narrowing of the ureteropelvic junction, pyelography is more instructive when applied to the opposite organ than to the obviously diseased one, in view of the tendency of the trouble to be bilateral. The opposite pelvis may exhibit some degree of deformity which, though slight and inappreciable by other examinations, may affect the prognosis and treatment. I have on two occasions seen nephrectomy of the palpable kidney promote a rapid distension of the remaining organ. This is due to the increased work thrown on it. Thomson-Walker, discussing the relationship of diuresis to hydronephrosis, says: "There are many cases of congenital valves and narrowings of the ureter . . . in which the lumen is sufficient for the escape of the urine under ordinary conditions, but is too narrow to drain a sudden diuresis. From the comparative obstruction thus established hydronephrosis begins to develop and the pressure it exerts upon the ureter increases the obstruction." Apparently the additional work to which these organs are subjected by the removal of their fellows, although slight, may be enough to precipitate the development of a hydronephrosis. Pyelography may show whether the second kidney has a tendency to develop a hydronephrosis, and will thus be of assistance as an operative indication, and also from the point of view of prognosis.

Technique of Pyelography.—Modification of the pyelographic technique is necessary when dealing with a hydronephrosis, for two reasons:—

1. The obstruction which is the cause of the hydronephrosis may arrest the catheter so that it is impossible to introduce it into the renal pelvis.

2. Whilst the normal and unobstructed pelvis is always empty, or practically so, the hydronephrotic pelvis ordinarily contains a residuum of fluid (the intermittent hydronephrosis may be an exception). Before the latter can be distended with solution it must be drained of its contents. This is obviously impossible where the catheter fails to reach the dilated sac.

a. When the catheter has reached the kidney this will become evident by the rapid drip of urine through its lumen. Plenty of time should be allowed for the pelvis to empty itself. The urine should be collected and measured, so that an idea may be gained of how much solution can be replaced in the kidney. Prior to the introduction of pyelography this method of estimating the size of a hydronephrosis was the only one available. It was crude and inaccurate. Obvious fallacies are the difficulty of deciding when the pelvis is empty and in obtaining complete evacuation, there being often a renal sump lying below the level of the outlet in which urine is retained. For the same reason the emptying of the kidney for pyelography is often incomplete, so that the medium on introduction becomes diluted with urine. When the dilution is considerable the radiographic density suffers, and the shadow may be indistinct or unevenly distributed (*see Fig.* 249, page 408). Therefore in distending large sacs a solution of increased strength is used by some surgeons, but is not really necessary.

b. In those cases in which the catheter is obstructed in the ureter or at the ureteropelvic junction it may or may not be possible to outline the pelvis. If the buttocks are raised, the solution may gravitate past the obstruction. On the other hand, it may fail to do so, and will then regurgitate into the bladder. In practice it is usually found that a proportion of the fluid enters the pelvis and a pyelogram is obtained. Whatever reaches the pelvis under these circumstances will be additional to that already present. Here again it may be advisable to use a solution of greater strength in order to get a satisfactory shadow. It should be remembered, however, that the solution which is introduced in this way cannot be withdrawn through the catheter, nor can the kidney expel it down the obstructed ureter with its normal ease, so that particular care should be taken to avoid overdistension.

In the case of intermittent hydronephrosis Papin has shown that during the attack of retention it is frequently impossible to introduce fluid into the kidney, but when the attack is over the obstruction disappears and a pyelogram may be obtained.

Significance of Pain.—The pain produced by pyelography should be carefully noted. It has diagnostic significance from two points of view :—

1. It varies in degree inversely with the dimensions of the hydronephrosis. The largest sacs when filled are almost or quite painless. The closer the pelvis approximates to the normal, the more is pain experienced.

2. It is important to inquire from the patient regarding the type of his pain. Does it correspond to that from which he is seeking relief ? In many of these cases the pain which is the reason for the investigation is not yet, at the time of the pyelography, definitely imputable to the kidney. If the discomfort of pyelography simulates that from which the patient has suffered, it may be assumed that the kidney is the organ affected.

Evidences of Renal Distension on the Pyelogram.—Large and medium-sized hydronephroses are easily diagnosed pyelographically, but with the smaller ones it is different. It requires much care and acumen to recognize the earliest phases of dilatation and to decide whether the condition is a variety of the normal or is pathological. Yet these minor distensions give pronounced symptoms and are the ones where assistance is most required, whilst pyelography is the only available method of diagnosis.

Small Hydronephroses (*Fig.* 238).—Distension will naturally first affect the delicate minor calices, and later the more fibrous pelvis. Pressure atrophy also occurs early in the papillæ so that they are flattened. The earliest pyelographic change therefore is seen in the

Fig. 238.—Tracings from various cases of minor pyelectasis.

cup-shaped *minor calices*, which become decreasingly concave and are eventually flattened or even convex (*Fig.* 239). The major calix, with its distended minor calices, thus assumes a club-shaped appearance. This is, perhaps, the most important of all early changes from the diagnostic point of view.

Fig. 239.—The progress of calicine distension.

The next structure to be involved is the *major calix*, its boundaries being pressed back so that it becomes broader and loses the slight waist which is generally to be observed in the normal state. Increase in the length of the calix may or may not be noted, for often atrophy affects equally the depths of the sinus and its portals—intercalicine papillæ. Later the calices are definitely shortened. Dilatation is almost invariably seen at the poles before becoming evident in the middle calix (*Figs.* 241–246).

It is not possible to say whether the *pelvis* itself is dilated until the process is well advanced, for normal pelves vary considerably in size, and before saying that any given example is dilated it would be necessary to know the natural dimensions of that particular pelvis. Braasch says it may be of value to make a bilateral pyelogram in order to compare the outline of the two pelves. As a rule an unusual increase in size, if normal, will be present on both sides.

A significant change which may escape observation unless specially looked for is an alteration in the symmetry of the curve which the upper ureter makes with the lower margin of the pelvis. " An early change which occurs when dilatation is developing is angulation of the lower ureterocalicine curve. This becomes more and more acute as the lower calix approaches the upper ureter." (Thomson-Walker.) Later the position of implantation of the ureter alters, and it comes to appear to be inserted at a point on the median border of the pelvis, though, as previously stated, this appearance may occur in the normal as an artefact due to the ureter approaching its insertion in the antero-posterior plane.

Inadequate distension of the pelvis may lead to error in two opposite ways : (1) If the size of the pelvis is normally large and yet it is inadequately filled, the minor calices may escape distension. The absence of their fimbriated extremities, taken in conjunction with the large pelvis, may lead to the diagnosis of hydronephrosis. (2) On the other hand, an early hydronephrosis may remain unrecognized when insufficiently distended because it appears of small size.

Medium-sized Hydronephroses (*Fig.* 240).—As distension progresses, all the features enumerated above become exaggerated, the pelvis is larger, the calices are broader and shorter, and the ureteric insertion is more displaced.

Large Hydronephroses.—As before stated, pyelography is not absolutely indispensable for those cases which can be diagnosed by

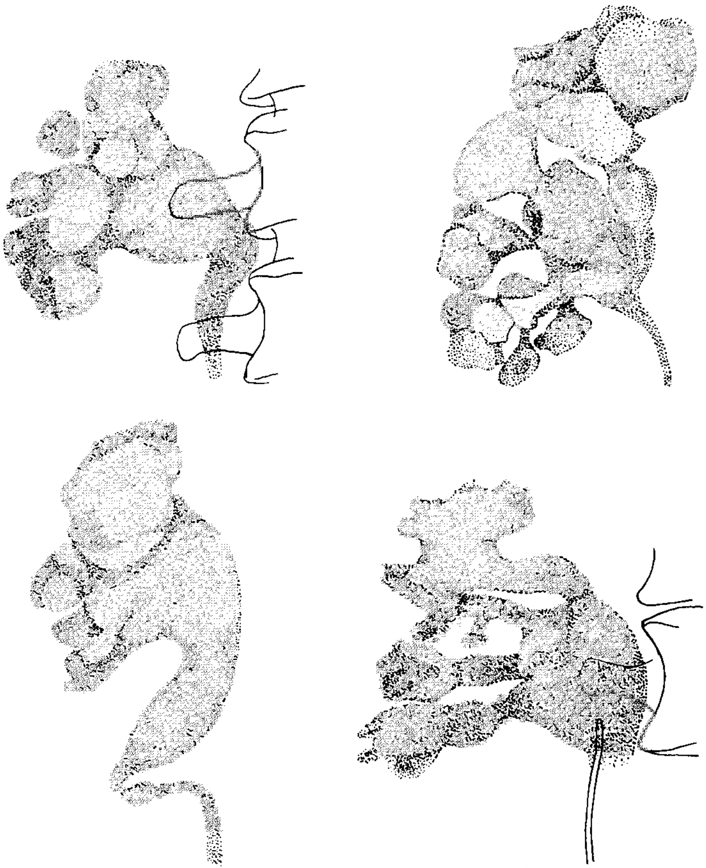


Fig. 240.—Pyelectasis of moderate severity.

symptomatology and abdominal palpation, especially as the diagnosis between a growth and a hydronephrosis can be made by emptying the latter through a ureteric catheter when such can be introduced into the renal pelvis. It is, however, usually undertaken. Little or no pain is caused by the distension of a large sac. When a considerable amount of urine is withdrawn by the catheter, this may be straightway replaced by an equivalent amount of solution ; but where there is uncertainty regarding the size of the pelvis, plates should be exposed at intervals in order to check progress. The sac is usually single, and the pyelographic shadow varies in contour according as

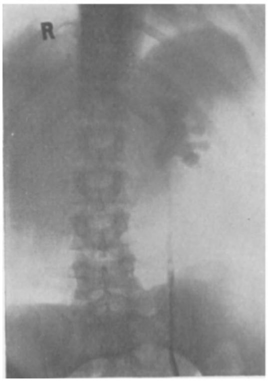


Fig. 241.—Dilatation slight but unquestionable. Chief evidence is the clubbing of the calices.

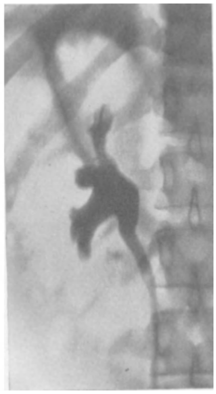


Fig. 242.—The tip of the catheter is seen in the upper calix, and the ureter is displaced.

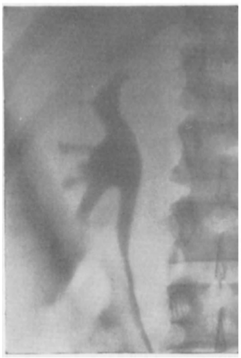


Fig. 243.—Minor pelvic distension. Upper calix mainly affected.

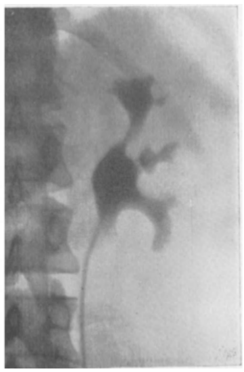


Fig. 244.—Pyelectasis evident but pelvis not fully distended with solution.

the pelvis (pelvic hydronephrosis) or kidney (renal hydronephrosis) has borne the brunt of the dilatation. Frequently it has been evenly distributed between the two (mixed hydronephrosis) (*see Figs.* 249, 252, 253).

In the *pelvic* type the enlargement occurs chiefly outside the renal sinus (extrarenal type). The pelvis is greatly enlarged and is often more or less rounded (*Fig.* 247), though it may retain its triangular contour (*Fig.* 248). A considerable quantity of renal tissue remains, though it is generally more or less excavated by secondary chambers opening into the main cavity.

In the *renal* type the pressure is chiefly felt inside the limits of the sinus (intrarenal type) (*see Fig.* 258, page 413). The pelvis may be little or not at all dilated, whilst the parenchyma is greatly reduced

Fig. 245.—Distension uniform and of medium severity. Minor calices completely effaced.

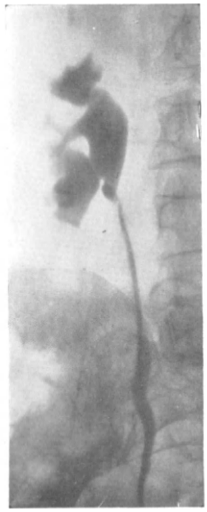


Fig. 246.—Upper and lower poles much dilated. Middle calix unaffected. A movable kidney.

Figs. 241–246.—PELVIC DISTENSION OF MINOR AND MEDIUM DEGREE.

Note the enlargement of the pelvis proper, the broadening of the major and the obliteration of the minor calices. The effects are felt irregularly, one calix yielding more than its neighbours. In every plate the upper and lower calices show distension more than the middle one. *Fig.* 244 is not fully distended with solution. This pelvis prior to dilatation was probably shaped like *Type B* (*see* page 396 and *Fig.* 236, *k*, *l*). Compare the shapes of these pelves carefully with those in *Fig.* 236. In *Figs.* 245 and 246 the catheter is arrested at the uretero-pelvic junction and the pressure of its tip has distorted the channel. Examine for backflow down ureter, best seen in *Figs.* 245 and 246, and observe the irregular distension resulting from peristalsis. In *Fig.* 246 the pelvis is low-lying and the distension was due to this. In *Fig.* 242 the tip of the catheter is seen in the upper calix, and the ureter is slightly bowed. In *Figs.* 245 and 246 pyelectasis is more advanced than in their predecessors.

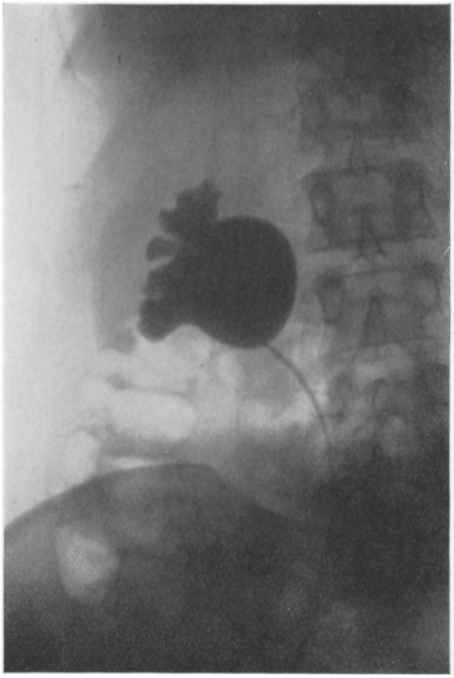


Fig. 247.—Hydronephrosis due to aberrant vessels. Pelvic type. Calices clubbed but still well formed. Pelvis lies opposite third lumbar vetebra.

Fig. 248. — Hydronephrosis, pelvic type, due to ureteric obstruction low down. Triangular contour retained. Large hydronephrosis of the pelvic type resulting from prolonged impaction of a calculus in the lower end of the ureter. The triangular contour of the pelvis is seen to be well retained.

Fig. 249.—Hydronephrosis of mixed type and congenital origin—pelvis and calices both much dilated. Pelvis could not be emptied prior to injection of solution, which has incompletely mixed with the contained urine, and has outlined the rounded upper calices distinctly, but the pelvis and lower calices less well.

in thickness. It may take the form of a single smooth-walled cavity, but more commonly the pyelogram shows a central cavity into which

Fig. 250.—Hydronephrosis in which the rounded calices are well seen but the pelvis is not obvious.

open numerous secondary loculi (*Fig.* 250), exhibiting an undulating or more deeply scalloped external border, in correspondence with the

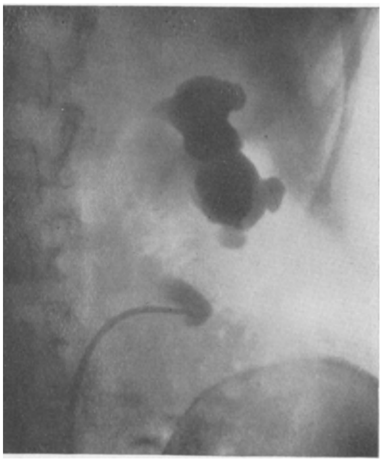


Fig. 251.—Hydronephrosis of large size incompletely filled.

lobulation which can be observed on the surface of the organ. The septa between the cavities correspond to fibrosed columns of Bertini.

Frequently the various parts of the cavity receive the opaque solution unevenly owing to its not mixing intimately with the urinary residuum (*Figs.* 249–251, and *see Fig.* 277 left side, page 423).

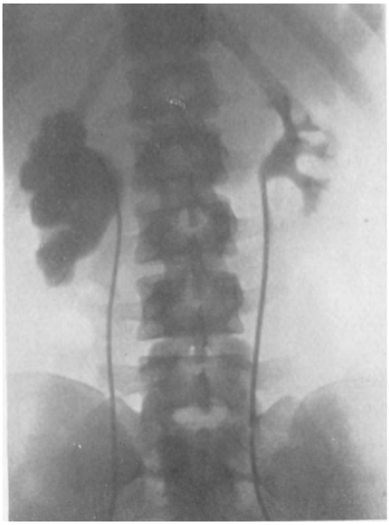


Fig. 252.—Cystoscopic pyelogram, bilateral. Shapely normal pelvis on left (*Type A*). Severe grade of distension on right, the large pelvis and grossly clubbed calices being evident.

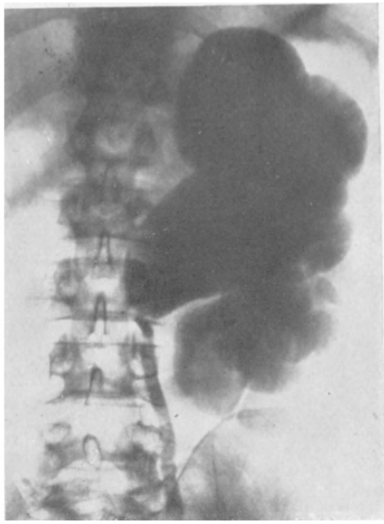


Fig. 253.—Huge hydronephrosis overlaps 11th rib above and iliac crest below. Note the inward position of the ureteropelvic junction.

HYDRO-URETER.

The correct reading of a ureterogram is even more difficult than that of a pyelogram, and it is certain that a great many mistakes are made in interpretation even by experienced workers. It is therefore desirable to warn beginners against a hasty or ill-considered diagnosis based on ureterographic evidence which may be misleading. The diagnosis of ureteral stricture or kink is frequently made on insufficient grounds; such indications should be definite, and similar outlines should be seen in the same section of the ureter on more than one plate before it is accepted as authentic. When the pyelographic evidence is unconvincing, and especially if the complaint is of recent development, all the possible alternatives should be fully explored before the diagnosis is made, and the ureterogram should be considered in conjunction with all the clinical data. There are three fallacies in particular which lead to erroneous interpretations :—

1. The normal variation in the bore of the ureter is well recognized, it having narrowings at the pelvic outlet, brim of the true bony pelvis, and at its vesical extremity (*Fig.* 254). Between these points of diminished calibre are well-marked fusiform dilatations. Histologically the narrowed sections can be shown to contain an excess of circular muscle, and it is thought possible that the contents of the tube may be temporarily locked up in the intervening compartments, giving an appearance suggestive of dilatation on the pyelogram. The position of these congenital narrowings determines the position at which stones traversing the ureter get caught, and at which these stones leave behind them ureteral injury or ulceration, which in its turn may cause stenosis during healing. It is therefore evident that the sites of congenital and physiological narrowing coincide with those of pathological contraction, so that the differential diagnosis calls for care.

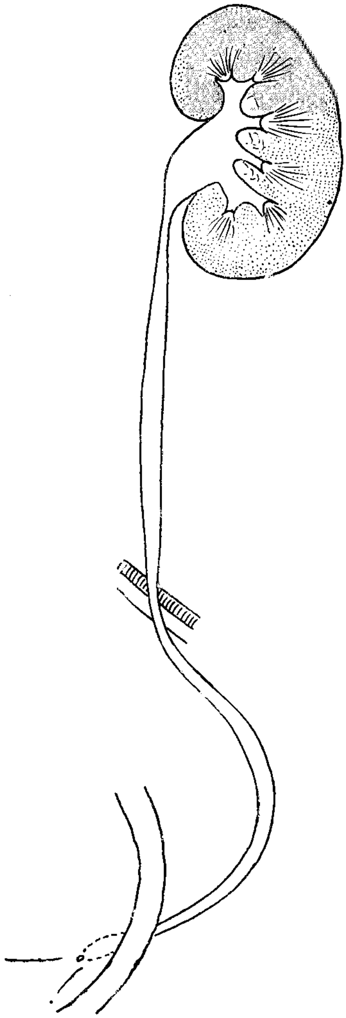


Fig. 254.—Diagrammatic representation of the variations in width of the normal ureter.

2. The peristaltic wave of the ureter is often evident in the pyelo-ureterogram, especially when the tip of the catheter falls short of the renal pelvis (*see Figs.* 245, 246, page 407). Above and below these spindle-shaped waves are lengths of the ureter which are physiologically empty. The novice may misinterpret them as pathological. A second plate will probably show the spindle in a different position.

3. A ureterogram may be made by filling the renal pelvis and allowing its contents to flow down the ureter, or by distending the ureter from below whilst the catheter tip is in its lowest segment (*see also* Chapter XXVII). In the first case the catheter must be withdrawn before exposing the plate, as otherwise the ureteric shape is liable to be distorted, owing either to the rigid instrument displacing it laterally or antero-posteriorly, or to its picking up a fold of mucosa and

causing a kink (*see Figs.* 245, 246). The ureter, as a result of either of these accidents, may be foreshortened and appear to be strictured.

Apart from disease, malformation, or artificial distortion, the ureter may run a slightly devious course to which no pathological significance must be attached. Foreshortening of the ureter as it climbs on to the psoas muscle (*Fig.* 255), produces an appearance which is easily recognized once it is known, the more so as the shadow of this muscle is readily identified on the film.

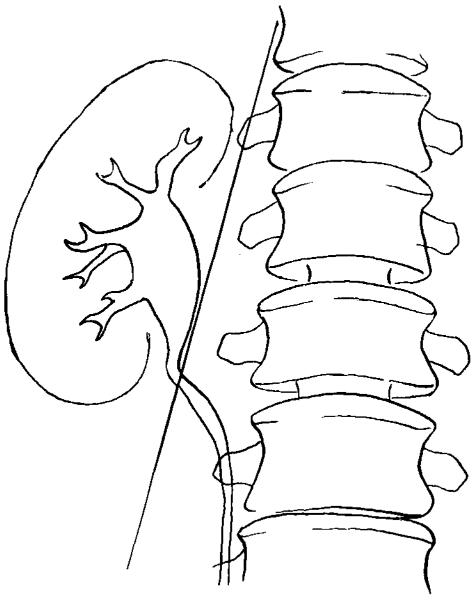


Fig. 255.—The relationship of the kidney to the psoas muscle is evident. The pelvis lies external to the muscle in the hollow under its shelter. The ureter generally runs a straight course downwards but sometimes climbs up steeply on to the belly of the psoas and then appears on a urogram to be twisted or even kinked.

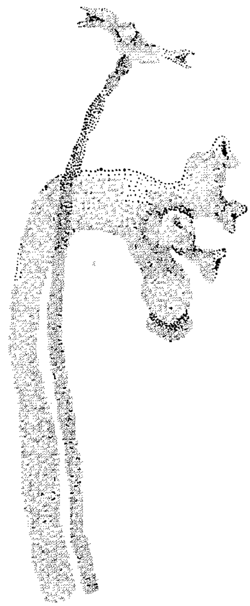


Fig. 256.—Dilatation affecting one portion only of a double kidney. The pelvis and ureter are more affected than the calices.

The most usual site for obstruction is the uretero-pelvic junction. but it may occur at any point along the ureter, when the section above the stricture will be dilated (hydro-ureter). When the obstruction affects one branch of a bifid pelvis or a bifid ureter (*Fig.* 256) its consequences will be limited to that branch and to the corresponding portion of the kidney (partial hydronephrosis).

CONGENITAL DILATATION OF THE URETER (MEGALO-URETER).

Congenital dilatation of the ureter is not infrequently seen, and takes two forms :—

1. A dilatation comparable with congenital idiopathic dilatation of the colon. It is usually of severe development, may be unilateral or bilateral, and does not extend below the uretero-vesical orifice (*Fig.* 257). Some authorities regard this condition as a neuro-muscular dysfunction. Others look on it as a failure of the primitive ureter (which is of large size in proportion to the body bulk) to assume its subsequent customary proportions.

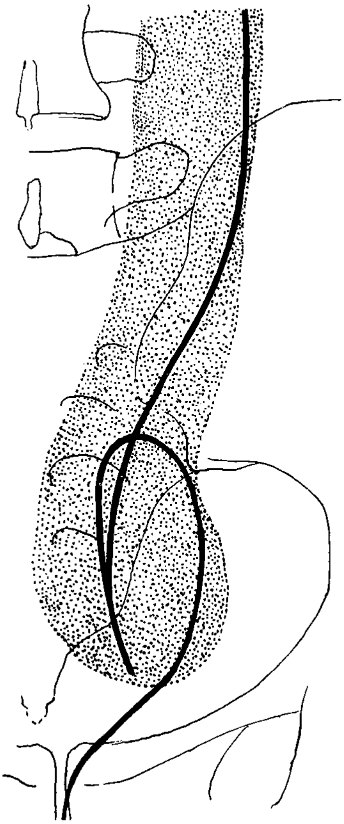


Fig. 257.—Megalo-ureter. Extreme dilatation of congenital origin.

Fig. 258.—Cystogram. Great distension of bladder in boy, age 10. Regurgitation into left ureter and renal pelvis, which are much dilated. Subsequent pyelography of right kidney showed a normal pelvis. Nephrectomy (left): recovery. (*Mr. Cyril Nitch.*)

2. The ureter may be affected by back-pressure from some congenital urethral malformation—valves, etc. (*Fig.* 258).

SIMPLE INFLAMMATORY CHANGES IN THE KIDNEY.

Pyelitis and pyelonephritis lead as a rule to some minor degree of pelvic dilatation, the brunt of which is borne in different cases by the calices, pelvis, or ureter. Simple pyelonephritis sometimes causes erosion of the renal papillæ, the damaged areas then showing up on the pyelogram as rounded excavations of the parenchyma. The ureter may be uniformly or irregularly dilated, and in some cases exhibits a sinuous outline.

A pyonephrosis may arise from infection of a hydronephrosis, when its outline will be similar in shape to that of its forerunner. It may assume a pelvic, renal, or mixed distribution, and be small or very large. Often it is impossible to evacuate its contents through a ureteric catheter owing to their thick consistency, and the pyelographic solution must be added to the already contained fluid. The medium tends to fill the cavities irregularly, and where these are lined with adherent débris the outline of the cavity is irregular and hazy.

RENAL TUBERCULOSIS.

(*See* CHAPTER VI.)

POLYCYSTIC KIDNEY.

In polycystic disease the renal pelvis is invaded by multiple cysts and its cavity is deficient where they trespass upon it. The cysts, being convex towards the pelvic cavity, are outlined by

Fig. 259.—Advanced polycystic disease. Note the long curved shadows, each probably related to the convexity of a cyst. (*Mr. Cyril Nitch's case.*)

Fig. 260.—Polycystic kidney.

concave shadows on the pyelogram (*Figs.* 259–261). When well developed the cysts almost completely obliterate the pelvis, and the pyelographic contour is much reduced in size and consists of narrow, erratic streaks with concave margins. Long arms of the pelvis, however, reach out to drain areas of parenchyma which have been ousted from their original situation by the interposition of the cysts, and they appear as irregular straggling shadows the extremities of which stretch well beyond the usual limits of the renal pelvis (*Figs.* 259, 261). A considerable development of cysts in the upper pole of the kidney may displace the pelvis downwards (*Fig.* 261), whilst a similar increment at its lower end may modify the course of the ureter (*Fig.* 262).

The condition is invariably bilateral, as can be demonstrated by taking a pyelogram of the second organ. Two instrumental pyelograms

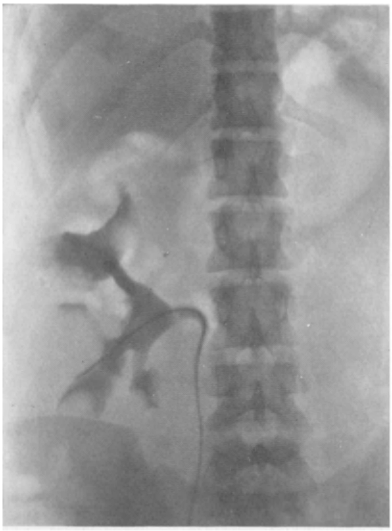


Fig. 261.—Polycystic kidney. Note large straggling pelvis, long arms, concave shadows, downward displacement of kidney and redundant ureter.

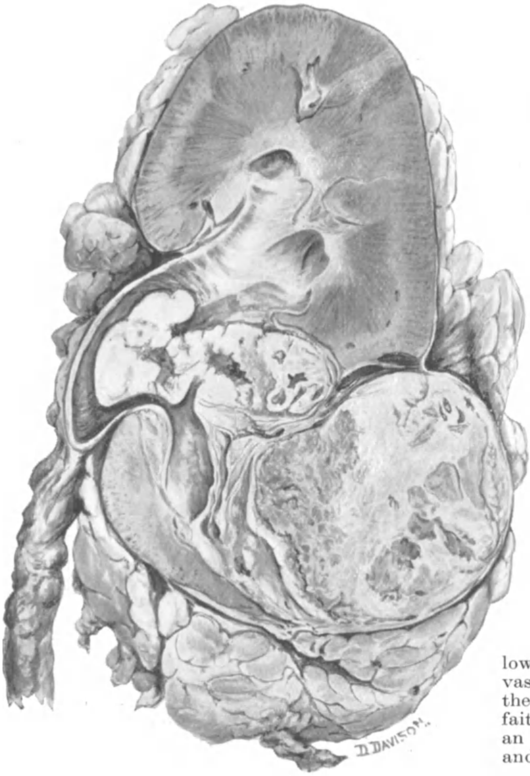
Fig. 262.—Polycystic kidney. Note that the ureter is displaced so as to overlie the spine, evidently as a result of cystic development in lower pole.

should not, however, be made simultaneously. The radiographic diagnosis between polycystic kidney and renal growth may be difficult, as the deformities produced are generally very similar, but the bilaterality of the former condition serves to distinguish them.

RENAL TUMOURS.

When a tumour involves the kidney the pyelographic appearances are variable and depend on the site primarily affected.

Tumours Arising in the Parenchyma.—When a growth arising in the parenchyma has attained to such a size that it involves the pelvis, it starts to obliterate the nearest calices and later proceeds to deal similarly with the pelvis itself (*Fig.* 263). A few calices or a portion of the pelvic shadow may therefore be missing from the pyelogram. In due course more calices, and perhaps the whole of the pelvis, disappear. Coincident with this obliteration of calices and pelvis, dilatation, elongation, or retraction of other calices in the remainder of the gland occurs. These elongated calices are



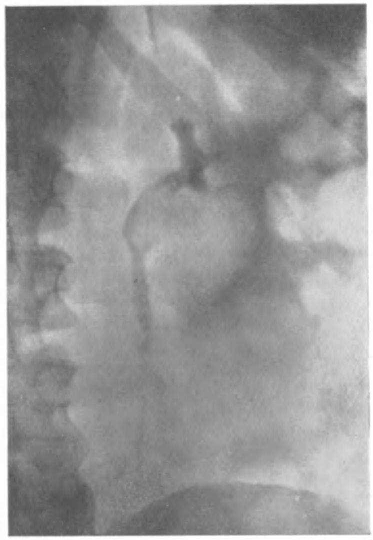


Fig. 263.—Malignant new growth of lower pole of left kidney. Note the invasion of the pelvis and the distension of the upper calix. The pyelogram gives a faithful silhouette of these features and an excellent impression of the position and extent of the growth.

usually very narrow, and appear on the plate as thin curved streaks (spider deformity). Alterations in the shape of the pelvis resulting from a combination of these two factors are very varied, and often extreme. Sometimes the pelvis and calices are represented on the pyelogram by a few irregular and often widely separated blotches.

Tumours Arising in the Pelvis.—Tumours arising in the pelvis itself may fill up in part or completely efface that cavity. A papilloma (*see also* pages 166–170) filling the pelvis may leave an area which is relatively clear, but is mottled where the solution has penetrated amongst the villi. If a pyelogram is made shortly after an attack of hæmorrhage, from whatever cause, blood-clot may still be present in the pelvic cavity (*Fig.* 264) and cause a filling defect suggesting a neoplasm. When the tumour becomes impacted in the pelvic outlet a hydronephrosis develops.

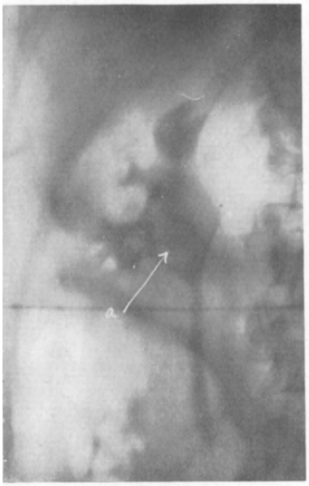


Fig. 264.—Stone in the renal pelvis (*a*). The pelvis was filled with pultaceous material, probably changed blood, and this accounts for the irregularity of the pelvic shadow, which has a vacuolated appearance. It illustrates the effect on pyelography of foreign material in the pelvis.

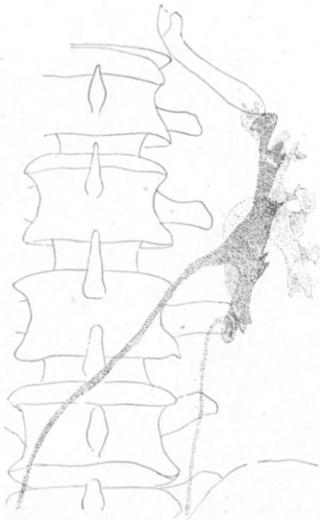


Fig. 265.—Extreme displacement of the right kidney (heavy dotting) by an extrarenal growth. The kidney lies on the left side of the spine and overlies the left kidney (light dots). (*Mr. Garnett Wright's case.*)

Effect of Tumours on the Position of the Kidney :—

Intrarenal Tumours.—Growths of large size arising in the kidney itself may cause displacement of the remainder of the gland. This is especially true when they involve the upper pole. The pelvis, in addition to being distorted, is then found to occupy a position lower than the normal, and sometimes also to be rotated.

Extrarenal Tumours.—Growths arising outside the kidney are capable of displacing that organ in an equal degree with the intrarenal variety (*Fig.* 265). Rarely they also cause deformity of the pelvis, but this is by pressure or invasion from without, and not, as in the case of intrarenal growths, by involvement starting in the neighbourhood of the parenchyma.

RENAL CALCULUS.

In discussing stone in the ureter it was shown that shadows in the region of that tube supposed to be calculi must in all cases be confirmed either with the assistance of an opaque bougie or by a ureterogram. A similar assertion would not hold good in the case of renal stones. In many instances renal, and especially pelvic, calculi are easily recognizable by their contour and position, and do not require confirmation. Nevertheless the precise location of a stone in the kidney which can be provided by pyelography gives operative indications which are not to be despised.

Fig. 266.—The mottled shadow of a calcified tuberculous gland was seen on a straight radiogram in a case of renal pain. Routine urography showed its relationship to the urinary passages and the probable fixation of the ureter.

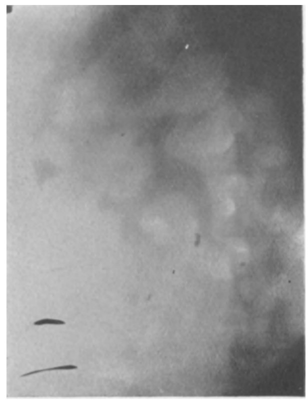


Fig. 267.—Case of shrapnel wound of the loin. Renal crises. Four foreign bodies are seen in the radiogram, two of which are situated in relation to the upper ureter. The ureter is distorted by them. Crises relieved by liberation of the ureter.

Many shadows, however, in the neighbourhood of the kidney are of uncertain origin, and pyelography offers great assistance in their interpretation (*see Figs.* 266–277). It will supply information as to whether the shadow arises within or without the urinary tract, and in the former event indicates the exact situation of the stone, showing whether it is in the parenchyma, a calix, or the pelvis. It will demonstrate the occurrence of renal dilatation if present, and may also be used to accentuate a stone's shadow when indistinct.

If originating *outside* the urinary apparatus, the shadow usually results from one of two causes—a calcified tuberculous gland (*Fig.* 266), or gall-stones. When the pyelogram is made it will be seen that the two shadows are separate from each other or that they do not completely overlap; or if they do coincide, by taking a picture from a different angle they can be dissociated. Calculous disease will thus be excluded. *Fig.* 267 shows a less usual variety of extrarenal shadow associated with symptoms referred to the urinary apparatus.

If the shadow is that of a *urinary stone*, it may lie in the renal pelvis, in a calix, or in the parenchyma. When situated in the pelvis the shadow of the solution, from whatever point the radiogram is taken, overlaps and perhaps completely masks that of the stone. If

Fig. 268. — Hydronephrosis due to stone blocking the ureteropelvic junction. The stone (*a*) has been displaced by the catheter into lowest calix, but at operation was at pelvic outlet.

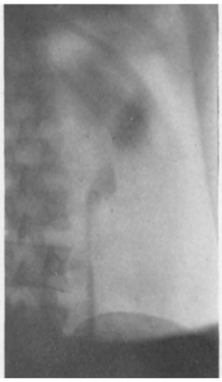


Fig. 269.—Stone impacted at outlet of pelvis. The catheter point makes contact with it, but when the solution is injected only a small portion reaches the pelvic cavity, the remainder returning down the ureter alongside the catheter.

it occupies a calix (*Fig.* 272), the shadow of the calculus abuts that of the pyelogram, and this relationship is maintained when the photograph is taken from varying positions. When in the parenchyma the shadow of the calculus is separated from that of the pyelogram but lies within the shadow of the renal outline. The distance between the pelvic outline and that of the stone is never great.

Information regarding the condition of the kidney is supplied by the pyelogram, and is often very valuable as an operative indication. When the stone is situated in the parenchyma there is generally no alteration in the shape of the pelvis. When it occupies a calix distension is limited to the area of kidney drained by that particular calix, but as the stone is generally tightly impacted, the solution may not reach this distended cavity, which would then not be shown on the pyelogram (*Fig.* 271). Occasionally, however, a communication exists, and then a localized hydronephrosis is observed on the pyelogram, the stone shadow intervening between this and the shadow of the pelvis proper (*Fig.* 272). When the stone is situated in the pelvis there is generally some distension of that cavity which may be of minor extent or may have progressed to the formation of any degree of hydro- or pyonephrosis (*Figs.* 268, 269, 274, 276, 277).

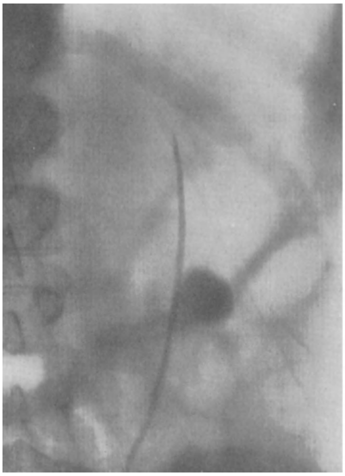


Fig. 270.—Rounded shadow lying low in renal area. Catheter passes close to it, but its tip is seen to have passed 2½ in. beyond it.

Fig. 271.—Same patient as *Fig.* 270. Solution has been injected. It outlines the upper calices only and they are dilated. Stone shadow occupies position of lower calices and no solution has escaped past it to the parenchymal aspect. Stone is therefore impacted in lower calices and this was confirmed at operation.

The situation occupied by the stone as evidenced pyelographically will predict the most suitable method of operative attack, whether this shall be by pyelolithotomy, nephrolithotomy, or a combination of these two methods. It will also, in the case of stones in the parenchyma itself, lead to their accurate pre-operative localization, and so eliminate unnecessary operative trauma. When the parenchyma of the kidney is shown by the pyelogram to be extensively destroyed (*Fig.* 276), nephrectomy may be forecasted, always presuming that the other kidney is proved to be healthy (cp. *Fig.* 277).

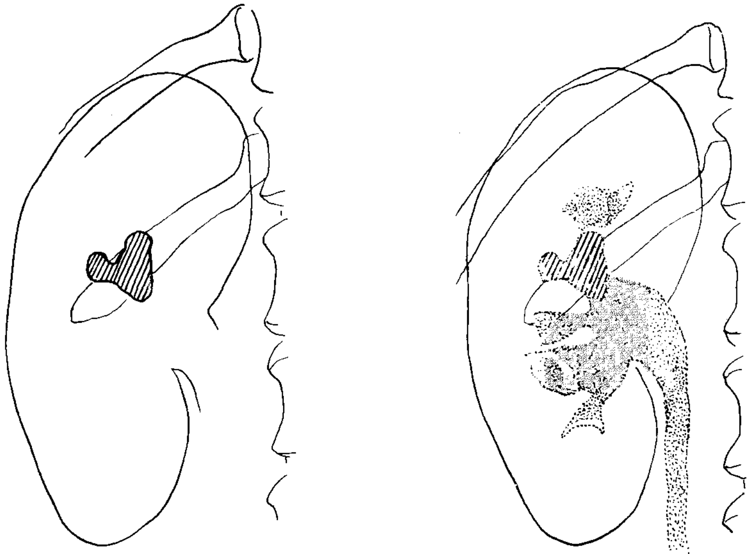


Fig. 272.—A stone shadow seen on a straight radiogram is shown by pyelography to be impacted in the upper major calix. A small cavity in the parenchyma of the upper pole is also displayed. The remainder of the pelvis is normal. Operative approach facilitated.

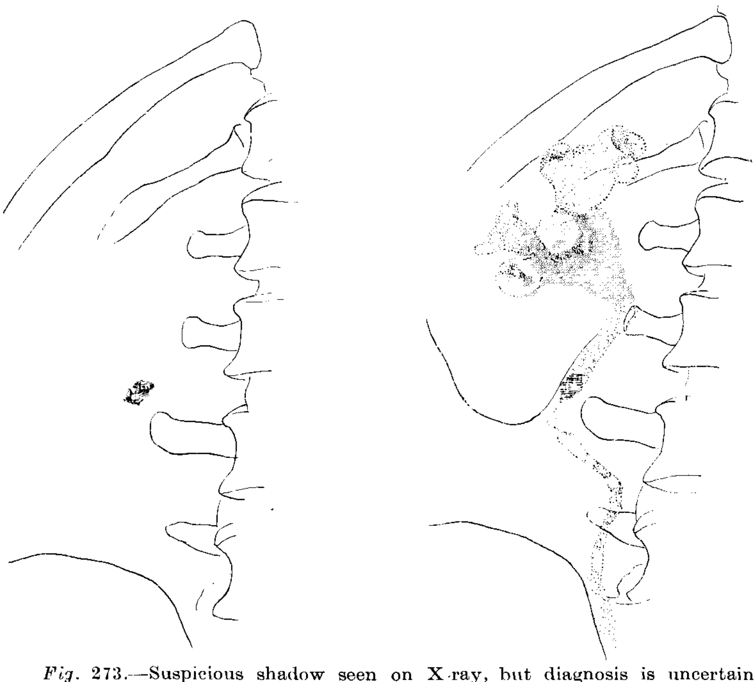


Fig. 273.—Suspicious shadow seen on X-ray, but diagnosis is uncertain because it is not in the position of the renal pelvis and too oblique for the ureter. Urogram gives the explanation. Impaction recent. Pyelectasis negligible.

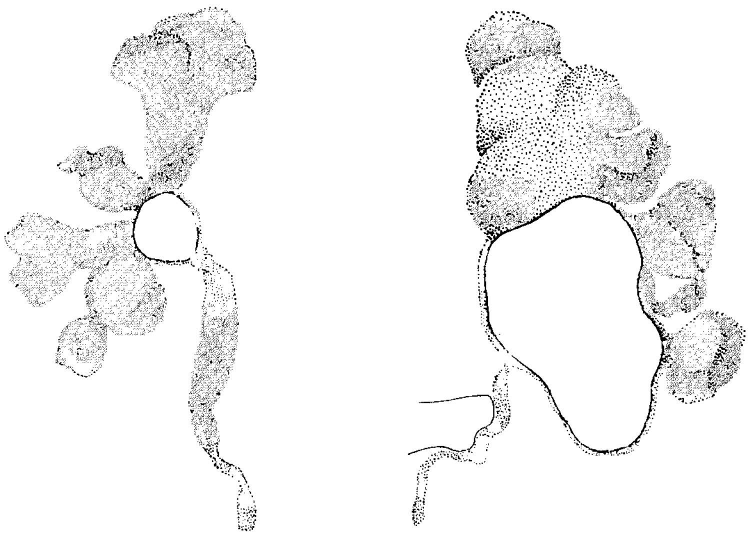


Fig. 274.—Two tracings from cases in which stones ball-valved the renal outlet, showing the effects of back pressure.

Fig. 275.—Numerous spherical shadows are seen in the left flank, probably small renal calculi.

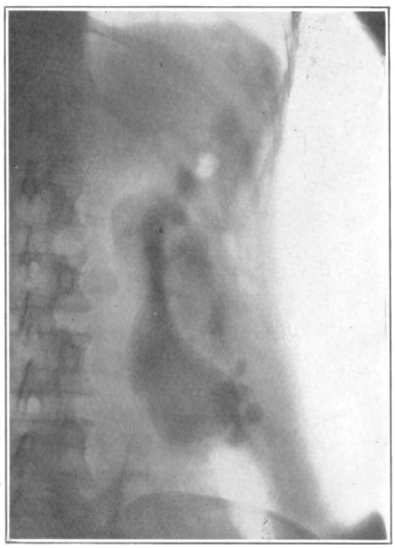


Fig. 276.—Shows that they are arranged around a large hydronephrotic sac which is, in this pyelogram, only partially filled.

Accentuation of the stone's shadow was described in the chapter on ureteric stone, and the same technique may be adopted with pelvic stones when indistinctly outlined by the X rays (*see* page 308). Sometimes a pelvic stone which throws a weak shadow or none at all on the radiogram may, on pyelography, cause a light patch within the area of the pyelographic shadow.

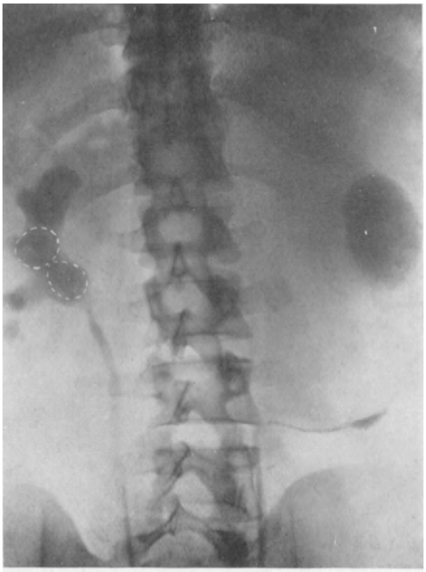


Fig. 277.—On right side : Three stones (dotted outlines) in renal pelvis. Moderate dilatation due to stones. On left side : Large hydronephrosis incompletely filled. The rounded shadow is contrast fluid in sump. Note the transverse trickle of fluid opposite the lower part of the third lumbar vertebra, which indicates the lowest point of the cavity. Cystoscopy on this patient showed no indigo-carmine from left ureter in twelve minutes. Explanation sought by urography. Observe how small a quantity of contrast fluid gave adequate knowledge regarding the left kidney. This plate shows the importance of a full investigation of the urinary system.

CHAPTER XXV.

PELVIC RESORPTION.

THE fact that the pelvic contents, especially if under pressure within the pelvis, can be resorbed into the circulation has been known for many years, certainly since the days of Gignon (1856), who was aware of its occurrence both in cadavers and in living animals.

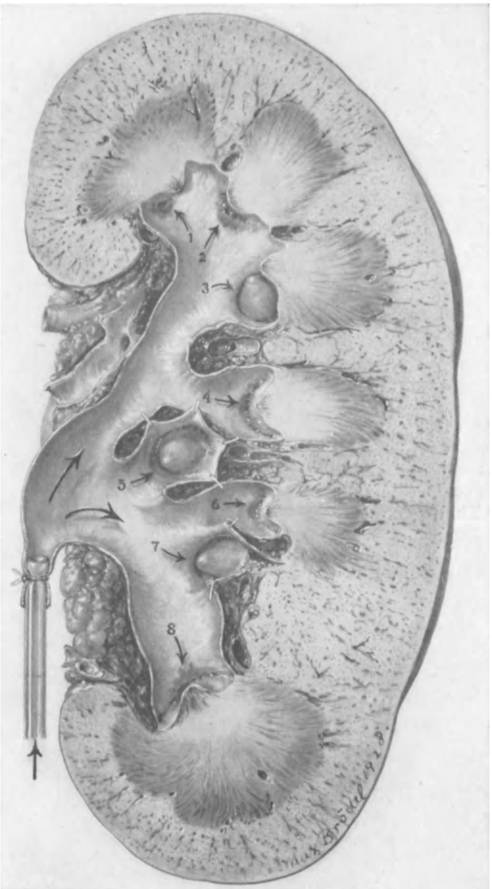


Fig. 278.—One half of a human kidney in which pyelovenous backflow has taken place. There are points of rupture in the fornices of every minor calix. The injection of the arcuate veins and the stellate veins is shown. The extravasation of the ink into the fat of the sinus renalis is quite evident.

In recent years it has aroused great interest, chiefly because of its importance in pyelography, but also on account of its bearing on other urological subjects, such as hydronephrosis. It has been known for some time that the contents of a hydronephrosis (the ureter being completely occluded) are not stagnant, that there is a perpetual give-and-take, excretion and absorption going on side by side, but the mechanism of resorption has remained obscure and it has been assumed that it is a function of the tubules. It now appears probable that various components of the kidney may, under suitable circumstances, undertake this rôle. The lymphatics and probably the tubules can be satisfactorily shown to take up various test substances introduced into the pelvis, but of late much interest has centred on the route, which has been brought into prominence by the work of Hinman and Lee-Brown in America and of Fuchs in Germany, in which regurgitation occurs from the region of the calices directly into the venous system. The two first-mentioned authors have given the name 'pyelovenous backflow' to this phenomenon (*Fig.* 278). The term has, however, been loosely applied to all varieties of pelvic resorption. It should obviously be restricted to the particular variety for which it was originally introduced, and the wider term 'pelvic resorption' should be employed to cover all varieties of regurgitation into the circulation, such as that from the tubules, lymphatics, and mucosa, and not excluding pyelovenous backflow proper. It is convenient to describe pyelovenous backflow first, and then to examine some other routes open for pelvic resorption. But it should be emphasized at the outset that there is more than one channel for absorption, that our knowledge of the subject is far from complete, and that considerable confusion still exists about many features.

PYELOVENOUS BACKFLOW.

HISTORICAL.

Our knowledge of backflow started in 1856, and from that time until, say, 1911, when the era of instrumental pyelography began, certain investigators observed and described phenomena which appeared to have little or no practical application and so received but little attention. Some of this instructive and interesting early work deserves a brief description.

Gignon (1856) is credited with the first experimental observation of pyelovenous backflow. On distending the pelvis with fluid he noted that it passed from the kidney pelvis into the veins and he came to the opinion that it passed through preformed venous plexuses which surround the calices. In 1863 Ludwig and Zaworykin observed a similar phenomenon and noted that the backflow took place through a small rupture in the mucous membrane of the renal pelvis.

In 1883 Ribbert injected small quantities of potassium ferrocyanide into the pelvis of a healthy dog's kidney and ligatured the ureter. In less than an hour he was able to demonstrate that substance in the urine from the other kidney.

In 1891 Poirier, working on human corpses, catheterized the ureters and injected fat into the pelvis. The fat was observed to pass into the renal veins. In another experiment he injected the ureters of dogs with water and showed that the water flowed out of the renal vein. " C'était un véritable lavage du rein."

In 1897–8 Lewin undertook similar experiments, employing air for the purpose of injection. The investigation was conducted on living dogs and the animals were found to die of air embolism. Lewin stated that he was unable to discover any injury to the pelvic wall. Yet Marcus, repeating these researches (1904), invariably discovered a rupture, generally in the neighbourhood of the minor calices, whenever air had entered the venous system. Lewin also recorded the unexpected fact that air introduced into a rabbit's bladder would pass up the ureter, distend the pelvis, and flowing back into the renal vein and vena cava, would cause sudden death. This important experiment undoubtedly explains not a few fatalities resulting from the use of air to distend the bladder before cystotomy. If, as so frequently happens, the ureteric valve mechanism is incompetent, the air pressure may be transmitted to the kidney with rapidly fatal results. Lewin's experiment should serve as a warning against the practice of employing air in bladder distension, and even more so against using it as a pyelographic medium.

In 1894 Tuffier introduced 0·5 c.c. of a weak solution of strychnine into the pelvis of a dog and tied the ureter. No untoward effects were observed until the renal secretion raised the intra-ureteric pressure, when the animal rapidly died of strychnine poisoning. The significance of this experiment becomes more evident when the relationship between the secretory pressure* of the kidney and the pressure at which resorption occurs is considered (*see* page 432).

These and many other experiments of similar significance had been performed before instrumental pyelography—an examination in which the conditions for a clinical repetition of the experiments constantly present themselves—came into general use. A further period of interest in pelvic resorption then became inevitable because of the unsuspected dangers which attended its early use. In the first instance collargol and other silver salts were used as pyelographic media. The fact that these metallic compounds may be very injurious to delicate organs was not foreseen, nor was the importance of maintaining a low intrapelvic pressure appreciated. These two factors were responsible for not a few serious accidents, including some fatalities. It was then discovered that collargol was capable of penetrating into the tubules, lymphatics, and interstitial tissues of the kidney, where its presence caused necrosis. Foci of collargol were

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* The secretory pressure is the intrapelvic pressure against which a kidney with a ligatured or otherwise obstructed ureter ceases to secrete.

also found beneath the capsule, in the perirenal tissues, and, in cases which came to post-mortem examination, emboli in the liver, lungs, heart, and other viscera were discovered, proving once more that some mechanism existed by which intrapelvic contents could reach the blood-stream. These disquieting observations were, however, in keeping with known facts such as those quoted above, and led in the first place to caution in the amount of pressure exerted in injection, and subsequently to the abandonment of silver and other injurious preparations in favour of the halogens. The period of danger from pyelography thus passed, and interest in the subject of renal resorption waned until revived by new work.

Hinman and Lee-Brown, who are largely responsible for the awakened interest in pyelovenous backflow, were led to start their observations by the fact that when making celloidin-corrosion preparations of the kidney they found that some of the venous system was filled by an overflow from the pelvis as though a communication existed between them. This was a not infrequent occurrence when they were working on post-mortem kidneys.

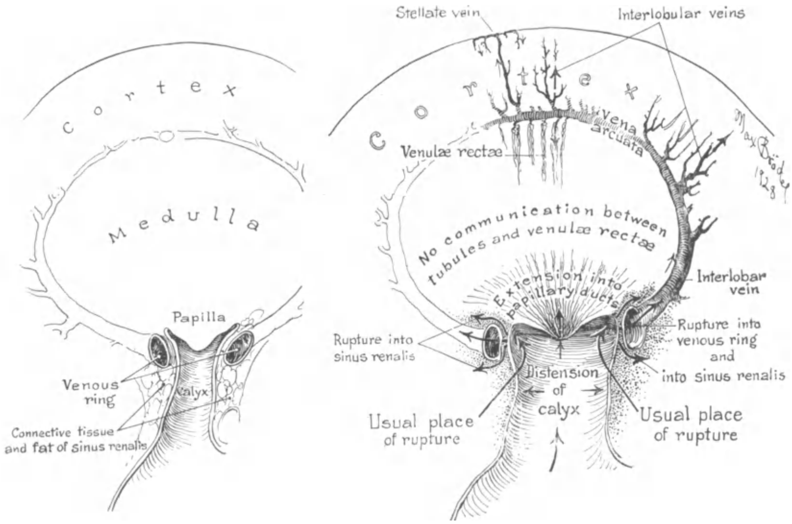

Fig. 279.—A schematic drawing illustrating the effects of distension of the calix and the pathways followed by the injection mass in the production of pyelovenous backflow.

ANATOMY.

The anatomy of the venous circulation and its relationship to the renal pelvis and the tubules requires a brief description before pyelovenous reflux can be understood.

Lying between medulla and cortex (*Fig.* 279) there are arcades of

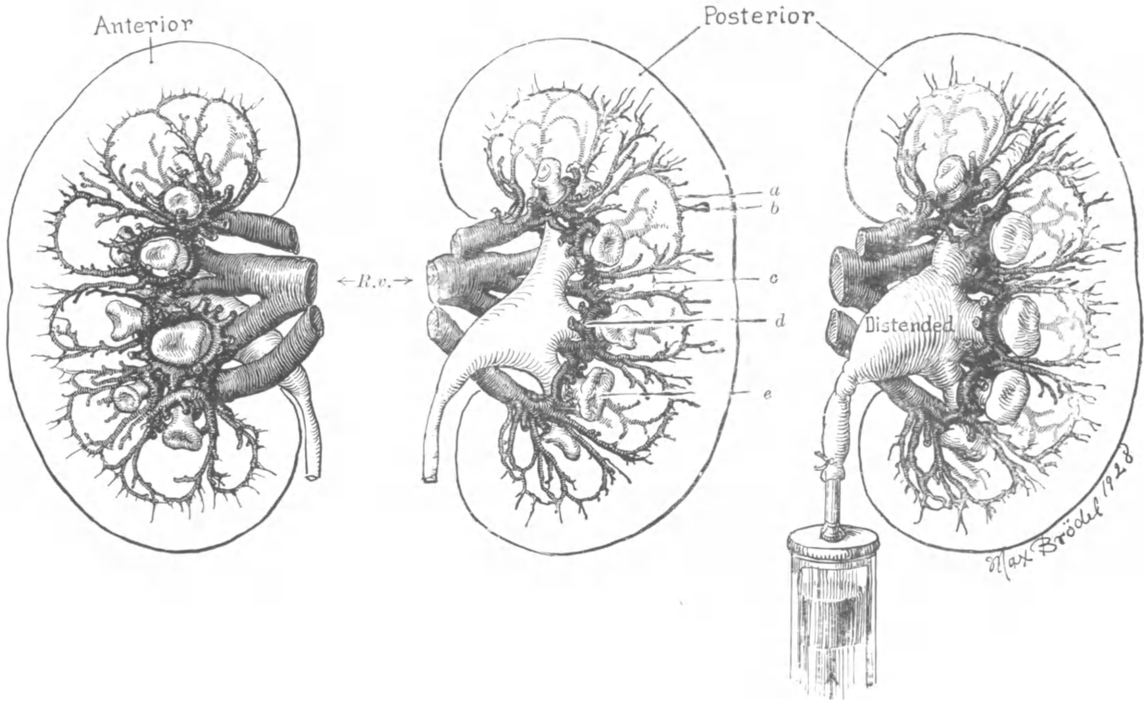

Fig. 280.—A simplified drawing demonstrating the inner and outer anastomotic venous circulation of the kidney. The relation of the inner venous collars to the minor calices is shown with the pelvis undistended and distended. *a*, Arcuate vein; *b*, Interlobular vein; *c*, Interlobar (peripyramidal) veins; *d*, Venous collar surrounding fornix calicis; *e*, Cup-shaped end of calix into which the papilla is received; *R.v.*, Renal vein.

veins (arcuate veins) running approximately parallel with the surface of the kidney and freely communicating with each other. These venous arcades receive on their convex surface tributaries from the cortex (interlobular veins) which have taken origin in the subcapsular plexus. On the concave side open vessels draining the medulla (venæ rectæ), which arise in the rich vascular plexuses of the papillæ and which, as they traverse the medulla, are in very intimate relationship with the uriniferous tubules. From the arcuate veins arise the vessels which pass to the exterior of the kidney by way of the hilus. Occupying the intervals between the pyramids (columns of Bertini) they are called peripyramidal or interlobar veins. A glance at any corrosion preparation of the renal pelvis and veins (*Fig.* 280) will show that in emerging from the columns of Bertini the veins follow the line of the pyramid till they approach its apex. The apex of the pyramid being surrounded by the calix, the veins continue their course in close apposition to the outer wall of the latter and in intimate structural contact with it. In some places they are in almost direct contact with the mucosa of the calices (Hinman). At or about this point the interlobar veins are connected up by transversely running branches which encircle the calix. This arrangement produces a second series of venous arcades, small in comparison with those lying at the bases of the pyramids, but important in that they make a rich, thin-walled, venous plexus or collar round the fornix calicis (*Figs.* 278–282).

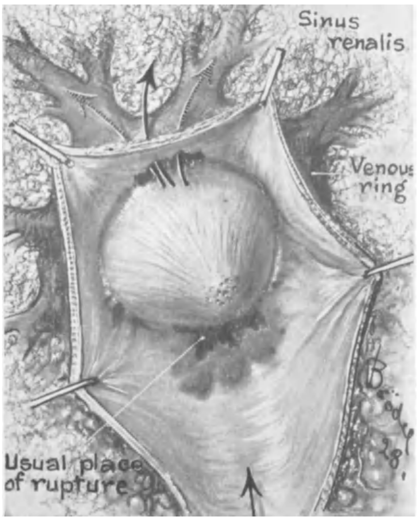

Fig. 281.—A minor calix opened to show multiple points of rupture at the margins of the papilla where the pelvis is reflected over the papilla. The relation of the point of rupture to the venous ring and the pathway of the injection mass is indicated.

The extreme apex of the minor calix—that is, the sharply angulated point where the calix is reflected on to the papilla (fornix calicis)—appears to be structurally the weakest, and therefore the most vulnerable point in the pelvic system. It will be easily realized tlhat the papilla, which forms the inner wall of the minor calix, is a soid, unyielding structure, whilst the outer wall of the minor calix lies in soft perirenal fat which lends it practically no support. As a sequel to pelvic overdistension tears can, in many experimental specimens, be seen following the actual line of insertion of the calix into the papilla (*Fig.* 281). When a rupture occurs at this point the fluid may extravasate into the connective tissue of the sinus renalis, but more frequently the tear extends into the vein itself, which is not to be wondered at when the above-described close anatomical relationship existing between the two is considered. That this method of backflow occurs is agreed by most authors, though not by all, but to demonstrate the

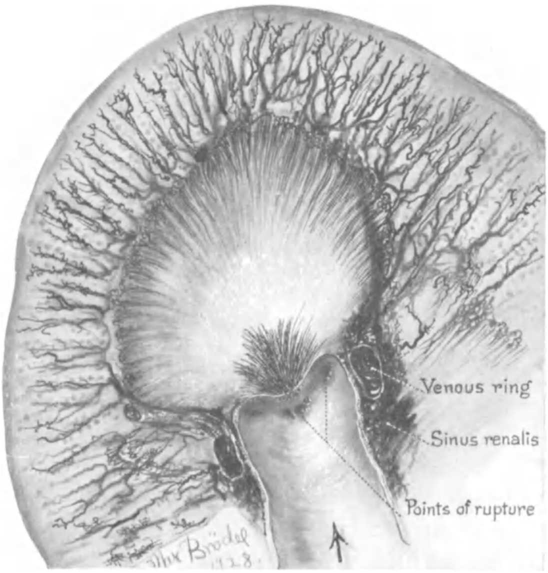

Fig. 282.—A longitudinal section through a renal pyramid and minor calix. The relation of the points of rupture to the venous ring and the arcuate veins is seen, as well as the injection of the interlobular veins and the venæ rectæ. The injection of the collecting ducts through the papillary foramina is shown to extend a short distance into the medulla.

point of leakage is admitted on occasion to be far from easy, though such leaks have been satisfactorily displayed in many specimens.

The injection is found to regurgitate up the interlobar veins to the arcuate veins and then proceeds to fill the interlobular and stellate veins and the venulæ rectæ (*Fig.* 282). The fact that the medium proceeds from the hilus towards the cortex against the stream of venous blood requires explanation. It is known that pelvic overdistension produces venous engorgement within the kidney. The probable cause of the retrograde route chosen by the pyelographic medium is the obstruction which it encounters at the hilus owing to the pressure of the distended pelvis.

METHODS OF STUDY.

Several methods are available for the study of pyelovenous backflow, amongst which the following are the principal :—

1. **Corrosion Preparations.**—Celluloid dissolved in acetone may be injected into the vessels of the kidney or into the cavity of the pelvis. The surrounding tissue is then digested or corroded away with pure hydrochloric acid, leaving the architecture of the filled passages displayed. This procedure has proved itself invaluable for the study of the relationships existing between the component parts of the kidney, any two or more of the hollow tube systems (pelvis, veins, arteries) being filled with suitably coloured celloidin and corroded. It was during anatomical studies of this kind that Fuchs in Vienna, and Hinman and Lee-Brown in San Francisco, independently observed the fact that pelvic injections tend to overflow into the venous system, giving a corrosion preparation in which some of the veins are included. This, however, was no new observation, for the fact was well known even in Hyrtl's day. The point of outbranching from the pelvis to the venous system was invariably the fornix calicis.* These findings have been corroborated by numerous subsequent observers. Other injection masses may also be employed for study, snch as Indian ink in gelatin (*Fig.* 278).

2. **Animal Experimentation.**—In the foregoing short historical section various experiments, in which fluids, fat, air, etc., have been introduced into the pelvis and have flowed out freely from the renal vein, have been noticed, and the fact that most, though not all, of the investigators found small ruptures at the apex of the calix has also been recorded. These experiments have been repeated by later investigators with similar results, though some of these workers have likewise found difficulty in discovering the point of rupture, and therefore have remained unconvinced that the backflow was traumatic.

In doing these experiments it is constantly observed that whilst a certain definite level of pressure is required to initiate the backflow, once that has started a smaller degree of pressure will continue it. Moreover, the piston of the syringe is noted to yield suddenly and a 'soft hissing noise' always follows the collapse of pressure. In Burger's and Fuchs' experiments on living rabbits, air was employed as an injection and the sudden fall of pressure in the kidney pelvis immediately preceded the appearance of air bubbles in the vena cava. Similarly

* Fuchs' work for the most part bears out that of Hinman and Lee-Brown, but recently he has formulated the view that the extravasation occurs primarily into the tissues of the sinus renalis and that it then spreads for a short distance into the kidney between the tubules and the interlobar veins before rupturing into the latter.

Fuchs, in a further experiment, studied by means of the X-ray screen the behaviour of a freshly removed kidney when being injected with sodium bromide solution. He watched the pelvis widen and the calices dilate. At a given moment the syringe piston yielded and immediately streak-like shadows appeared in the parenchyma, arising at the point of insertion of the small calices and rapidly spreading so as to display the venous arcades and their tributaries. These observations strongly support the view that the ballooned-out pelvis actually bursts. There appears to be little doubt as to the essentially traumatic mechanism of production of pyelovenous backflow.

Experiments to determine at what pressure reflux commences have frequently been made. Lindemann (1904) was the first to examine the level, and recently it has been studied by Hinman and Lee-Brown, and others. Hinman states that a pressure of 20 mm. of mercury is required in a sheep's kidney to obtain slow reflux, but that with 30 to 40 mm. of Hg a rapid outflow from the renal veins occurred. Once established, this flow could be maintained by a relatively slight pressure. All these pressures are below the secretory pressure, and it might therefore be surmised that if the ureter were simply ligatured, the secretory pressure would itself provide sufficient tension to cause a backflow. Evidence in support of this view is to be found in Tuffier's experiment (1894), for, as stated above, he placed in the pelvis a small quantity of strychnine and ligatured the ureter. No effects were obvious until the secretory pressure was reached, when the animal quickly succumbed to strychnine poisoning. In a similar series of experiments Hinman and Vecki imprisoned phenolsulphonephthalein in the ureter. The pelvic contents, examined periodically, showed that the dye gradually disappeared. It is therefore argued by them that when the renal outlet is closed excretion goes on until such an increase of the intrapelvic pressure has taken place that conditions favour a pyelovenous backflow.

This view is not universally accepted. Amongst others Fuchs and Morison may be mentioned as doubting the occurrence of pyelovenous backflow at a pressure below the secretory pressure of the kidney. But whatever the mechanism of resorption the fact that rapid removal of pelvic contents occurs cannot be denied. In a unilateral retention, as shown in the experiment of Ribbert already quoted (page 425), the contents under compression in one kidney pelvis were re-excreted by the opposite organ, and in a similar experiment carried out by Magoun phthalein confined in a normal pelvis was demonstrated in the urine from the other side within twenty minutes.

3. **Radiological Evidence.**—X rays may bear witness to extravasation either in the living subject or in post-mortem specimens.

In *post-mortem specimens* Lee-Brown states that " the most spectacular method of demonstrating the phenomenon is by injecting a series of kidneys by way of the ureter with a suspension of barium sulphate, and at intervals taking roentgenograms of the kidneys. By this means the establishment and development of pyelovenous backflow can be observed and followed " (*Figs.* 283, 284).

A striking experiment carried out by Heinrich is to fill the renal veins with 20 per cent iodipin solution and radiograph them. The pelvis is then distended with air and a further exposure is made. Air is found to have entered the veins, where it produces clear, bubble-like lacunæ in the shadow of the iodipin-filled vein.

Fig. 283.—Sheep's kidney. in which pyelovenous backflow is advanced but incomplete. Made with a barium sulphate suspension at 40 mm. Hg. pressure.

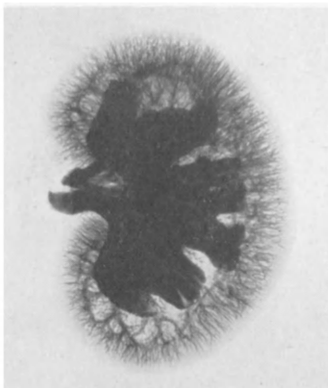

Fig. 284.—Complete venous injection without any evidence of tubular injection or extravasation, resulting from pyelovenous backflow at a pressure of 40 mm. Hg.

In some cases the *tubules* only are shown up on the radiogram, but this will be described later (page 437).

In the *living*, and especially in clinical work, pyelovenous backflow does not give a picture comparable with that of the post-mortem organ, partly because of the intervention of other tissues and organs, partly because less opaque media are used, but chiefly because the onflow of the circulation quickly carries away the medium and reduces its density. *Figs.* 285 and 286 are clinical examples of pyelovenous backflow. In each case some of the extravasated fluid is probably lying in the fat of the hilus.

Hinman maintains that evidence of extravasation obtained on the film during pyelography is caused by fluid which has flowed back within the venous system and that the fornix calicis is the level of entry of the venous system. He admits that tubular injection can occur and that in the human kidney and in the kidney of the dog it is more easily produced than it is in the kidney of certain other animals, for example the sheep. For the most part, however, he maintains that tubular penetration is limited to the large terminal collecting tubules (*Figs.* 279, 282). The possibility of pyelovenous regurgitation by way of the medullary tubules into the venæ rectæ of the pyramid or the arcuate veins, as argued by Bird and Moise (*see* page 435), is not completely denied though it is held to be uncommon.

Fig. 285.—Pyelovenous backflow.

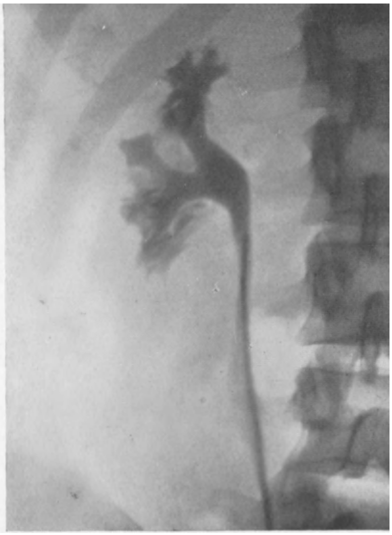

Fig. 286.—Severe pyelovenous backflow.

OTHER ROUTES OF RESORPTION.

It is clear that pyelovenous backflow is a phenomenon occurring in very special circumstances, and it is an unsettled question whether it actually occurs at all in normal conditions (*see* page 432) or even when there is total obstruction of the ureter as by a calculus. Yet in the case of absolute ureteric blockage we know that there is an interchange between the blood-stream and the pelvic contents. What alternative routes are available ?

1. **Animal Experimentation.**—In an attempt to exclude the injury done to the renal pelvis by overdistension and to simulate more closely the natural process, Duncan Morison has introduced into the pelvis amounts of dye which were known " to be well within the pelvic

capacity ". He finds that when a dye is introduced into a previously unobstructed pelvis and the ureter is then tied the lymphatics of the pelvis and ureter are the sole route of absorption during the first three or four days. The particles of dye are gradually transferred through the thickness of the mucosa, musculature, and adventitia to the extramural lymphatics and subsequently to a lymphatic gland lying near the inferior vena cava. From the third or fourth day onwards, however, the dye starts to penetrate the tubular system and will ultimately reach the distal convoluted tubules of the cortex corticis.

If, however, before introduction of the dye the ureter has been ligatured for a period of three or more days, conditions are different. The dye in these circumstances enters the tubules from the beginning and lymphatic absorption is absent. In the convoluted tubules the dye is found not only in the lumen of the tube but actually within and between the epithelial cells. At a later time the lymphatics become as active in absorption as the tubules. These experiments appear to show that in the absence of overdistension and trauma there are two possible routes of absorption from a totally obstructed pelvis—the tubular and the lymphatic—and that the respective parts played by these alternative routes varies according to whether or not there is some degree of hydronephrosis.

"Why is there an initial period of delay before the dye begins to ascend the tubules? Is it due to some natural valve-like action at the tip of the renal papilla, as suggested by Cushny? Longitudinal sections of the normal rabbit's kidney show that the epithelium covering the sides of the pyramid is cuboidal in type and arranged in a single layer (*Fig.* 287). As the tip of the papilla is approached this layer becomes elaborated till around the mouths of the papillary ducts it is fully five to eight cells in depth, and almost papillomatous in form. With sudden raising of the intrapelvic pressure, as produced by total ureteral obstruction, it may be that this redundant epithelial layer becomes sufficiently compressed, so as to lie in a position over the mouth of the papillary ducts, and thus prevent any regurgitation of the pelvic contents. But with continued pelvic distension there is a radial and outward pull on the papilla which would tend to stretch the epithelial layer and remove its obstructing influence from the mouths of the papillary ducts, thus allowing a patent communication for the pelvic contents" (Duncan Morison).

It has been argued by some writers (Bird and Moise) that backflow of pelvic contents passes up the tubular system and from this ruptures through into the veins, perhaps into the venæ rectæ or into the venous arcades in the cortico-medullary area at the point where the tubules cross them. These writers have been unable to confirm the occurrence of a calicine rupture and offer this theory as an alternative. In answer to this view two counter-arguments may be advanced: (1) That it is impossible to imagine that a massive injection of the venous system such as has been repeatedly seen can traverse these minute channels; and (2) That, as shown by Hinman and Lee-Brown, when backflow has been established with a pigmented and therefore easily recognizable solution, the solution is clearly visible in the cortical area, in the venous arcades, and in the bases of the pyramids, but it does not extend down the pyramids more than a

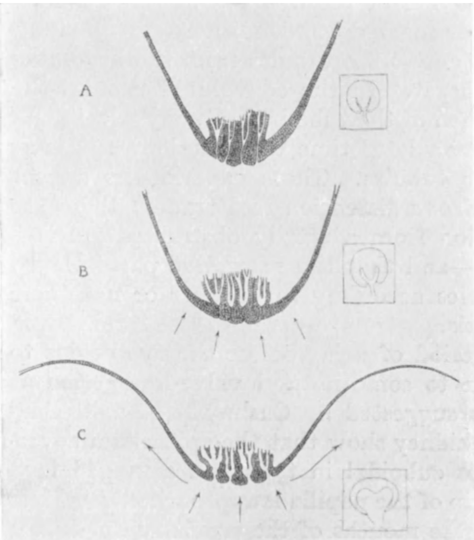

Fig. 287.—Diagram representing longitudinal sections of the tip of the renal papilla in three phases: A, Normal papilla, showing greatly thickened layer of epithelium around the mouths of the papillary ducts; B, With onset of total ureteral obstruction, the intrapelvic pressure is raised and compresses the redundant epithelial layer over the mouths of the papillary ducts, thus preventing any backflow of the pelvic contents; C, With advancing hydronephrosis, the increasing radial distension, by removing the epithelial barrier, establishes patency of the papillary ducts, and allows free communication between the pelvic contents and that of the tubule system.

Fig. 288.—Section of a sheep's kidney after pyelovenous backflow had been produced by injecting the ureter with dilute Indian ink at 40 mm. Hg. The entire venous system of the cortex is injected, while only a small area of the medulla in the cortico-medullary zone is filled. The tubular penetration produced simultaneously is confined to the terminal ends of the collecting tubules, at the apex of the pyramid. If the dye had gained the venous system as a result of tubular penetration and rupture, the venæ rectæ in relation to the penetrated tubules would be filled, but the medulla in this area is entirely free from vascular injection.

few millimetres (*Figs.* 279, 282, 288). On the other hand, the dye in the tubules does not extend up the tubuli colligentes more than a millimetre or two so that there is no meeting place, a clear, unstained, intermediate zone extending over the greater length of the pyramid and separating the two areas of pigment. The failure of these two areas of injection to make contact appears to be conclusive evidence against this explanation of pyelovenous backflow.

2. **Radiological Evidence.**—After filling the pelvis with a radio-opaque fluid it is observed that in some *post-mortem specimens* (20 per cent, Scott) tubular injection is plainly visible on an X-ray film (*Fig.* 289). It is quite easy to distinguish this from pyelovenous backflow, the shadow which it produces on the film springing from the central depression of the calix and being

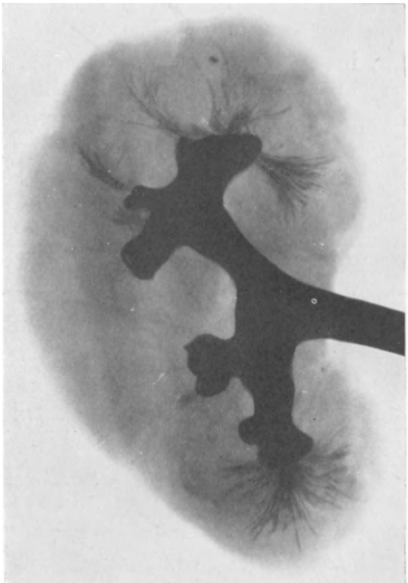

Fig. 289.—Tubular injection of human kidney without evidence of pyelovenous backflow.

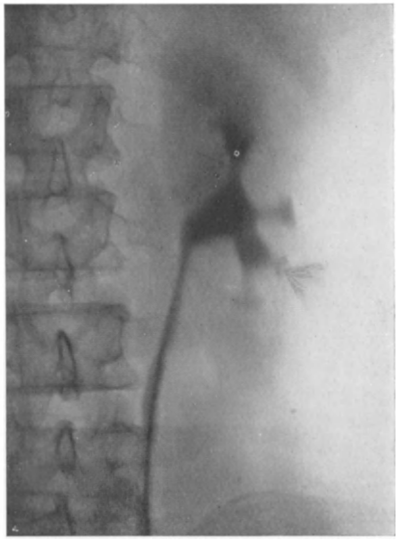

Fig. 290.—Tubular injection on a pyelogram. Diverging rays springing from centre of calix.

brush-like or ray-like in appearance. Such rays may be seen at one or more of the calices and they expand fanwise into the corresponding papilla, though rarely penetrating far beyond the apices of the papillæ. Whether the injection elects to follow the tubules or ruptures into the venous system depends in considerable measure on the kidney used. Kidneys from the sheep have been much used in experiments and lend themselves to pyelovenous back-flow, tubular injection being difficult to produce. Conversely in working with kidneys from the pig, cow, etc., the opposite conditions obtain, for tubular filling is more easily produced than backflow. The human kidney occupies an intermediate position and either type of filling may be seen, but " any kidney which shows extensive tubular injection seldom shows any pyelovenous backflow, while any kidney which shows free backflow is almost invariably devoid of tubular penetration " (Lee-Brown).

In the *living* similar shadows are occasionally seen in pyelograms (*Fig.* 290)—sheaf-shaped, curved pencils which spring from the papilla and diverge as they pass outwards. At their origin such shadows may be so densely packed that they present a uniform shadow, but this becomes differentiated as it widens out. Such sheaves may spring from several calices.

3. **Corrosion Experiments.**—During corrosion experiments it is sometimes found that the menstruum, instead of invading the veins, elects to enter the collecting tubules, but it never penetrates these for more than a short distance. The specimen will then show a very characteristic brush-like protrusion centrally attached in the hollow of the calix.

PRACTICAL APPLICATION.

It remains only to point out the practical application of these facts, and for the most part this is sufficiently obvious. The amount of pressure used must be carefully controlled with a view to the exclusion of all chance of pyelovenous backflow (*see* page 391). The solutions we use to-day are fortunately relatively non-toxic, but this cannot excuse incautious overfilling of the renal pelvis. Instrumental pyelography remains one of the most valuable diagnostic agencies at our command and has many advantages over the intravenous method even if it has also some disadvantages. The somewhat lengthy attempt to review the present state of our knowledge regarding backflow appears to the writer to be justified because it is necessary to a proper understanding of the subject and without this understanding the dangers of cystoscopic pyelography may not be fully realized.

Resorption is a problem having many facets which do not fall within the scope of our inquiry. It would be fascinating, for example, to pursue the question in its relation to ureteric obstruction combined with sepsis in which it goes far to explain the severe toxæmias associated with that state. But this and other problems must be left as an exercise for the reader's fancy or preferably for further original research in this, as yet only partially worked out, field.

CHAPTER XXVI.

EXCRETION UROGRAPHY.*

HISTORICAL.

THE urologist has long hoped that some substance might be found which would be excreted by the kidney and give a shadow on radiography. Immediately, indeed, on the heels of the introduction of instrumental pyelography, Voelcker and von Lichtenberg (1905) attempted excretion pyelography by means of the *colloidal heavy metals*, but had to acknowledge failure on account of the great toxicity of these substances. A long period then elapsed during which urologists were occupied with the evolution of instrumental pyelography, and it was not until 1923 that Rowntree and Scholl again took up the problem, using *sodium iodide* administered either intravenously or by the mouth. In about one-half of their cases they were successful in visualizing the upper urinary apparatus. Nevertheless this compound also proved unsatisfactory, and attempts by several workers to supplement it, either with pneumo-radiography or by compressing the ureters in order to detain and concentrate the excreted solution, were likewise abandoned on various grounds. In the succeeding years Graham solved the problem of cholecystography, an achievement which stimulated fresh research. It may be remarked, however, in passing, that the two examinations are not comparable, because the renal pelvis does not retain and concentrate its contents as does the gall-bladder. Any drug employed must, therefore, be excreted by the kidney in good density and with sufficient rapidity if it is to throw satisfactory radiographic shadows. In 1927 Roseno achieved a passing success with *pyelognost*, a drug in which he linked iodine to urea, hoping that excretion would be expedited by the diuretic action of the urea, but, as was the case with the previously mentioned drugs, the iodine proved itself to be too weakly combined, and, being split off within the body, it was undesirably retained and produced symptoms of iodism. It thus became evident that a much more stable body would be required if excretion urography were to be placed on a sound basis.

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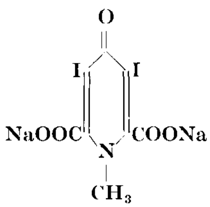
* *Synonyms* : Excretion, descending, intravenous, or elimination {urography / pyelography}

Uroselectan.—The discovery of the radiological properties of bodies to which uroselectan belongs, came, in a measure, fortuitously. Binz was working with the benzine ring in the hope of improving drugs of the salvarsan group for use in syphilis. Iodine was attached at various points to the pyridine nucleus, and some success was registered when an antiseptic capable of controlling streptococcal mastitis in cows was discovered. It was called ' selectan ' and was known to be excreted in the bile and in the urine. Working with an allied body (' selectan-neutral ') in human beings, Lichtwitz was attempting to obtain a cholecystogram. No picture of the gall-bladder was obtained, but in its place the urinary tract showed up so well that all interest was diverted to it. At this point the clinical side of the inquiry was handed over to von Lichtenberg and Swick, Binz and Raeth continuing the chemical investigation. Seventy-two other substances allied to selectan were synthesized and tried, some because of their large iodine content and others on account of their solubility. Eventually (1929) a body was chosen as being the best available and was named ' uroselectan '. Uroselectan gave good shadows and proved serviceable, but was cumbrous to use in view of the great care required in its preparation and of the large quantity of fluid (50 to 100 c.c.) which had to be injected intravenously. Persistent research by von Lichtenberg and his co-workers culminated (1931) in the introduction of ' uroselectan-B ', which has superseded the older drug by virtue of the small quantity of fluid required for injection (20 c.c.) and the convenient form in which it is marketed.

Uroselectan-B.—Like its predecessor, this is a pyridine derivative. Containing 51·5 per cent of iodine in organic combination, its formula is :—



Di-sodium salt of 3·5 di-iodo-4-pyridoxyl-N-methyl-2·6-dicarboxylic acid

Its molecular weight is 493. It is very soluble and is conveniently put up in an ampoule, sterilized and ready for use. It does not undergo chemical change when kept. In contrast to the original uroselectan, only 20 c.c. (15 grm. of uroselectan-B) are required for injection. The iodine is in close organic combination, and uroselectan-B passes through the organism without its liberation. Any chance of iodine poisoning is thus precluded. The ampoule as supplied contains invert sugar which renders it hypertonic. Fluid, therefore, is attracted from the tissues into the blood and " in this way the absorption of uroselectan-B by the tissues is hindered, with the result that excretion is increased and tolerance improved."

Uroselectan-B is well tolerated, healthy dogs surviving for seven hours a dose corresponding to twenty times the human dose if the drug is slowly injected. With healthy kidneys it is excreted in good quantity in two to five minutes. At this time or during the subsequent forty-five minutes urograms may be made, fifteen or twenty minutes being the time chosen for the optimum anatomical demonstration of the renal pelvis. Von Lichtenberg states that 30 per cent is excreted in the first hour, 12 per cent in the second, and in the succeeding six hours a further 21·8 per cent—63 per cent in the first eight hours. The absolute quantity of uroselectan-B found in the urine is greatest in the first fifteen minutes, but during this time it

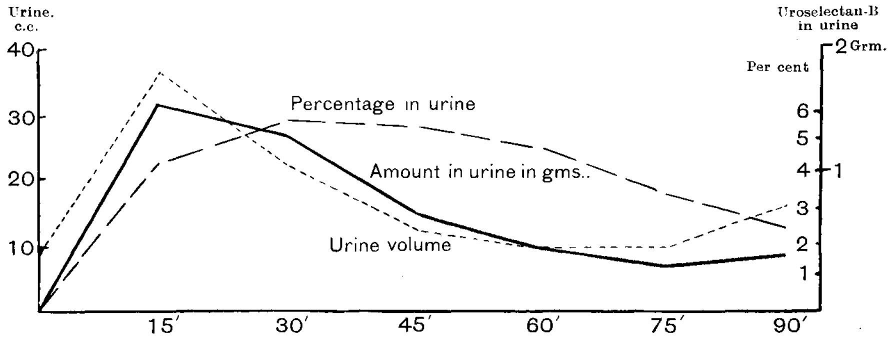


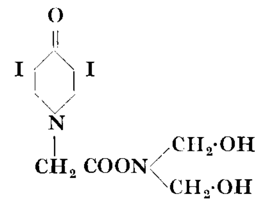
Fig. 291.—Graph to show: (1) urine volume, (2) percentage of uroselectan-B, and (3) total uroselectan-B in the urine at 15 minute intervals after injection of 0·75 grm. per kilo. into a bitch weighing 10 kilo. (three times the human dose). The diuresis reaches its peak at 15 minutes and rapidly diminishes. The percentage rises to a maximum at 30 minutes, remains nearly constant for 30 minutes, and gradually decreases afterwards. The total amount found reaches its maximum at 15 minutes, and afterwards runs nearly parallel with the urine volume. (*After Gardner and Heathcote.*)

is diluted by the large quantities of urine secreted. The actual concentration is highest in the second fifteen minutes. After forty-five minutes the amount excreted is small, although the concentration remains as high as 2·7 per cent after ninety minutes (Gardner and Heathcote—*see also Fig.* 291).

The injection should be given slowly, several minutes being occupied in order to allow admixture with a sufficiency of blood. Gardner and Heathcote, in the case of the original uroselectan, found that with dogs and rabbits death occurred very rapidly if the administration was quickly performed. Œdema of the lung was discovered post mortem and was attributed to rapidly induced changes in the osmotic pressure of the blood. With uroselectan-B also these writers note that the minimum lethal dose depends on the rate of injection, though here failure of respiration and a very low blood-pressure appeared to be responsible for the death.

Perabrodil.—Almost immediately after the introduction of uroselectan another excretory body with radio-opaque properties was brought forward under the name of ' abrodil ' and proved satisfactory in use. In 1932, however, it also was superseded by a superior and more convenient substance called ' perabrodil ' (' neo-skiodan ' in America). The advantages of perabrodil over its predecessor, abrodil, are the small quantity of solution required and the facts that it is better tolerated, more rapidly excreted, and that its shadows show superior density. Also its viscosity is very low and this facilitates introduction.

The formula of perabrodil is :—



3·5 -di-iodo-4-pyridon-N-diethanolamine

It has a molecular weight of 508 and is a white, odourless powder containing 49·8 per cent of iodine in firm combination, and is unchanged by boiling. The dose is 7 grm., which is supplied in sterile, 20-c.c. ampoules. This relatively small quantity of fluid makes perabrodil easy to handle. The dose administered (7 grm.) is less than half that of any other excretion compound. It can be injected into the circulation rapidly. The makers recommend that its introduction should take about forty-five seconds, but Samuel advises the retention of the tourniquet until the injection is complete so that the circulation may be suddenly flooded by the drug with a view to increasing the head of perabrodil in the circulation.

That it is well tolerated is shown by the fact that the full human dose may be given to a rabbit of 4½ lb. weight without important ill effects, or that a dose proportionately fifteen times larger than the standard human dose, if given slowly to a dog, is not fatal. The drug passes rapidly into the urine, 80 per cent being recoverable within seven to nine hours and a concentration of 5 per cent or more of iodine in the urine being observed. It is excreted unchanged. There is a complete absence of evidence of renal irritation in the kidneys of experimental animals, and in the human subject albuminuria is not seen. Accidental extravasation around a vein is harmless and painless. On occasion, as for instance in childhood or when no vein can be discovered, perabrodil may be injected subcutaneously. Local pain is thus less marked with perabrodil than with any of the other drugs used for intravenous urography. Pain in the shoulder (vein spasm) and thrombophlebitis are not observed, and general reaction, vomiting, sweating, etc., do not occur. The peak excretion with normal kidneys starts about eight minutes after introduction of the drug and continues for twelve minutes, this period being the best for radiography. Good urograms may, however, quite frequently be obtained at five minutes or even earlier. The time sequence of perabrodil is slightly quicker than that of uroselectan-B, but both these recent drugs are more rapid than either of their predecessors.

TECHNIQUE OF INJECTION.

The preparation of a patient for the X-ray examination is more than usually important on account of the weakness of the radiographic shadows. Meteorism is a greater source of trouble than it is with retrograde pyelography, not only because of the pale images but also because the drugs themselves appear in some way to assist the production of intestinal gases, as is shown by the increased amounts present in the later plates. On this account some urologists, in addition to the usual laxative, forbid supper and breakfast prior to intravenous urography, and no fluids are allowed for at least twelve hours before the examination. This is expected to give more intense concentration within the urinary passages, but is not in the writer's opinion necessary and is troublesome to enforce (*see also* page 446). Enemata are recommended by some, but probably introduce more gas than they evacuate. Patients should, however, when possible, be up and about before they are submitted to excretion urography in order to encourage the free discharge of flatus. Prior to administration of the drug the bladder is emptied and a preliminary skiagram is obtained. The injection is given on the radiographic table, an antecubital vein being preferred for the purpose. The solution, warmed in a water bath to body temperature, is introduced with a Record syringe. The needle should lie centrally in the lumen of the vessel, its correct position being confirmed by the regurgitation of a few drops of blood into the lumen of the syringe.

Authors differ in practice regarding the use of suprapubic compression in order to concentrate the dye. Von Lichtenberg is opposed to it because it interferes with the normal motility of the passages. There is little doubt that it increases the density of the shadows and is thus not to be lightly rejected. A good method, suggested by Moore, is to take the first plates under compression and the subsequent ones without, which plan combines the advantages of both procedures.

This author, by publishing plates exposed alternately with and without compression, has conclusively shown the superior density of the former.

As is common when any hypertonic solution is injected into a vein, the patient may experience a sensation of general warmth or flushing. Towards the termination of the injection there may be cramp-like pain in the shoulder and axilla, probably caused by venous spasm. These discomforts are, however, less common with the recent preparations than they were with the original ones, and in any case they are of short duration. Thirst may be experienced owing to the withdrawal of fluids from the tissues by osmotic action. Vomiting, giddiness, flushing of the face, and shivering occasionally occurred with the previously used fluids, but are rarely seen now and are in any case transitory. The pulse-rate increases by 10 or 15 beats per minute, and the blood-pressure, after a preliminary fall, rises 10 or 15 mm. of mercury. Heathcote and Gardner point out a noticeable effect of perabrodil on the respiration. There is an immediate acceleration of its rhythm, together with an increase in its depth, which they attribute to direct stimulation of the respiratory centre. Fever has continued in rare instances for a day or two. Neither the clotting time nor the sedimentation time of the blood is altered, and venous thrombosis does not result. If paravenous extravasation of uroselectan-B occurs, the patient suffers considerable pain at the site of the injection. This does not hold good for perabrodil, which may actually be administered subcutaneously (*see* page 457).

FATE OF THE DRUG IN THE BODY.

The original uroselectan* was shown to be excreted mainly (90 per cent--Swick, Heckenbach) by the kidney, but in part by the liver, this latter organ being responsible presumably for the remaining 10 per cent. When there is functional disturbance of both kidneys, the liver takes an additional share in elimination. Some storage is said to take place in the skin (Tourné and Damm). The reasons for avoiding uroselectan in severe bilateral disease of the kidney, especially if complicated by hepatic inadequacy, are sufficiently obvious. Amongst the lower animals it has been shown that the ligation of the renal arteries followed by a normal dose of uroselectan is rapidly fatal, capillary damage being the main cause of death, though in

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* In several places in this chapter experiments with the original uroselectan and with abrodil are quoted. In such cases it may be taken that no similar work done on the subsequent compounds is available to the writer in spite of a careful search. It is implied that the results are equally applicable, but corroboration would, of course, be acceptable.

addition there is found a severe injection of the serous membranes, in the transudate from which uroselectan can be found.

Urine.—The output of urine rises sharply in the first two hours succeeding the administration of uroselectan-B or perabrodil, but in spite of this polyuria the specific gravity may increase to 1050, 1060, or even 1080. It then falls to about 1030 and remains there for several hours.* " It is remarkable that the highest specific gravity is usually reached in the third or fourth hour, a time when the greatest concentration of uroselectan is past " (von Lichtenberg). Uroselectan increases the acidity of the urine. If the renal function is good, the P_H falls to 5·6 or even 5·2 and returns in the next few hours to the normal. Poor renal function will give a less steep rise in P_H (Hughes). Albuminuria is frequently noted, but is mild and transitory. With perabrodil the diuresis is less severe, probably owing to the smaller dosage. It is most marked in the first fifteen minutes. Uroselectan-B and perabrodil are found unaltered in the urine.

The burden imposed on the kidney is a heavy one, yet no parenchymal changes are demonstrated in experimental animals so long as doses corresponding to those used in the human subject are employed, and when excessive doses were administered " there were only very trifling, transient tubular changes, such as swelling and fatty degeneration, while in the glomeruli no changes whatever were observed " (Bronner and Schueller, working with abrodil). Corresponding results were obtained for the original uroselectan by Galbraith and Mackey.

RADIOLOGICAL RESULTS.

Excretion urography is, under favourable circumstances, capable of rendering evident on an X-ray film the whole of the urinary apparatus from the renal periphery to the internal urinary meatus.

The *renal parenchyma* is saturated with solution, which renders it opaque so that it can be clearly seen on the film (nephrography). The kidney's size, position, relationship to opacities observed on a previous skiagram, and the presence of hiatuses in its substance become apparent. Nephrography is instructive, and in certain cases may be extremely important, but it has not yet received the attention which it merits. It is one field in which descending urography has definitely proved itself superior to ascending. Some years ago similar information was desired of pneumo-radiography, but this form of investigation fell into disrepute owing to its associated risks, and it was discontinued. Though easily enough seen, the parenchymal shadow is invariably

* The height of the specific gravity is related to the molecular weight of the drug.

weaker than the pelvic shadow. Attempts have been made to strengthen it by withholding fluid for a time before administration of the solution in order to concentrate the latter in the tubules. The effects of such abstention are uncertain, and, indeed, some writers maintain that a better shadow is got when the patient takes fluids freely. Certainly when renal function tests are to be undertaken simultaneously the fluid intake should not be interfered with. If the renal outlet is obstructed, the drug collects in the tubules, and the parenchyma becomes increasingly obvious.

When the kidneys are excreting satisfactorily the *pelvis and ureter* become filled with drug-laden urine, and their position, size, and type, whether they are normal or diseased, and their relationship to other shadows can, in favourable circumstances, be judged. In excretion urography only those portions of the pelvis and ureter which are in diastole contain the shadow-throwing reagent ; those which are in systole do not appear on the radiogram. Any section of the tube system from the calix to the bladder may, therefore, be missing on a given plate, but unless pathological will certainly be shown on some subsequent one. Slight shadows which appear in good time, then come and go, and finally disappear in an hour or so, indicate normal conditions. Shadows which appear late show weakness of secretion. Dense and constant shadows are abnormal. They suggest good, or at least reasonably good, function, combined with obstructed drainage. Sometimes excessive peristalsis hurries the contents along so quickly that poor delineation is obtained and the shadow of the healthy side is quite often inferior to that of the diseased.

Excretion is dependent on renal function. If *both kidneys* have inferior capacity, the onset of excretion will be delayed. The drug is temporarily stored in the organism and not till one, three, five, or more hours have elapsed will it produce a urogram. In advanced bilateral disease skiagrams taken at twenty-four hours may be positive. In extreme disease no excretion can be discovered. Where *one kidney* alone is diseased, conditions are different. A kidney which could have produced a delayed shadow will have little or no drug available because its healthy neighbour has already rid the circulation of most of it before the damaged organ could act. In the case, therefore, of severe disease, whether unilateral or bilateral, the grade of the disability will be manifest, but descending pyelography will not reveal its variety or cause ; it will merely show that the kidney is out of action, and instrumental pyelography will be called in to complete the picture.

About twenty minutes after the introduction of the drug a *cystogram* is obtainable, as sufficient urine is usually secreted in this period of time owing to the diuretic action of these compounds.

When this has been done the termination of the ureter must be studied. For this purpose the patient should be instructed to empty his bladder, as the lower ends of the tubes are partly or entirely hidden by the shadow of the bladder.

PHYSIOLOGY OF THE URINARY TRACT.

Excretion urography supplies a silhouette of the urinary passages as they exist unaffected by instrumentation or by irritant injections. The picture, therefore, differs materially from that supplied by infusion pyelography in being truer to the physiological conditions obtaining, whereas instrumental methods probably represent the anatomical state more accurately. A series of urograms will show the peristaltic activities of the urinary drainage system, as demonstrated by nodes and spindles, dilatations and contractions, which are found to occupy different situations at different times and result from the onflow of the drug-containing urine. In serial radiograms one can see the transportation of this fluid down the channels, and it has also been watched on a fluoroscopic screen and with the cinematograph camera (*see* Chapter XXVII). Hyper- or hypo-activity of the tubular system may be observed, together with displacements, kinks and loops, strictures and dilatations. The healthy ureter not only moves laterally in the periureteral tissues but also appears to coil itself momentarily in loops. Distortions and displacements of the ureter which are short-lived and ever-changing are physiological or functional; those which persist are pathological. By watching the character and permanence of these deformities the dynamics of the urinary tract may be studied and information of much value may be obtained, particularly in hydronephrosis, where it may reveal the cause to be, on the one hand dynamic (neuro-muscular), or, on the other hand, anatomical (obstructive). The treatment will be influenced thereby.

INDICATIONS FOR AND CONTRA-INDICATIONS TO EXCRETION UROGRAPHY.

Indications.—The chief occasions when excretion urography is indicated are set out below.

1. The advantages of excretion urography are very pronounced where cystoscopy and ureteric catheterization are difficult, impossible, or undesirable, and therefore instrumental urography cannot be undertaken or is inadvisable. The causes of such conditions are dealt with on pp. 293–299, to which the reader is referred. Descending

urography then comes in as a welcome substitute for ascending urography and perhaps also for renal function tests.

2. Some technical matter in the diagnosis may have been overlooked or may have been imperfectly explained by the preceding investigation, or some unsettled question arises when the case is being finally reviewed. It may be possible to clear up such a point by means of excretion urography. In actual practice it is not at all uncommon for this to happen, and a second cystoscopy is circumvented.

3. Sometimes the urologist elects to use excretion urography as a way of getting a rapid preliminary survey of a case (*see also* page 120). This method is especially valuable when it is not at all certain whether the urinary organs are accountable for the illness, as, for instance, with indefinite abdominal symptoms or a tumour of the upper quadrant of unknown origin. According to the circumstances, urography may help to impeach or acquit the urinary system.

4. When the object is to acquire information about the dynamics of the pelvis and ureter (*see* page 447 and Chapter XXVII).

5. It is valuable as a way of acquiring a cystogram in any patient on whom it is not desirable to pass a catheter. In particular it constitutes an excellent method of showing the residual urine in prostatic disease of urethral stricture. At the time when there is a sufficiency of the drug in the bladder (say, half an hour after the injection) the patient is told to urinate, and when he has passed what he can a skiagram will give some idea of the measure of his retention. It thus provides an admirable way of averting that catheterization which is sometimes so hazardous.

6. A heterogeneous group of conditions are suitably subjected to excretion urography, amongst which may be mentioned transplanted or ectopic ureters, fistula of the ureter or pelvis, ruptures of the kidney, and urinary troubles in childhood.

Contra-indications.—Excretion urography is contra-indicated in advanced renal insufficiency, especially if complicated by a low hepatic function. If there is any reasonable doubt about the renal capacity, the blood-urea should be estimated. The writer finds that, as a rule, a clinical appraisement is sufficient for this purpose, but some surgeons have the blood-urea examined routinely. Renal function must be severely reduced before it constitutes a contra-indication to intravenous urography, for even a much embarrassed kidney retains a fair measure of excretory power. Patients with severe renal infections are intolerant of excretion urography, and it should not be employed in the presence of advanced heart disease, febrile conditions, hyperthyroidism, or an iodine idiosyncrasy.

APPRAISEMENT.

Excretion urography has, in a comparatively short period, firmly established itself as a valuable line of investigation—indeed, it now appears to be an absolutely indispensable one. Its field of usefulness is very wide. It has nevertheless, like many other newcomers, suffered much from the over-enthusiasm of its advocates and is at present in process of settling down to find its correct sphere of application. The shadows provided by it compare ill with those obtainable with ascending pyelography. As a delineator of the shape of the renal pelvis there is no comparison between the two methods. This is due partly to the fact that the pelvic cavity is less completely filled and in part to the actual weakness of the excreted solution. "Healthy kidneys excrete a 40 per cent uroselectan solution as one containing 5 per cent of iodine, and the 20 per cent abrodil solution as a 2·5 per cent iodine containing urine" (Jaki). They both therefore give a much paler shadow than does 13·5 per cent sodium iodide. The difference between ascending and descending urography is, of course, accentuated by any renal deficiency, and this, in its turn, is frequently the direct result of the very disease which is under investigation. It follows that disappointing results are of frequent occurrence. The shadows thrown are so weak in most instances that they can be relied upon to indicate only gross lesions of the kidney or ureter, or alterations in the position, size, or shape of the kidney. The finer points of architecture require the richer shadows and the better filling provided by instrumental pyelography. Minor modifications of the urinary tract cannot be recognized.

On the other hand, under favourable circumstances excretion urography shows the condition of both sides of the urinary tree and avoids the pain and inconvenience of ascending urography, whilst it is further claimed that the shape of the parts is not distorted either by over-distension or by the presence of a catheter. Moreover, excretion urography is often available when instrumental urography is for some reason rejected.

The recent method does not legitimately threaten to supersede instrumental urography, from which much more exact information may be gleaned, the two methods being complementary rather than antagonistic, and usable in conjunction. Of great moment, however, is the fact that there are many who, ignoring not only instrumental pyelography but also cystoscopy and all the other old-established urological procedures, try to make a full diagnosis by means of excretion urography alone. An attempt on the part of the patient to side-step the discomforts of cystoscopy is understandable and is one with which we may fully sympathize, yet excretion urography has its proper uses and severe limitations and it cannot with safety be allowed to trespass beyond them. Acquiescence on the side of the practitioner in allowing the examination to be limited to intravenous urography is rarely in the patient's true interests, even though admittedly it is at times permissible to depend solely thereon.

Improper reliance on it is responsible at the present time for many mistakes, as is borne home daily in any urological practice. The incursion of a host of workers, untrained in urology and light-heartedly willing to give a full diagnosis and opinion solely on the evidence of an X-ray film, is pregnant with untold possibilities of disaster. Many of the better radiologists are fully alive to this state of affairs and acknowledge the unsatisfactory quality of much of the evidence on which they must perforce base an opinion. At the risk of its sounding like an *ex-parte* statement, it must be unequivocally laid down that the trained urologist—he who is experienced in the after-course of urological disease, he on whom will devolve the subsequent responsibility for the case—shall prescribe, and indeed is alone competent to judge, the measures suitable for the individual case. Properly used, and severely restricted to its correct sphere, intravenous urography is a great asset, but if allowed to overstep its proper boundaries, as at present, it may become a real danger.

RENAL FUNCTION TESTING.

The elimination of contrast substances introduced into the circulation depends on renal function and may therefore be used as a test. Various methods of judging the power of elimination are available, of which the following are the most important: (1) *Urography*; (2) *Radiography of the drug-containing urine*; (3) *Recovery of the drug from the urine*; (4) *Specific gravity of the urine*—these four are elimination tests; (5) *Estimation of the drug in the circulation*—retention test.

1. **Urography.**—As the depth of the shadow and the time of its onset depend on the kidneys' efficiency, excretion urography may be regarded as an indicator of renal function. The *depth* of the shadow, however, is determined by many accessory factors, such as the stoutness of the patient, variations in radiological technique, apparatus, etc. Moreover, the radiogram may be unfortunate in reproducing a period of full systole or that following a peristaltic wave, the system then holding the least possible quantity of the radio-opaque solution; or again the musculature may be hypertonic and peristalsis very active, as it is physiologically in childhood, or pathologically in some irritative lesions (pyelitis, etc.). Von Lichtenberg points out that " normally functioning kidneys with normal or hypertonic motility of the urinary tract are least suitable for radiological

visualization." Conversely, a shadow of good density may be supplied by a hydronephrotic and therefore not over-efficient kidney, as the secretion collects behind a closed outlet. Such a picture flatters the powers of the kidney, but as the obstruction is itself generally sufficiently obvious, the depth of the shadow will be discounted. As a criterion of renal function the density of a shadow must be accepted with reserve, but it is nevertheless of definite value where for any reason cystoscopy is impossible or contra-indicated.

The *time* at which the shadow appears and disappears is also an index of renal function. With uroselectan-B and with perabrodil the pelvis should be well displayed in eight minutes, and is generally visible at four minutes or even earlier. Excretion should be so nearly finished after one hour that no shadows remain with either of these compounds. A late onset, diminished intensity, a prolonged period of excretion, and defective filling generally indicate an impoverished renal function. Probably a late onset is more significant than a poor shadow in view of the uncertainty of the renal shadow, and, moreover, the observation of onset excludes errors arising from the presence of known or unsuspected stagnation.

A *shapely pelvis* and a sufficiency of parenchyma (nephrography) are also points to be taken into account, for they, at least, show if the kidney is morphologically intact.

2. **Radiography of the Drug-containing Urine.**—The drug-containing urine may be collected in test-tubes and radiographed alongside a standard solution, the relative depth of its shadow indicating its concentration.

3. **Recovery of the Drug from the Urine.**—Uroselectan-B may be precipitated from the urine by acidulation with a concentrated mineral acid (hydrochloric or nitric). With excess of acid the drug goes into solution again, so that the greatest precipitate is obtained by titration with acid and alkali alternately. The precipitate is then filtered off, dried, and weighed. The weight of uroselectan-B excreted in a unit of time is used as a test of renal function and proves itself a satisfactory indicator.

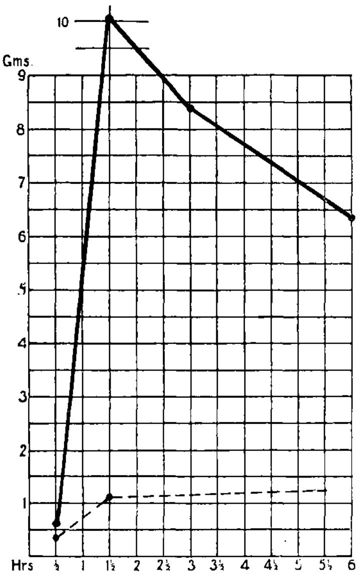

Fig. 292.—Two graphs combined from Wade and Band. Normal uroselectan excretion curve ▬▬▬. Chronic nephritis excretion curve ----------.

An investigation of renal function, carried out on these lines by Wade and Band with the original uroselectan, shows that excretion with normal kidneys rises steeply and reaches its peak between one and a half and three hours after injection, to fall gradually until none, or only a trace, is observable at the end of twenty-four hours. A graph modified from their work (*Fig.* 292) shows the reaction of normal kidneys and contrasts therewith the response of a patient suffering from chronic nephritis in which a " uniform low excretion of uroselectan was found ".

4. **The Specific Gravity of the Urine.**—This is greatly increased after the administration of any of these drugs, a fact which was observed (for uroselectan) by von Lichtenberg in his first publication. Specimens obtained and tested at stated intervals show a rise which may reach 1050, 1060, and occasionally more, during the first hour. This increase in specific gravity might be used as an index of renal function. It is, however, accompanied by a very marked polyuria, which must obviously lower the reading. To take the level reached by the specific gravity and ignore the polyuria would be fallacious, as the diuresis is very inconstant. Boeminghaus recommends, therefore, that the figure representing in cubic centimetres the quantity of urine produced in one hour be multiplied by the last two figures of the specific gravity, the resultant being an index figure representing function, as for example :—

	First Hour Output	Specific Gravity	Function Index
Patient A	435 c.c.	1022	9570
Patient B	200 c.c.	1042	8400
Patient C	730 c.c.	1018	13,140

The above are elimination tests. Of them, Number 1 shows the separate performance of each kidney. Numbers 2, 3, and 4 concern only total renal function, unless, indeed, the urine has been obtained by ureteric catheterization. But to avoid catheterization is one of the advantages of excretion urography, and if that is to be undertaken, renal function may just as well be estimated by the older and better established means.

5. **Estimation of the Drug in the Circulation (Retention Test).**—The blood, which immediately after the injection is flooded with uroselectan, shows a very steep fall in the curve during the first two hours and a subsequent gentler fall, till, at the end of four hours, no drug should be found in the circulation if the kidneys are healthy (Tourné and Damm). An estimation at this time will therefore constitute a blood-retention test. A remainder of 0·5 grm. of uroselectan four hours

after the injection indicates some minor renal disability, whilst a higher quantity shows severer damage (von Lichtenberg). In the case of perabrodil Heathcote and Gardner regard the estimation of the blood content of such small amounts as valueless.

The results of function testing by these substances appear for the most part to run parallel with other function tests, though the two kidneys do not always give identical results even when both are presumably healthy. As the excretion of this group of drugs occurs principally at the glomerulus, disease involving that structure is reflected more certainly in renal function testing than disease of the tubules (Hughes and Peterfi). Surgical disease falls principally on the tubules. Wade considers that the primary value of excretion urography is its service as a test of function, and states that "as a means of delineating the form and capacity of the renal pelvis and thereby demonstrating the morbid anatomy of any lesion which may be present, it is unreliable."

EXCRETION UROGRAPHY IN SPECIAL CONDITIONS.

In the section on instrumental urography a description of the value of that procedure in individual diseases was given (pages 398–423) and there is no necessity to repeat this matter. The majority of what was said holds good for excretion urography, but in some fields descending urography enjoys special value or applicability, whilst in others it has special limitations. The following remarks are meant to draw attention to these differences and should be read in conjunction with the corresponding matter in the preceding section. A few observations made under the heading 'Appraisement' (page 449) also bear on the relative value of the two methods, and if re-read should help to complete the picture.

Congenital Malformations.—Maldevelopment of the kidneys and ureters may be diagnosed by intravenous urography. The position, number, and shape of the misformed organs become manifest from this examination, always granted that the kidneys are functioning. Malformations are diagnosable by ascending pyelography in most instances, and if so with greater precision than by descending pyelography, yet there are not a few cases in which a ureter cannot be catheterized owing to disease or misplacement, and then the intravenous method is invaluable (*see also* Chapter XXII).

In *ectopia vesicæ* I have employed descending urography to determine the contour of the renal pelvis and the function of the kidney, both before and also after operation. When the ureter has been implanted into the intestine for ectopia (as also for vesical growths, etc.) cystoscopic pyelography becomes impossible, and descending pyelography is the only available resort and is a useful means for renal function testing and for finding out whether the organs have suffered dilatation as a result of the implantation. It is most satisfactory to have this information. Prior to the introduction of intravenous urography we relied on an impression of the patient's general health together with a nitrogen-retention test to form some estimate of the renal condition, but it nevertheless remained mostly a matter of surmise. Concrete radiological evidence of the anatomical and physiological effect that implantation has had on the kidney is most acceptable to the surgeon.

Stone in the Kidney.—Excretion pyelography in renal lithiasis provides valuable information which concerns : (1) The relationship of suspected shadows to the kidney ; (2) The presence and degree of dilatation ; (3) The function of the affected kidney ; (4) The condition of the second kidney.

1. The relationship of suspected shadows to the kidney is judged in the way described for instrumental pyelography on page 418. The weakness of the excretion shadow is sometimes advantageous in that it allows the stronger image of the calculus to be recognized in its midst where the greater intensity of an instrumental pyelogram would have completely eclipsed it. For the same reason the late plates, in which the radio-opaque fluid is clearing away from the pelvis, may prove to be the most instructive. On the other hand, an incompletely filled pelvis has on occasion shown up distinct from a pelvic stone and misled one into thinking that the stone was not in the pelvis.

When a stone is impacted at the uretero-pelvic outlet it may be impossible to obtain a distension pyelogram because neither catheter nor reagent will pass the obstruction. An excretion pyelogram overcomes this difficulty because the opaque fluid is secreted on the opposite (renal) side of the stone. The same fact obtains when a calculus blocks a calix, the localized hydronephrosis which is cut off by the stone cannot be displayed by ascending pyelography but becomes evident by descending pyelography.

A large dendritic stone filling the whole pelvis and the calices may give a skiagram that is almost indistinguishable from a pyelogram, and it is curiously easy to be misled into thinking that one is examining a pyelogram (*Fig.* 293). Also when looking at a urogram it is possible to attribute the whole shadow to the radio-opaque solution, and I have known the presence of a stone overlooked in this way. Routine radiography before urography would have prevented this mistake.

2. Pyelectasis has been dealt with in part above. It usually results from the blockage of the whole or a part of the pelvis by the

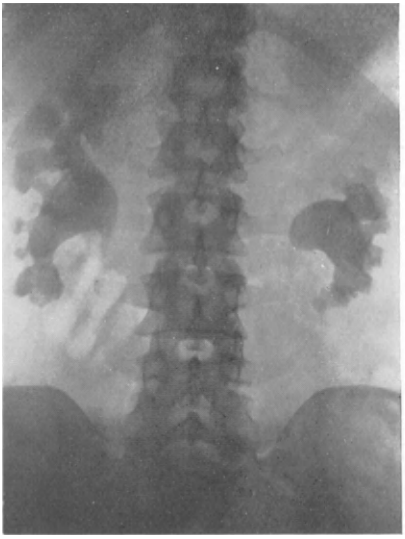

Fig. 293.—Bilateral dendritic renal calculi imitating a pyelogram.

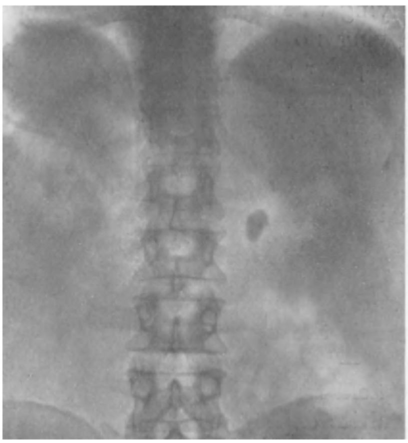

Fig. 294.

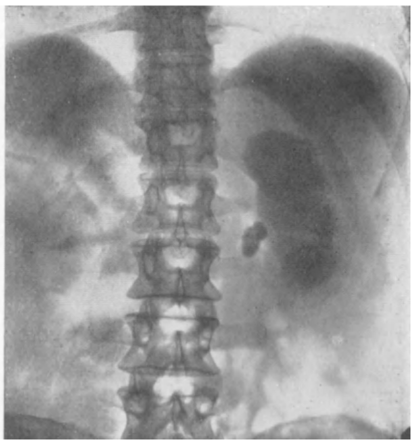

Fig. 295.

Figs. 294, 295.—Stone blocking left uretero-pelvic outlet. Exposed at 6 minutes and 30 minutes respectively. The figures illustrate the accumulation of contrast solution behind the stone, its increase in density with the passage of time, and show how a dilated and injured kidney may, when obstructed, provide a dense shadow, much denser than that of the healthy but freely draining neighbour (*see* right kidney of *Fig.* 294).

stone. Where infection is present pyelectasis may be of the inflammatory type. Not rarely it is to be seen in the absence of both these causes and is then presumably a manifestation of pelvic atony.

3. The function of the affected kidney may be judged by the manner in which it excretes the dye. Stagnation, however, is very liable to flatter its capacity by accumulating the dye (*Figs.* 294, 295). It is quite common to find the image of an obstructed kidney more dense than that of its completely healthy neighbour. The period of onset should be noted and will provide a better representation of the kidney's true capacity. Nevertheless good shadows, even though produced with the aid of obstruction, promise some recovery in the capacity of the kidney after removal of the stone, and clinical experience bears out this expectation.

4. The presence, health, and function of the other kidney may be demonstrated. Braasch points out the frequency with which excretion pyelography has discovered pyelectasis in this second organ, a fact not previously known and one which suggests that the condition on each side is the remainder of a foregoing pyelonephritis, and perhaps that the stone is a secondary phenomenon arising from infection and stagnation.

Polycystic Disease of the Kidney and Renal Tumours.—Excretion urography is particularly unsatisfactory for either of these diseases. The plates leave uncertainty in the mind of the investigator because small sequestered shadows appear, lying where the renal parenchyma might have been expected and having no certain signification. A pelvis which has been displaced by a polar growth may, on occasion, be usefully outlined and correctly interpreted, and sometimes, though rarely, the outline of the tumour itself is permeated with the drug and can be recognized as a rounded, mottled area ; but for the most part, excretion pyelography is a failure. In many cases, indeed, the renal substance has been so extensively destroyed that there is no output of the dye. But, as will be recalled, cystoscopy is *de rigueur* in the investigation of symptomless hæmaturia (page 143) in order to trace the origin of the bleeding, and since cystoscopy is being done in any case, an ascending pyelogram is the obvious procedure.

Urological Conditions in Childhood.—Disease of the upper urinary tract in childhood is an important field for the application of these newer methods because of the difficulties experienced in instrumental pyelography. The dose for a child of 7 years is half that given to an adult, and for one of 2, a quarter the full dose. The veins in childhood are fairly obvious and the lumen is easily found with a fine needle. If the child is alarmed, a brief anæsthesia with ethyl chloride is induced (Ogier Ward). Longer anæsthesia is undesirable because the respiratory movements spoil the skiagram.

Should the veins prove difficult to enter, the subcutaneous administration of perabrodil may be used. It can be given into the subcutaneous fat of the pectoral region or axilla, is painless, and produces no ill effects except a localized œdema which disappears within twenty-four hours. It can be given in full concentration, but may with advantage be diluted to a 7·5 per cent (isotonic) solution. After subcutaneous administration the exposures are made at the end of half an hour, three-quarters of an hour, and later if judged necessary. Compression of the lower abdomen should be employed to intensify the urogram as the shadows are faint. They are, however, sufficiently strong in most cases to be serviceable. Exposure to the rays need only be short in children owing to their small size, and this in some measure overcomes the difficulty of persuading a child to stop breathing. Gas in the colon is more troublesome than it is in the adult, especially if the child has been confined to bed. Aperients and enemata only aggravate the trouble, and the best remedy is, where possible, to have the child up and about before the injection (Teall), though the drug itself appears to be chiefly responsible for the production of the flatulence. Speaking generally, the skiagrams are satisfactory and a diagnosis can be reached, but the results may be disappointing and the shadows weak, irregular, and much interfered with by colonic meteorism. The liver appears to excrete more of the reagent in children than in adults, and this, taken with the great activity and rapid emptying of pelvis and ureter in childhood, may be responsible for some indifferent results.

Pregnancy (*Fig.* 296).—It has been known for some time that there is in late pregnancy an almost constant widening of the ureter and pelvis, and frequently some dilatation even in the earlier months. The study of this interesting physiological phenomenon received a fresh impetus by the introduction of excretion urography, a procedure which appears to be without ill effects either to mother or child. The changes are found to be most marked in the second half of pregnancy—that is, from the fifth month onwards—and the dilatation to become more pronounced as pregnancy advances. A hundred women who were beyond the half-way were submitted to excretion urography by Schumacher, and dilatation of both sides was seen in 83. The remaining 17 all showed involvement of one or other side, the right being affected 15 times, the left only twice. In the later stages the changes are more pronounced in primiparæ. When dilatation is really severe the right side is implicated three or four times more frequently than the left, and primiparæ more often than multiparæ. If dilatation is discovered in the first half of gestation, it is less severe and is more likely to be observed in multiparæ. The ureter is affected more than the pelvis, and the pelvis proper more than the calices.

The Ureter.—It is the lumbar section of the ureter which suffers principally, the part below the pelvic brim only rarely sharing in the dilatation. In half the patients past the fifth month the upper ureter has the thickness of a finger, and in many of these it equals the breadth of two thumbs. In a few it runs a direct course, but the tube, in addition to being dilated, is also elongated, and, in order to accommodate its additional length, it becomes tortuous and may be

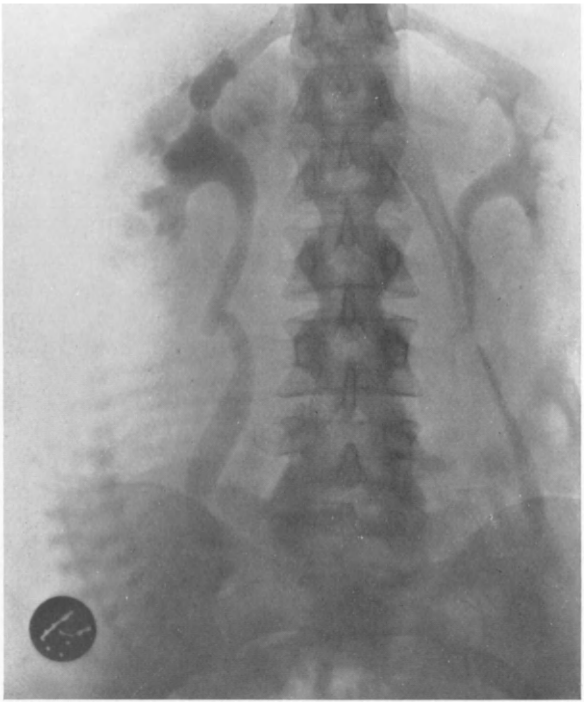

Fig. 296.—Excretion urogram on an eight months pregnant woman. The fœtal skeleton is seen. The right upper urinary tract is moderately dilated. The ureteric shadow reaches a breadth of ½ in. at one point. Owing to increase in length of the tube it becomes twisted and the silhouette has the appearance of being kinked. Early but definite clubbing of calices is observed. The left pelvis is normal, but there is some deviation of the ureter with slight dilatation at the level of the iliac crest on this side.

severely twisted and kinked. Sometimes the radiographic silhouettes of these deformities appear as right angles, acute angles, or even double hair-pin bends; yet they comparatively rarely interfere with the onflow of opaque solutions, and, for this reason, the condition has been regarded rather as a hypotonia than an obstruction by pressure. Pronounced bends and kinks are confined to the top four or five inches of the ureter and are definitely more prevalent on the right side. In late pregnancy, kinks are seen in about four-fifths of all patients examined, and at that time there is also a backward displacement in many. If a series of films relating to this condition is examined, much variety will be found to exist amongst them, and this is true not only as between different ureters, but the same ureter examined at different times may show considerable variations, this last fact being, perhaps, related to the position of the fœtus.

The pelvis shares the dilatation to some degree, but the calices are not usually much involved till the last month or two. The pyelitis of pregnancy does not accentuate the radiographic evidences of dilatation either in the ureter or in the pelvis, but it materially slows down the rate of recovery after parturition, whilst in not a few infected cases the pyelectasis persists.

Involution of the Urinary Tract after Delivery.—This has been studied by Mengert and Lee, who have shown that in twenty-four hours the urinary organs take a surprisingly large step in the direction of normality and that within nine or eleven days of parturition the recovery is complete in healthy women. In primiparæ the recovery is, for the most part, slower than in multiparæ and it is noticeably retarded by pyelitis.

Menstruation.—In normal menstruation the upper urinary tract undergoes temporary dilatation, comparable with that witnessed in pregnancy, but of less degree. It can be displayed by intravenous urography in about 66 per cent of women and is especially pronounced in dysmenorrhœa. Saitz believes that this type of dysmenorrhœa is ureteric in origin and that it can be relieved by ureteric catheterization. He has christened it ' ureteric dysmenorrhœa '.

CHAPTER XXVII.

PYELOSCOPY. CINEMATOGRAPHIC PYELOGRAPHY.

PYELOSCOPY.

Pyeloscopy is the name given to the visualization and examination of the renal pelvis and ureter on a fluoroscopic screen. It aims, through detecting the filling and emptying of the urinary cavities, at an extension of our knowledge of their physiology and pathology. It portrays peristalsis, motility, spasm, and inefficient drainage, and, though much more difficult of accomplishment, it attempts to play the same rôle in renal diagnosis as the screening of the stomach following a barium meal plays in gastric diagnosis. Pyeloscopy was first employed by Menges in 1912 and was described by him in 1918. An important monograph by Legueu, Fey, and Truchot appeared in 1927.

TECHNIQUE.

A ureteric catheter having been introduced, the room is darkened and a considerable time (five to fifteen minutes) is allowed to elapse so that the eye may adapt itself to detecting the minutiæ of the filled pelvis. The patient lies on his face, the X-ray tube being below the couch. Sodium iodide (30 per cent) and iodipin have been used as contrast fluids in the past, but uroselectan-B and perabrodil will probably displace them in the future. As the fluid flows into the pelvis it is seen to fill that structure and then to outline the calices, usually one calix after another undergoing distension. As soon as the cavity is satisfactorily filled, the catheter is withdrawn and the process of emptying begins. A normal renal pelvis ejects about 1 c.c. per minute (Hryntschak). Five minutes or more—even up to fifteen—may be required for its complete evacuation, but these longer times are usually evidences of disease. A normal pelvis empties more rapidly in the upright than in the recumbent position. Evacuation appears to start with the calices, which have been likened to the heart's auricles (Herbst). These do not act synchronously, but individually empty their contents into the main pelvic cavity (ventricle), which in its turn undergoes systole, displacing a portion of its contents downwards into the ureter. Occasionally a portion of the pelvic contents is returned to a calix. The ureteric spindle is at first but an appendix (bulbus ureteris—Legueu) to the pelvic shadow. As the spindle elongates, however, its apex passes down, and when a certain distance (usually about 10 to 15 cm.) has been traversed the connection with the pelvic shadow is broken, the ureteric contents passing on steadily till their apex reaches the bladder, into which the whole is discharged. The speed of the whole wave is about 20 to 30 mm. per second (Engelmann). A period of diastole ensues. It spreads from above downwards, the same order being followed as that which the systolic wave adopted. The pelvis is in full diastole shortly after the ureteric spindle has separated. Diastole exceeds systole in duration. The cycle is repeated at intervals of about ten to thirty seconds (*Fig.* 297).

By inspecting the inflow of iodine one can almost completely exclude the possibility of over-distension of the pelvis. That the

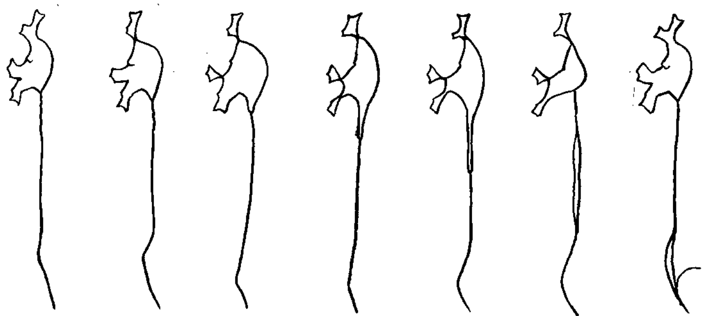

Fig. 297.—Cycle of changes observed in the pelvis and ureter. 1, Pelvis and calices in diastole, ureter empty; 2, Upper calix ocntracted and expelling its contents into pelvis, ureter empty; 3, Upper and middle calices contracted and expelling contents into pelvis, upper ureter relaxing; 4, All calices contracted, expelling contents into pelvis, upper ureter more relaxed; 5, All calices and pelvis contracting, expelling portion of contents into ureter; 6, All calices and pelvis completely contracted (completed systole), ureteral shuttle moving downward in streak-like manner; 7, Diastole of calices and pelvis. Ureteral streak passing into bladder. Pelvis ready to start a fresh cycle. (*Re-drawn from Herbst*).

usual pyelographic routine which accepts the patient's sensations as a guide to the degree of filling often misleads can be shown by pyeloscopy. Thus pain may be elicited in sensitive individuals as soon as the first few drops of fluid enter the pelvis, and the pelvis is then seen to pass into immediate spasm. The spasm is apparently the cause of the pain, but it soon subsides and the injection may then be cautiously continued. Normal pelves react more violently to this irritation than pathological ones, but if over-dilatation occurs in either of these, the pelvic sphincter may go into spasm and retention results, the patient experiencing severe pain. This last observation appears to confute the theory that if a small catheter is used for pyelography over-distension is avoided, for the sphincteric contraction grips the catheter and prevents the pelvis draining itself into the ureter. Again, if the catheter tip lies in a calix, distension may be limited to the calix and the pain is then immediate. Withdrawal of the catheter until its apex occupies the pelvis proper corrects this cause of pain. A similar effect is produced when the catheter end does not reach to the pelvis. In this event it is the ureter which becomes inflated beyond its capacity. The return of the catheter to its correct position is less easy in this case, and the best available method is to lower the patient's head to obtain assistance from gravity and to inject very slowly. Legueu says that pyeloscopy properly carried out causes no pain whatsoever. X-ray films are exposed periodically to make the record of the findings permanent.

ADVANTAGES AND DISADVANTAGES OF PYELOSCOPY.

Pyeloscopy should not be employed to displace pyelography, but merely to supplement it. However, from the preceding description of how the waves of contraction constantly sweep over the renal pelvis and ureter it will be appreciated that the record obtained on a pyelogram is that of a series of states superimposed upon one another and not a picture of any single momentary condition. In general, the information acquired by pyeloscopy runs parallel with that obtained by pyelography, but in addition several vital or dynamic phenomena are witnessed. In inflammatory states of the renal pelvis the wave of contraction is more sluggish than in the healthy condition and is provocative of less pain. When the contraction does take place, however, it is usually quite strong. Pyeloscopy may be expected to solve some problems in inefficient renal drainage, especially those relating to faulty dynamics of the upper urinary apparatus. Legueu claims that it is possible to exhibit hyperactivity or stagnation, retention, and spasm, and in many cases to locate the exact site of the fault or obstruction. Spasm of the pelvic sphincter can be witnessed when the patient experiences colic, and the two are conterminous. It is particularly helpful in inflammatory states, early hydronephrosis, and movable kidney. In small hydronephroses contraction is sluggish and evacuation takes twenty to thirty-five minutes. In large hydronephroses the pocket is motionless, there is no contraction and no undulation of its margins. An affected kidney may have outlines which are normal, but the motility of its walls be severely reduced or absent.

The formation of the ureteric spindle has been described. It must be carefully examined and the progress of the shuttle-shaped streak along the ureteral canal will prove interesting because it can reveal important variations in the ureteral mechanism. Its progress may be checked, and several questions immediately arise. Is the obstruction always at the same place ? Is it complete or partial ? Can a stone be seen ? Watch the shuttle attentively as it approaches the obstacle to its progress. The apex impinges on it and is held up. The oncoming wave drives the rest of the spindle forward and the ureter above it is momentarily ballooned. The opaque fluid recoils from the face of the obstruction and may be thrown back in its entirety to the pelvis or proximal ureter ; or if the blockage is only partial, the slow seepage of fluid alongside, together with the disappearance of the overlying accumulation, will be remarked. A second wave may arrive before the first is cleared, but in such cases the whole of the tube system above the block is distended ; there is no isolated spindle ; only the undulatory movement caused by the peristaltic wave is seen. Over-filled or constantly filled ureters are always a sign of faulty renal drainage, whether the cause be neuromuscular, inflammatory, or obstructive. As a rough generalization it may be laid down that the neuromuscular variety is variable in position, the inflamed ureter is lazy and infrequent in its contractions and more or less uniformly filled over fairly long reaches, whilst an organic obstruction is constant in position and the hypertrophied ureter above it contracts vigorously and often.

Jona and Flecker have made a pyeloscopic study of the action of various drugs on the renal pelvis. They have demonstrated that atropine relaxes the musculature and leads to painful retention, whilst strychnine, morphine, eserine, and pituitrin produce contractions and relieve the pain caused by atropine. Histamine was shown to cause relaxation with vasodilatation and a fall of blood-pressure ; ergot a relaxation followed by a prolonged contraction.

Instructive as pyeloscopy has proved itself, it suffers from several important disadvantages :—

1. The presence of a foreign body in the ureter which is known to excite efforts at expulsion.

2. The unnatural filling of the cavities with a more or less irritating fluid. Overfilling may occur and lead to artificial pictures.

3. The difficulty of satisfactorily visualizing fluoroscopically such fine cavities as the renal pelvis and ureter.

4. The impossibility of mentally registering impressions of conditions which are constantly and quickly changing and which are in any case highly complex.

5. The failure to obtain a permanent graphic record of the cycle of change which each calix undergoes.

CINEMATOGRAPHIC PYELOGRAPHY.

Jarré has taken a further step forward in producing serial roentgenographic films with modified cinematography. An average series consists of twenty individual pyelograms with an exposure time of from a half to one and a half seconds, and intervals of a half to three-quarters of a second. Usually it is found possible to take five or six successive pyelograms without interruption for breathing. Excretion pyelography was used almost entirely and the images are thus freed from the artificial conditions produced by the presence of a catheter or the introduction of media from below. The physiological integrity of the tract is therefore preserved with striking accuracy.

Only two minor criticisms can be levelled against this method : (1) The fact that all intravenous media cause a high diuresis ; (2) The comparative weakness of the images. The former is probably not very important, as it merely leads to acceleration of the cycle. Partly to overcome the second difficulty, but also to produce a connected record, the films are " carefully traced under a reducing lens with a sharply pointed pencil and photographed ". Much experimental work has been done on the peristalsis and dynamics of the ureter, but little on that of the pelvis. The presence of muscular tissue in the calices, at the fornix calicis, and even on the papillæ has been known ever since Henle's classical paper. This muscular provision postulates contractility in these structures, but hitherto no such contractility had been demonstrated. Jarré's figures show the periodical filling and the apparently motor evacuation of the individual calices, and he has been able to show modification (hyperactivity or sluggishness, according to the circumstances) in inflammatory or other diseased states.

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