CYSTOSCOPY

A THEORETICAL AND PRACTICAL HANDBOOK
CONTAINING CHAPTERS ON SEPARATE
RENAL FUNCTION AND
PYELOGRAPHY

BY

JAS. B. MACALPINE, F.R.C.S. (Eng.),

Honorary Surgeon and Surgeon in Charge of the Genito-urinary Department,
Salford Royal Hospital, Manchester

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PREFACE

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.

ILLUSTRATIONS

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.

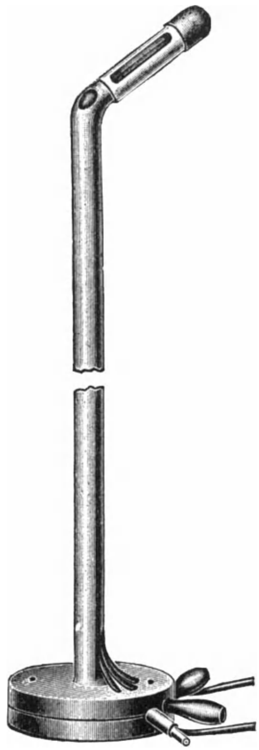

Fig. 2.—Nitze's first cystoscope. Optical system terminal. Platinum filament lamp. Note water-cooling system. (*Redrawn from the original.*)

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. 3a*, 4); (II) *A Telescope containing the optical system* (*Fig. 3b*).

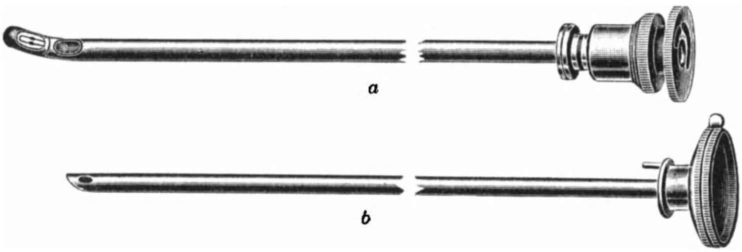

Fig. 3.—Examination cystoscope, irrigating pattern. *a*, Catheter or sheath with lighting apparatus; *b*, Telescope.

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

The sheath (*Fig. 3a*) 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

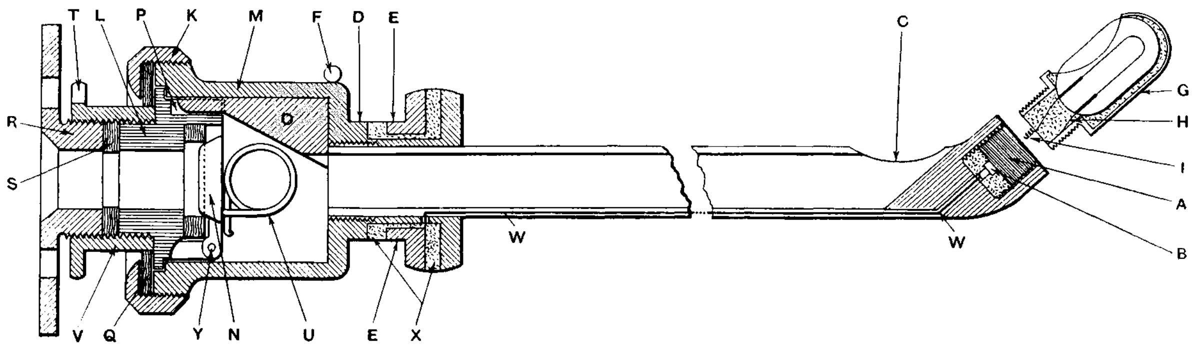

Fig. 4.—LONGITUDINAL SECTION OF EXAMINATION CYSTOSCOPE (SHEATH). A, Female portion of screw for lamp; B, Insulated electric terminal; C, Fenestra; D, Metal ring for reception of coupler, and in contact with valve chamber; E, Other ring insulated from sheath by ebonite seating (X), but connected to B 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 bakerlite 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.

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 bakerlite (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. 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.

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 further of the two rings. 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.

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 furthest 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.

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 (S) 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 27).

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.

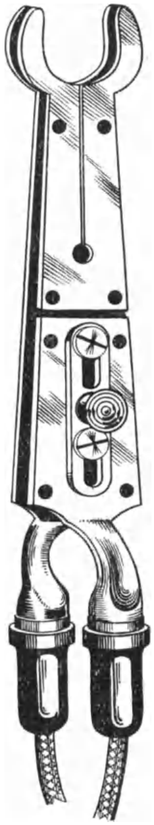

Fig. 6.—The switch.

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

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.

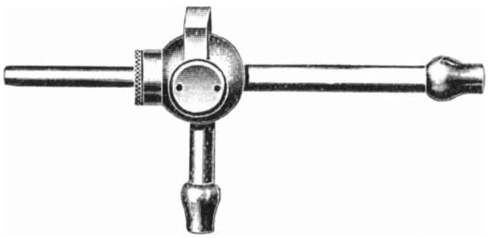

Fig. 8.—Two-way irrigating tap.

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.

Fig. 9.—The telescope.

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 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,

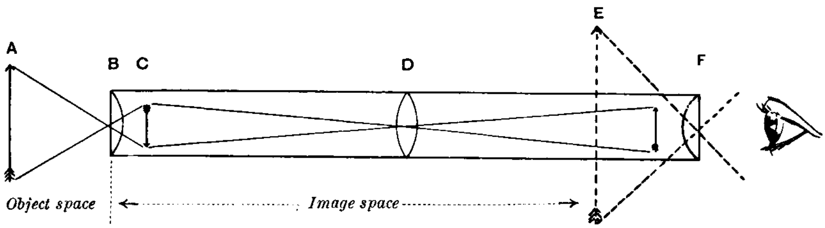

Fig. 10.—The lens system of Nitze's cystoscope. A, Object; B, Objective; C, Real inverted diminished image; D, Central, inverting or transporting lens; E, Upright magnified virtual image; F, Ocular.

there being no reflecting device, and the inlet of the system being 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.

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* 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.

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

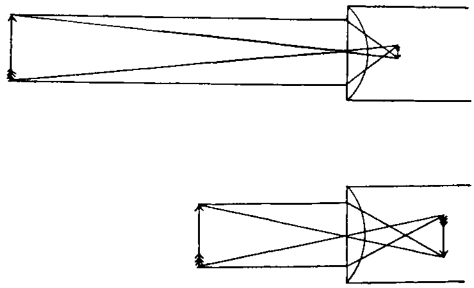


Fig. 11.—Diagrams showing effect of distance on the size of the resultant image.

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.

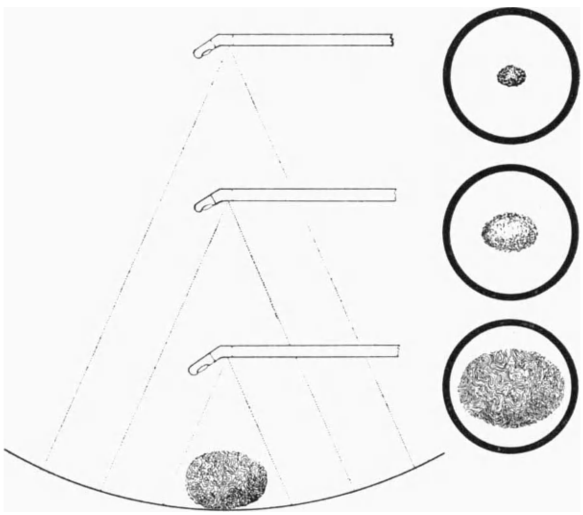


Fig. 12.—Examination of vesical calculus from three different altitudes, showing the effect of distance on magnification.

* 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.

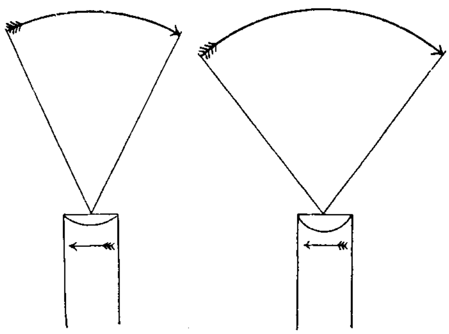


Fig. 13.—*a*, Objective with small angle; therefore small field of view, good magnification and illumination. *b*, Wider-angled objective; large external field, loss of magnification and illumination.

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

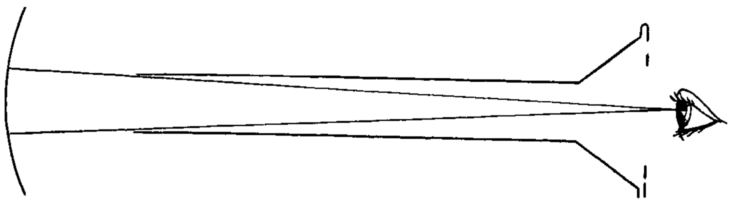


Fig. 14.—Inspection through Kelly's tube. The field of view corresponds in size to that of the lumen of the tube.

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 ¼ 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 ⅛ 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.

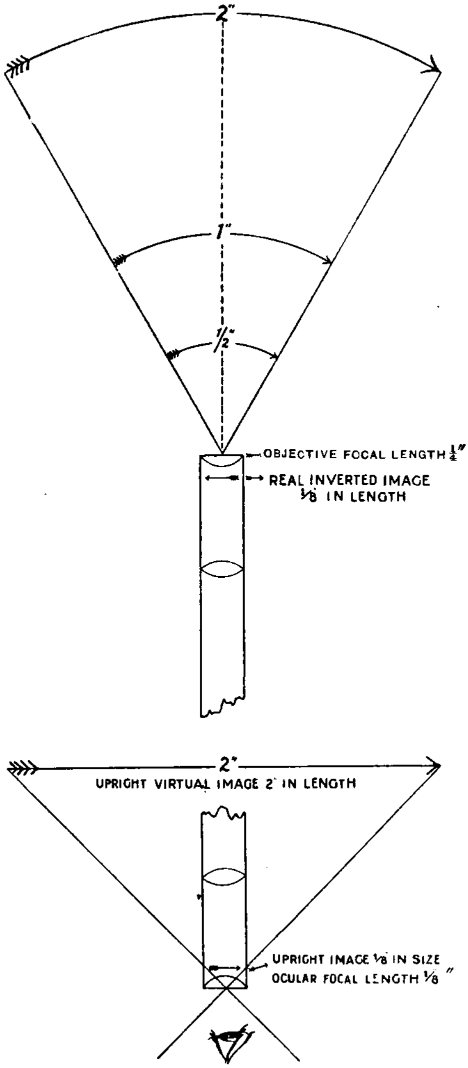


Fig. 15.—Diagram illustrating the properties of the telescope.

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 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. 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).

This last fact 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.* 59).

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 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).

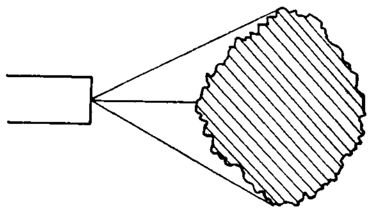


Fig. 16.—Diagram to indicate that the portions of a convex object closest to the prism are more highly magnified than those which are more remote.

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

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

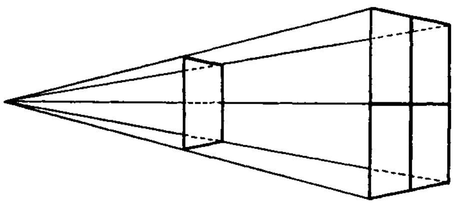
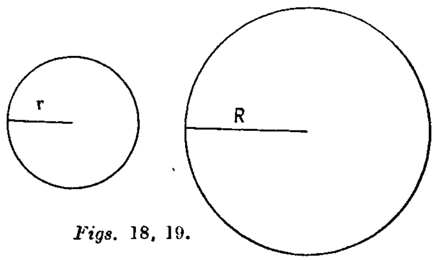


Fig. 17.—Illustrating loss of light by distance of lamp from object.



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

* 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

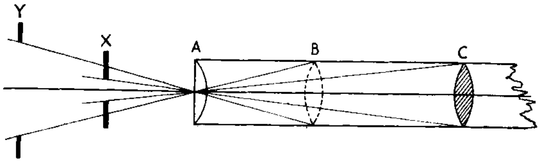


Fig. 20.—Diagram illustrating the respective size of the entrance pupil in the new and the old lens systems.

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

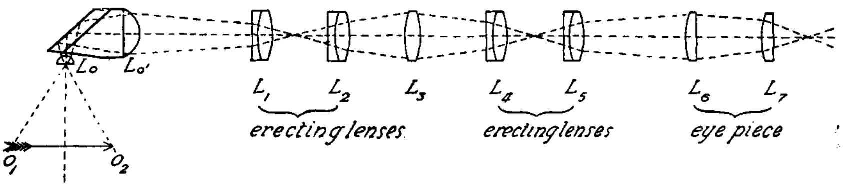


Fig. 21.—Lens system used in instrument made by the Genito-Urinary Manufacturing Co., London. O_1 O_2, The object; L_0 L_0', Two parts of objective separated by a roof prism; L_1, L_2, L_3, L_4, L_5, Transporting system; L_6, L_7, Eye-piece.

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* 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.

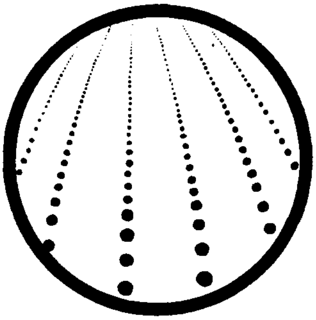
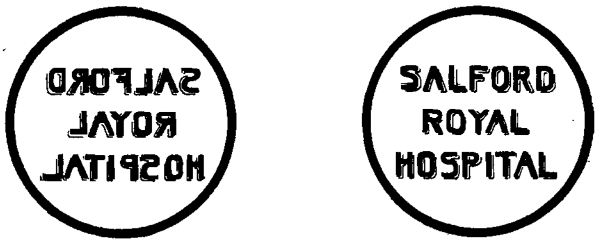


Fig. 22.—Lines of parallel dots on a printed card seen through the cystoscope, showing the effects of foreshortening and distortion.

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.

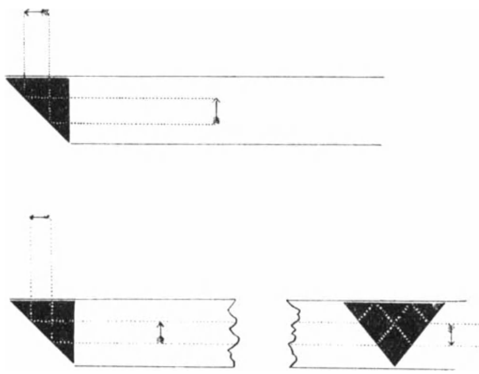


Fig. 25.—Correction of image by insertion of an extra prism.

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.

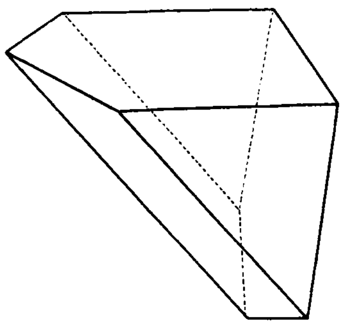


Fig. 26.—Amici's 'roof' prism.

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 aberration.

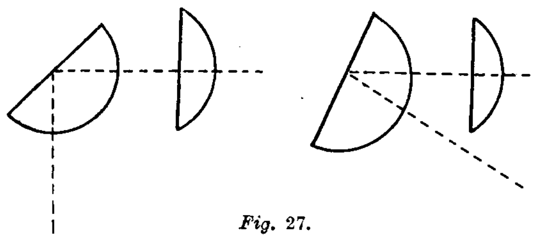


Fig. 27.

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.* 5 C) 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

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* 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.

† All parts of Swift Joly's cystoscope withstand boiling except the telescope. This constitutes a notable advance.

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.

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

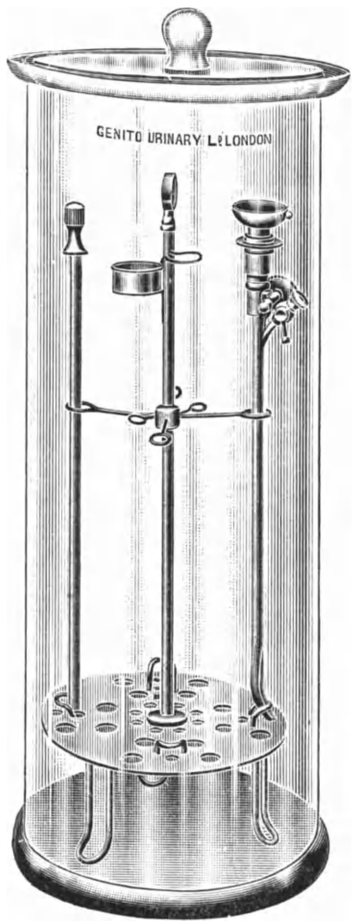


Fig. 29.—Jar for sterilization of cystoscopes.

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 and which are liable to 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.

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 con-

veniently 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.

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.

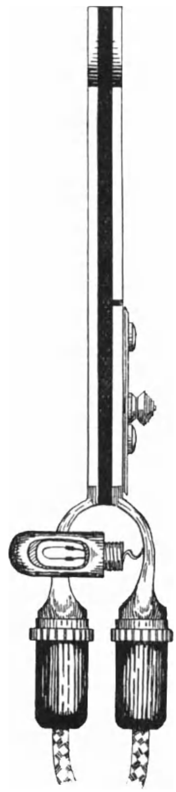


Fig. 30. Method of testing the lamp.

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. This is often due to carelessness in grasping the wires instead of the terminals when withdrawing them from the cystoscope or the battery, as the case may be. 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 the seating of one of these screws became disturbed or perished, with the result that a short-circuit was produced. In modern instruments ebonite or bakerlite pegs have replaced the metal screw, and this cause of trouble has therefore disappeared, at least so far as recently made instruments are concerned.

2. **The Valve.**—Examine the valve before inserting it into the valve chamber, for it is often found to be out of order through some trifling portion of grit or other foreign substance holding open the clappet. The hinges may become stiff so that the spring is incapable of closing the valve, whilst the soldering of one or other of the wires not uncommonly gives way.

When the valve is faulty, fluids escape from the bladder until the telescope is inserted. A finger may be placed over the outlet to counteract this. Some surgeons consider that the frequency with which the valve goes out of order renders its use inexpedient and have discontinued to employ one, closing the outlet with a finger. The 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.

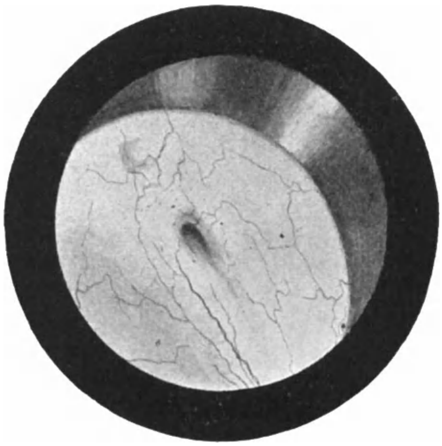


Fig. 31.—Ellipse of field of view cut off owing to bend in the telescope.

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.

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.

ADJUSTING THE CURRENT.

It frequently happens that beginners increase their current too rapidly when adjusting the lighting of the lamp, and overshoot its capacity through not appreciating its delicacy, with the result that they soon run through their store of lamps. The correct method is to attach the cystoscope to its source of electric energy, noting before doing so that the current is shut off, throw in the full resistance of the shunt, and then switch on and gradually increase the current until the lamp commences to glow. Once the lamp has lit, the progress of the slide should be slow, and it is even well to impart to it a lateral motion in order to avoid jerky movements. Jerkiness is liable to occur if the shunt does not work smoothly, but can be avoided if the surface is kept clean and is occasionally rubbed over with a little lubricant.

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. The improvement in visibility is sufficient justification for this extravagance. Having settled the degree of brightness which it is expedient to use, the slide of the rheostat is left at this position in readiness for the cystoscopic examination, and the cystoscope is 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 six 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*.

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.

Fig. 32.—Dry-cell battery.

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

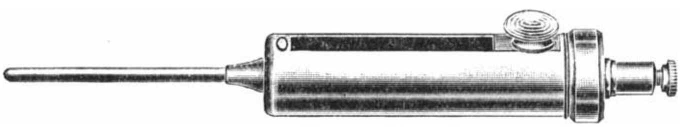


Fig. 33.—Sliding rheostat for direct connection to the terminals of dry cell.

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.

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 32 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 44). It

SCHEMA FOR THE EXAMINATION OF A UROLOGICAL PATIENT.

First Visit to Out-patients' Department.	*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
Second Visit to O.P.	*X-ray Examination*
Third Visit to O.P.	*Cystoscope*— Exploratory Bacteriology of catheter specimen of urine
Wards	*Cystoscope*— Catheterizing :—Histological examination, Functional examination } Separated urines Pyelogram Treatment *Function*— Total renal function Separate ,, ,, —ureteric catheter and separation of urines

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 certain limited number of cystoscopies should be arranged for. 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.

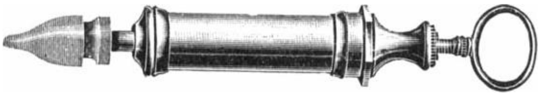


Fig. 34.—Everidge's urethral syringe.

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 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) and stovain

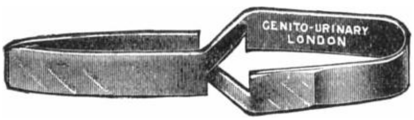


Fig. 35.—Thomson-Walker's penile clamp.

(4 per cent) can be recommended. 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 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.* 38).

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 they remark that "The paucity of afferent nerve-fibres is the reason for the high threshold of 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-distention or prolonged distention 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 2½ 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. 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. It is gently guided along this channel for a distance of about 1½ to 2½ in. Occasionally it is impeded by irregularities in the bony boundaries, from which, however, it is easily freed by a little manipulation, 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. The solution is now introduced. 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 not be painful.

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 40 c.c. of distilled and sterile water.

Much emphasis is laid by many writers on a sufficiency of fluid. 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. The solution is cooled, and to it may then be added, if thought desirable, two or three 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 is superior to that provided by local injection. A temporary return to this latter, to review the relative merits of the two methods, confirmed the view that sacral anæsthesia is the better. The pain arising from distortion of the prostatic area, which is unrelieved by local medication, causes but little discomfort to the patient, and there is little or no straining or reflex micturition. The 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 anæsthesia for the treatment of vesical tumours (*see* Chapter X, page 146). 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-distention.

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.

Fig. 36.—Cystoscopic chair.

Fig. 37.—Patient in position for operation.

[*To face page* 41

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.

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

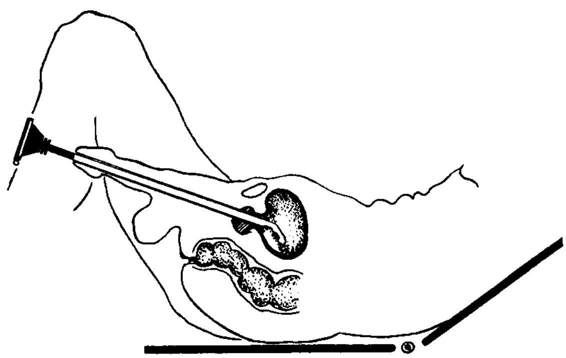


Fig. 38.—Correct position of patient on the cystoscopic chair.

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.* 47) 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.* 36), conditions are favourable for an easy examination. The patient is put on the chair with the buttocks reaching to the edge of the seat, and the back of the chair is slightly raised. The knees are supported on the rests, and the feet occupy the stirrups* (*Fig.* 37). The thighs should make an angle of about 45° with the trunk (*Fig.* 38), 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

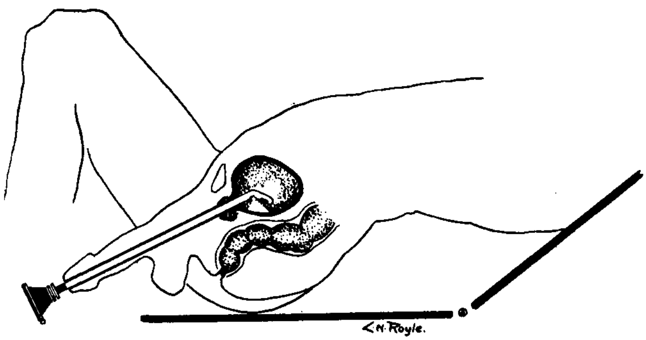


Fig. 39.—Shows arching of the lumbar spine and the depression of the ocular necessitated thereby.

involuntarily arches his lumbar spine (*Fig.* 39). The pelvis is thrown forwards, and, in order to maintain the correct relationship of the cystoscope to the bladder, the surgeon is compelled to depress the

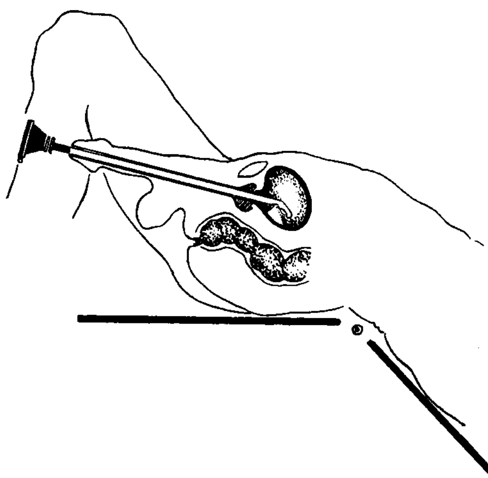


Fig 40.—The back of the chair lowered to correct extension shown in *Fig.* 39.

ocular end inconveniently. Even when advised of the desirability of 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.* 40).

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.* 41). 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* page 57). 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.

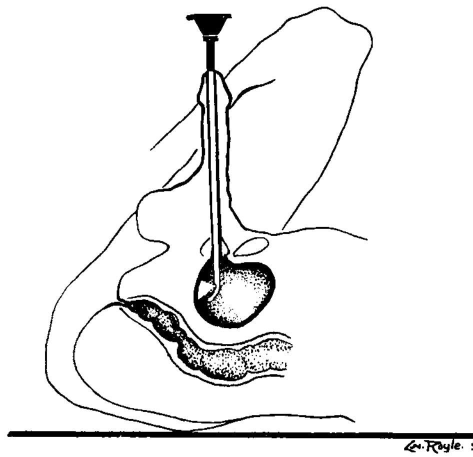


Fig. 41.—Incorrect position, with thighs flexed strongly on the abdomen.

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 convenient. 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 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.* 42) is made

Fig. 42.—Metal bladder syringe with tapered nozzle to fit faucet. It is graduated on the piston shaft.

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. 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 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 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 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-distention 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 distention 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 distention 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 distention 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-distention. 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 distention 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 distention, 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-distention 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.

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.

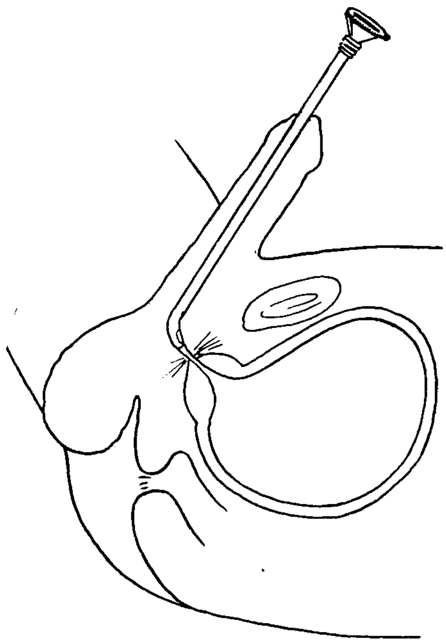


Fig. 43.—Introduction of the cystoscope: beak ready to pass into the membranous urethra.

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.* 43) 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

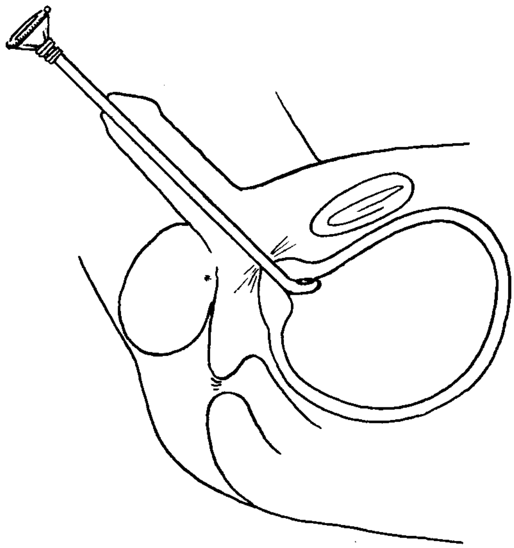
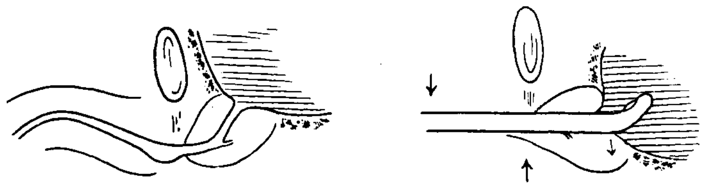


Fig. 44.—Introduction of the cystoscope: ocular end depressed between the thighs of the patient; the beak entering bladder.

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.

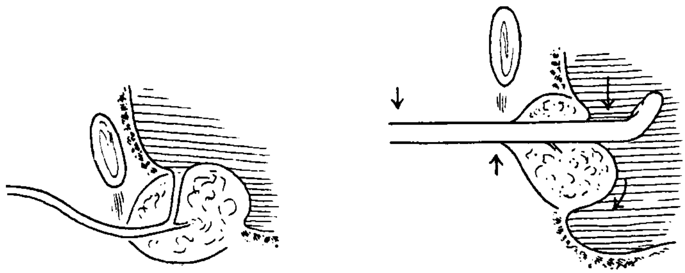
During the next stage (*Fig.* 44) the ocular is brought down by a circular sweeping motion until it comes to lie between the thighs of the patient. As it does so the beak slips through the pursed-up aperture in the compressor urethræ and passes along the prostatic urethra into the bladder. As the beak 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.* 45 *a* and *b*). The gland



a *b*

Fig. 45.—*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.

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



a *b*

Fig. 46.—*a*, Male urethra in prostatic hypertrophy. Note increase in the curve of the prostatic urethra as compared with the normal (*Fig.* 45*a*). *b*, The same after introduction of cystoscope. Marked retroversion of prostate causing exaggeration of the retroprostatic pouch.

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 cystoscope is introduced in prostatic hypertrophy there will be a very considerable amount of retroversion of the prostatic gland (*Fig.* 46 *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 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-distention.

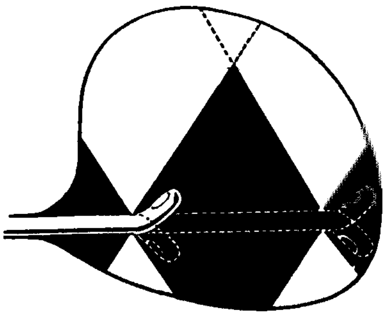


Fig. 47.—Cystoscope in the primary position. Note the distances from base and vault respectively. The movements of introduction and withdrawal are also shown.

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.

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.* 47 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 ½ 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.* 47).—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.* 48).—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 :—

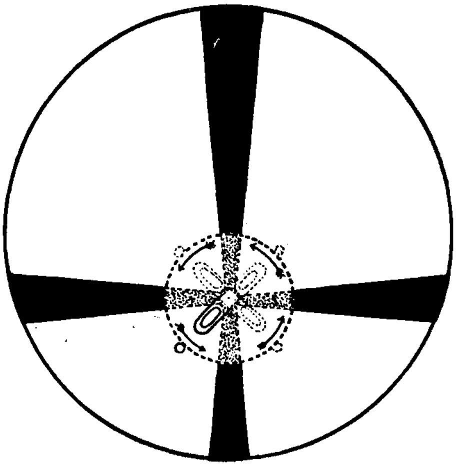


Fig. 48.—Movements of rotation of the cystoscope on its long axis. The shaft of the instrument occupies the primary position and is therefore excentrally placed as regards the bladder.

3. **Pendulum or See-saw Movements** (*Fig.* 49).—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 intravesical to the extravesical portions of the instrument. The distance from the ocular to the objective is usually about 12 in.; if therefore the shaft could 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 ½ in. may lie within the viscus. It is obvious that if a given excursion—say, ½ 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.

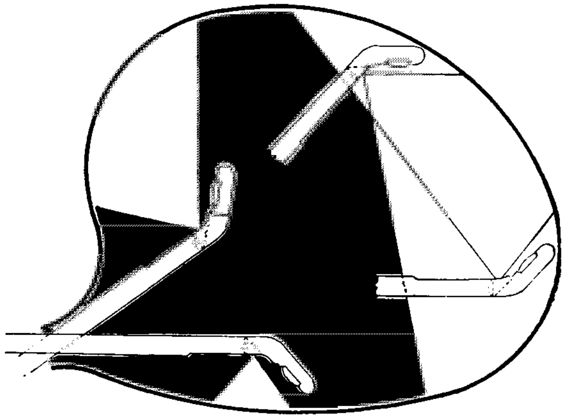


Fig. 49.—Showing rocking movements of the cystoscope, and also methods of examining the fundus of the bladder.

The advantages which accrue from rocking movements are the result of the greater approximation of: (*a*) The light, whereby the

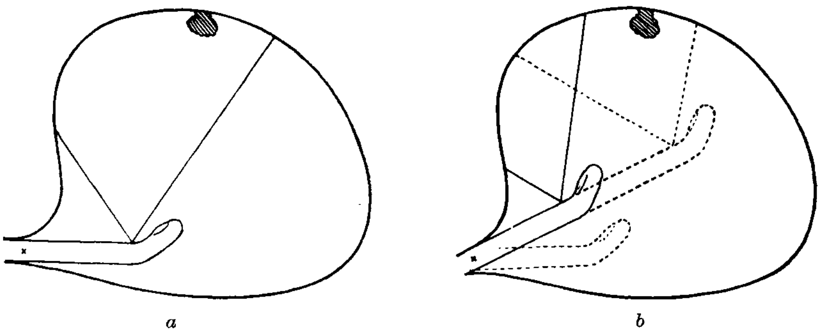


Fig. 50.—*a*, An object seen in the distance through the cystoscope; *b*, Rocking movements of the cystoscope throw it out of the field of view. To recover it the instrument must be pushed further into the bladder.

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.* 50 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 further 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

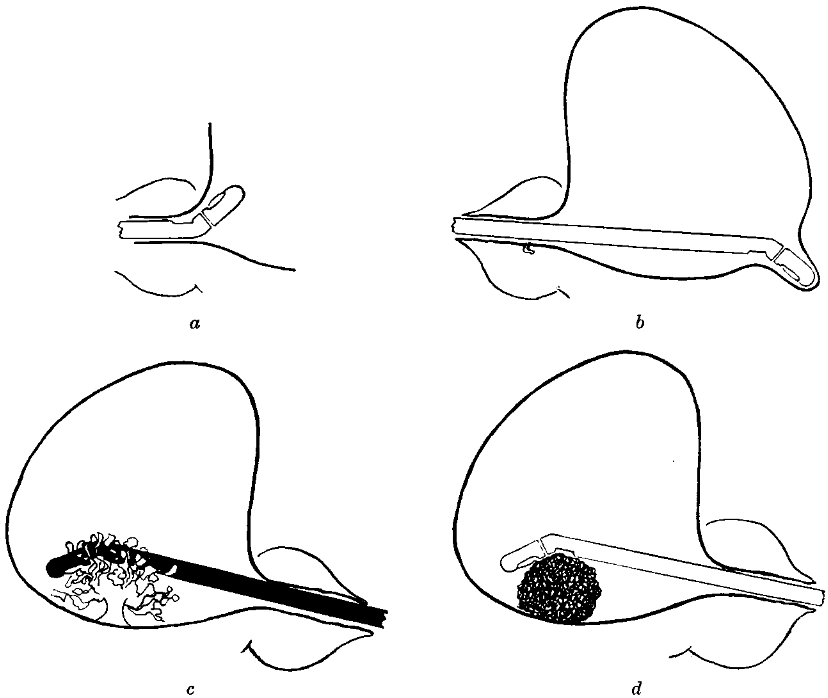


Fig. 51.—Four reasons for seeing nothing in the bladder: *a*, Window still in the urethra; *b*, Beak of cystoscope sunk in posterior wall of bladder; *c*, Beak of cystoscope embedded in neoplasm; *d*, Prism and lamp in close contact with a stone. Fields of illumination and of view do not correspond.

should not be hastily withdrawn from the bladder to make sure that the lamp is still burning.

Fig. 51 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.* 51*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.* 51*b*). In the same way it may be embedded in a neoplasm (*Fig.* 51*c*) or be in too close contact with a stone (*Fig.* 51*d*). Sometimes the vesical cavity is misshapen, usually as the result of extrinsic causes. Prominent amongst these may be mentioned the mechanical results of change in the shape or position of the uterus (Chapter XVI). 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.

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.* 52). 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.

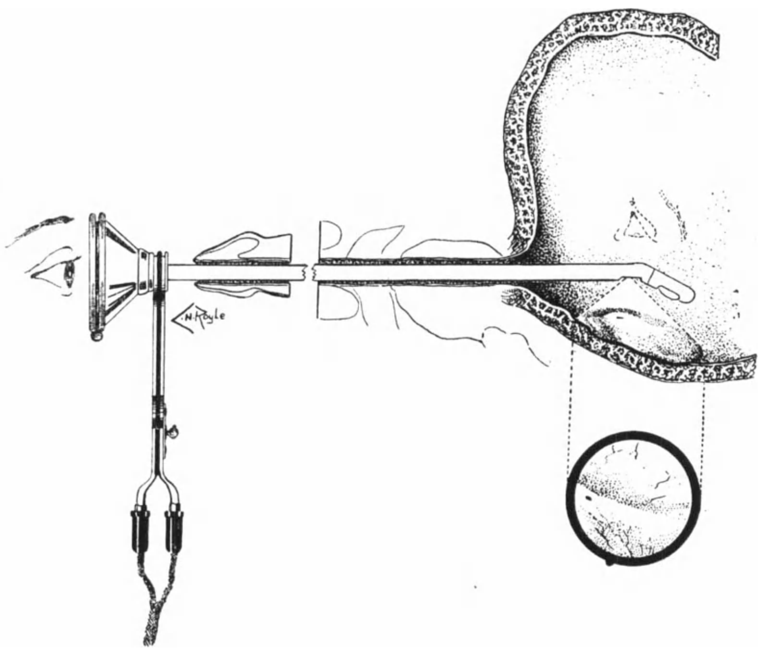


Fig. 52.—Scheme of examination of the interureteric bar. N.B.—The switch should face towards and not away from the operator, as erroneously shown here.

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 ¾ 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.* 53). When this is done a translucent line will be seen to pass across the field of vision (*Plate I* C). 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.* 54), 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 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 X* A and B, page 176). Occasionally also some inflammatory process involves the sphincter of the bladder

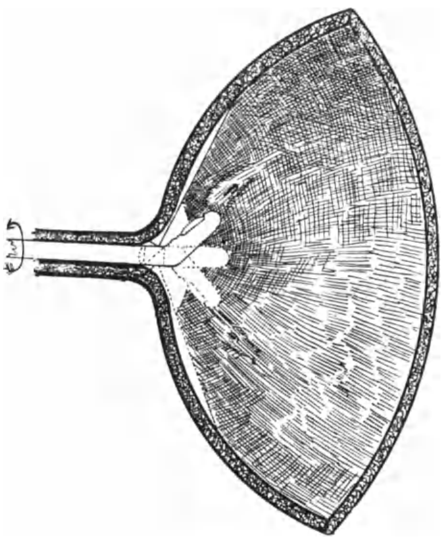


Fig. 53.—Method of inspecting the bladder neck. Note that the vesical orifice and portions of the bladder mucosa in the region of the neck are contained in the same cystoscopic field, and that they vary considerably in the distance to which they are removed from the fenestra and therefore in the quality of their illumination and magnification.

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.* 55). Those which lie in the transverse body plane—that is, which bulge towards the urethra—cannot be

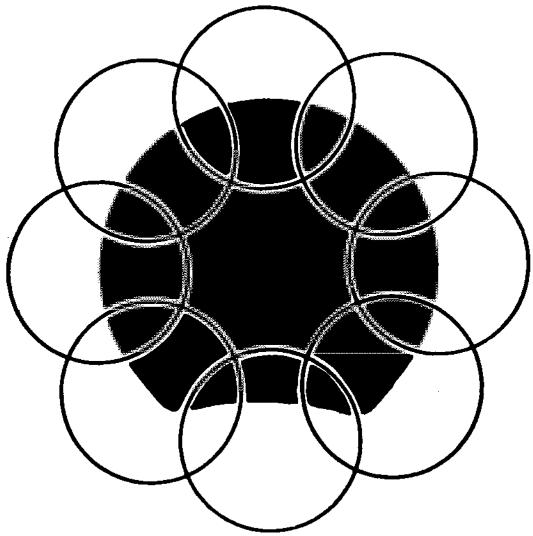


Fig. 54.—Series of cystoscopic fields collectively showing the contour of the internal meatus as the instrument is rotated on its long axis. The orifice is circular save at the lowest point, where it is flattened or slightly convex.

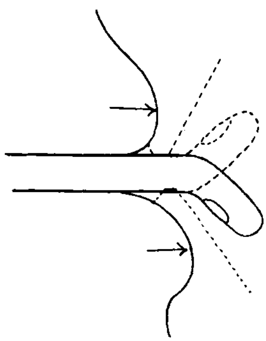


Fig. 55.—Cystoscope examining prostatic hypertrophy appreciates increase of the gland occurring in the sagittal body plane.

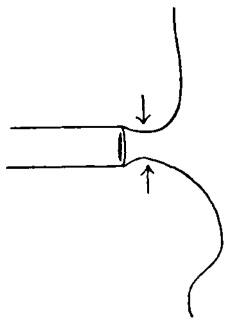


Fig. 56. — Urethroscope examining prostatic hypertrophy appreciates increase of the gland occurring in the transverse body plane (cf. *Fig.* 105, page 179.)

perceived by this instrument, as their only effect is one of magnification. They require a posterior urethroscope for their demonstration (*Fig.* 56).

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 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.*** 49). 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.*** 49.

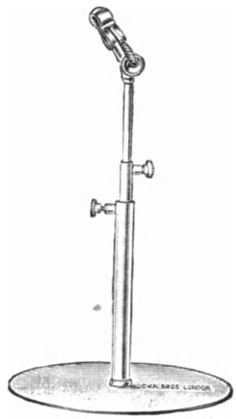


Fig. 57.—Canny Ryall's cystoscope holder. Useful for steadying the instrument when intravesical conditions are being demonstrated or are under prolonged inspection, as when being drawn.

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. Canny Ryall's cystoscope holder (***Fig.*** 57) 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 XIX).

Variations in the Shape of the Bladder due to Different Degrees of Distention.—The shape of the bladder is governed by its distention (***Fig.*** 58). 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.* 58. 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

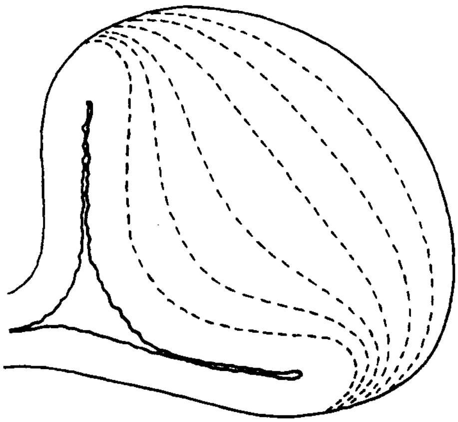


Fig. 58.—Shape of the bladder as altered by various degrees of distention. (*Modified from Poirier and Charpy.*)

fundus and at the junction of the anterior and superior walls of the viscus. Eventually transverse sulci form in these situations. The 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.* 58 is compared with *Fig.* 76, 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 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 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

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.

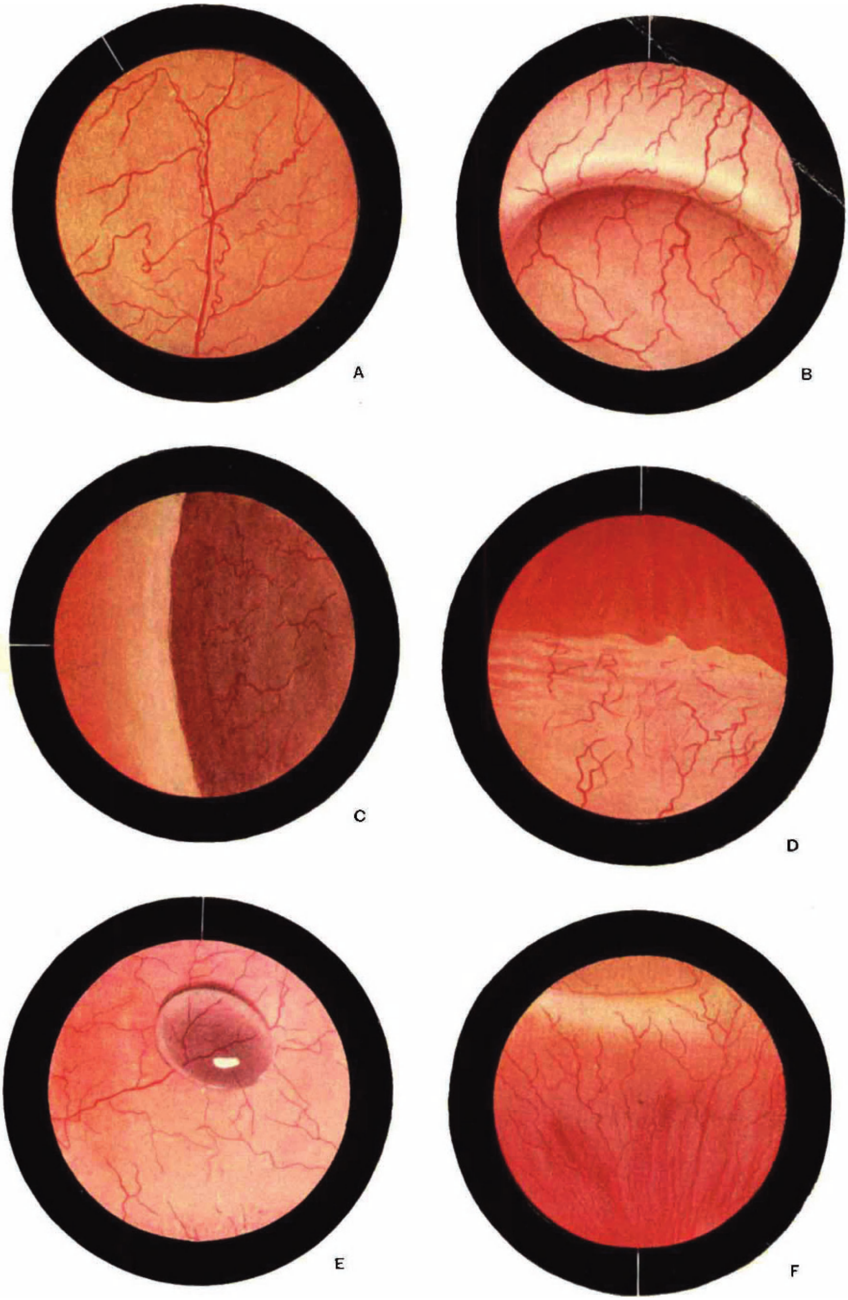
is straining to urinate, they become more numerous and more evident. They may also be seen when a bladder is under-distended, particularly in the female. A distinction must be made between this normal trabeculation and that of vesical hypertrophy as seen in cases of stricture, prostatic hypertrophy, 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

PLATE I.

THE NORMAL BLADDER



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

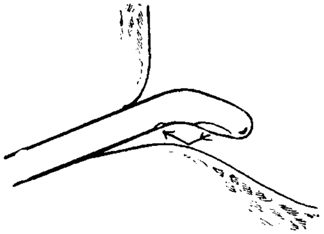


Fig. 59.—Examination of the most anterior area of the trigone. Note approximation of fenestra to object, which produces a high degree of magnification ; also the oblique way in which the light is reflected from the membrane to the prism, often resulting in a sheeny appearance. Cystoscope tilted to obtain 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.* 60.

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 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.

VIEW OF OPEN BLADDER

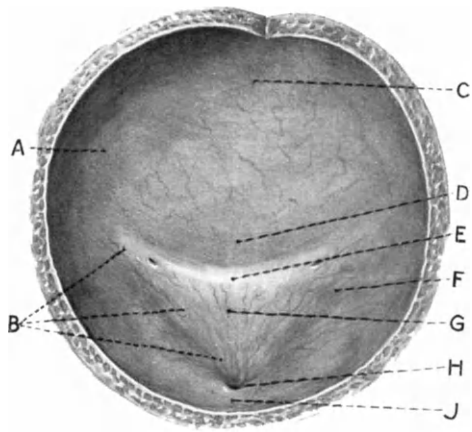


Fig. 60.—Interior of bladder. A, Lateral wall ; B, Ureteric bar ; C, Fundus ; D, Retrotrigonal recess or bas fond ; E, Interureteric bar ; F, Lateral recess ; G, Trigone ; H, Internal meatus ; J, Anterior wall.

To face page 66]

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 :—

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.

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 *distance between the two ureters* is 1½ 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 2½ 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 2½ 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 ulcera-

PLATE II.

THE NORMAL URETER

tion, 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 240), and on reaching the bladder can be recognized as a blue jet (*see Plate XII* D, page 232). 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 59.

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 64) 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. LEUCOPLAKIA.

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 87). 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 47. 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 47).

1. Good anæsthesia is essential (*see* page 34).
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 229) or in the prostate and urethra (an ascending infection, *see* page 183). 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.

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 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 63).

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

PLATE III.

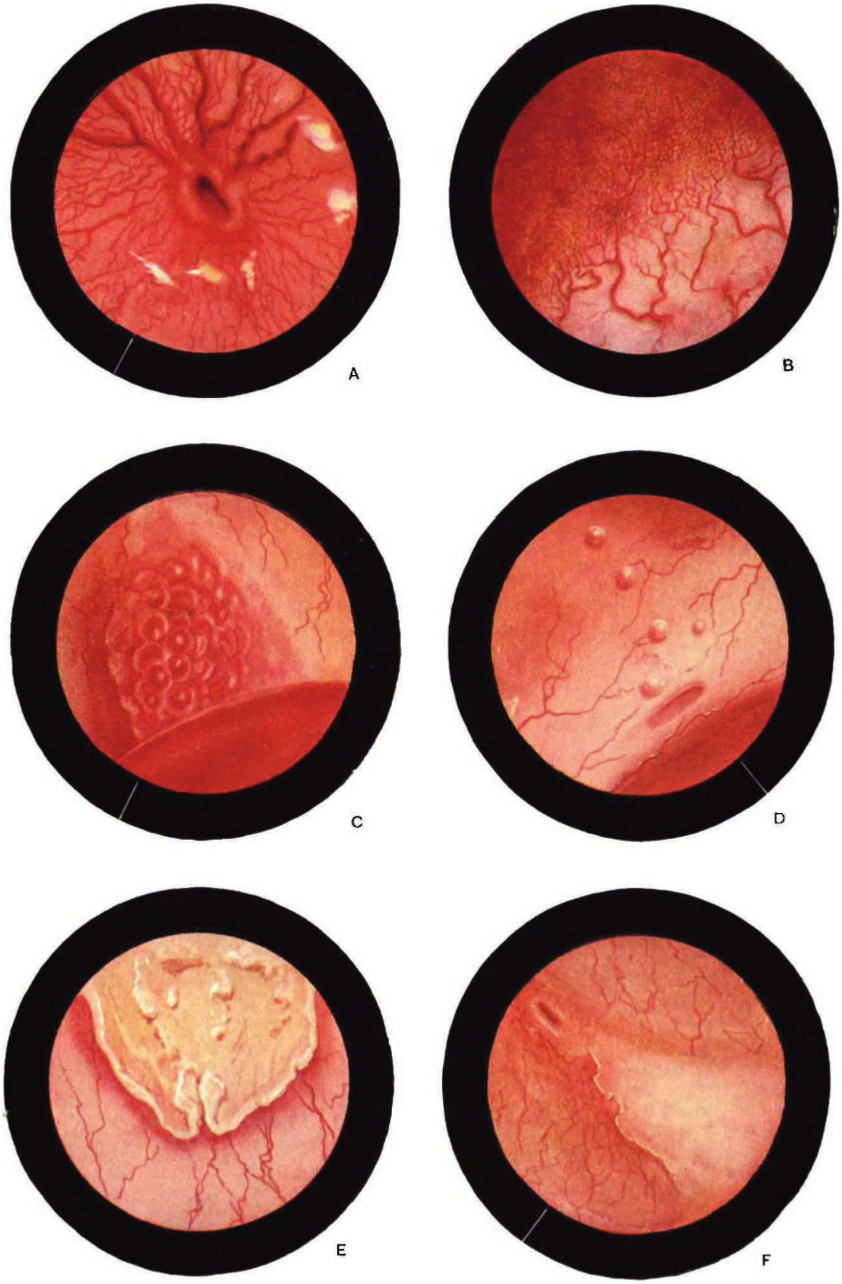
A, *Cystitis of medium severity.* Note the hyperæmia, the laked appearance of vessels' edges, and the washy mucosa. Mucosa appears puffy—purulent deposit. B, *Severe cystitis.* Redness of one portion very marked. It rapidly fades into an area of much less severe inflammation. Submucous hæmorrhages seen 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 180.) 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, *Trigonitis 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.

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 'trigonitis 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.

PLATE III.

SIMPLE CYSTITIS



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 64), 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 100; *V* D, page 112; *X* F, page 176, 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 XI* C, page 214). It is seen around the base of a neoplasm, especially a malignant one (*Plate VII* E, page 132), or near the site previously occupied by a simple papilloma following treatment with the high-frequency current (*Plate VIII* D, page 142), 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 88).

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 100). Some times 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 V* D, page 112); 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 phospatic 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 at the end of this chapter (page 90).

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 75.

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 XII* B, page 232) 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 trigonitis pseudo-membranosum, *see* page 76.

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 $CO\genfrac{}{}{0pt}{}{\diagup NH_2}{\diagdown NH_2}$ 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.

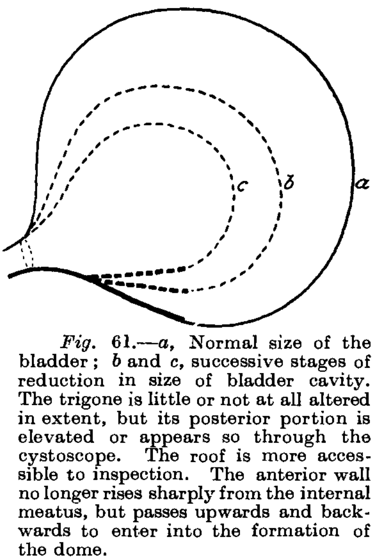


Fig. 61.—*a,* Normal size of the bladder; *b* and *c,* successive stages of reduction in size of bladder cavity. The trigone is little or not at all altered in extent, but its posterior portion is elevated or appears so through the cystoscope. The roof is more accessible to inspection. The anterior wall 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 100, 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.* 61 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 further 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 71).

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 229). 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 77). 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 XII* C, page 232).

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 the consequence of late complications, such as stricture, chronic prostatitis, etc.

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 is 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 distention 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 of tuberculosis, syphilis, and neoplasm, was, prior to the use of diathermy for intravesical 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 causes simple ulceration probably escapes recognition fairly frequently.

Four 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).

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 VIII* D, page 142). 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 distention. 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, that 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 75 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. It is

very rarely seen. Its site of election is the trigone, though it has been observed further 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. It is found in a bladder which is otherwise healthy.

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.

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 VII* F, page 132). 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 calyces 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.

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 and pathological 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-distention 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 47). 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 fifteen 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. Occasionally, however, as will be seen later, the bladder picture is inconclusive, and therefore it is desirable, *before* the examination is undertaken,

TUBERCULOUS KIDNEY

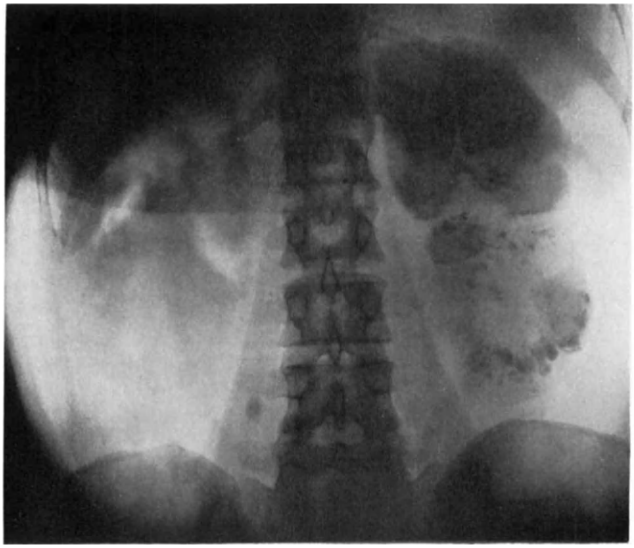


Fig. 62.—Marked calcification of a large tuberculous kidney. Nephrectomy by the transperitoneal route : recovery. (*Radiogram by Drs. Barclay, Paterson, and Twining.*)

[*To face page* 97

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 (*Fig.* 62) ; 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 104, and in Chapter XX.

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 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 232). 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 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

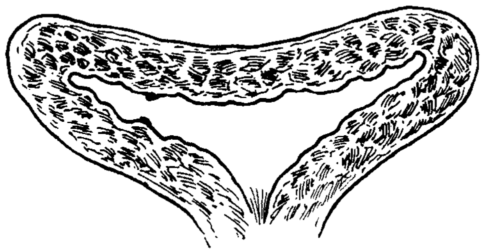


Fig. 63.—Shows how infection by contact is responsible for the involvement of the summit of the bladder.

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.* 63). 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 183).

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.

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.

Close inspection with the cystoscope can detect the small vessels entering into the formation of these areolæ.

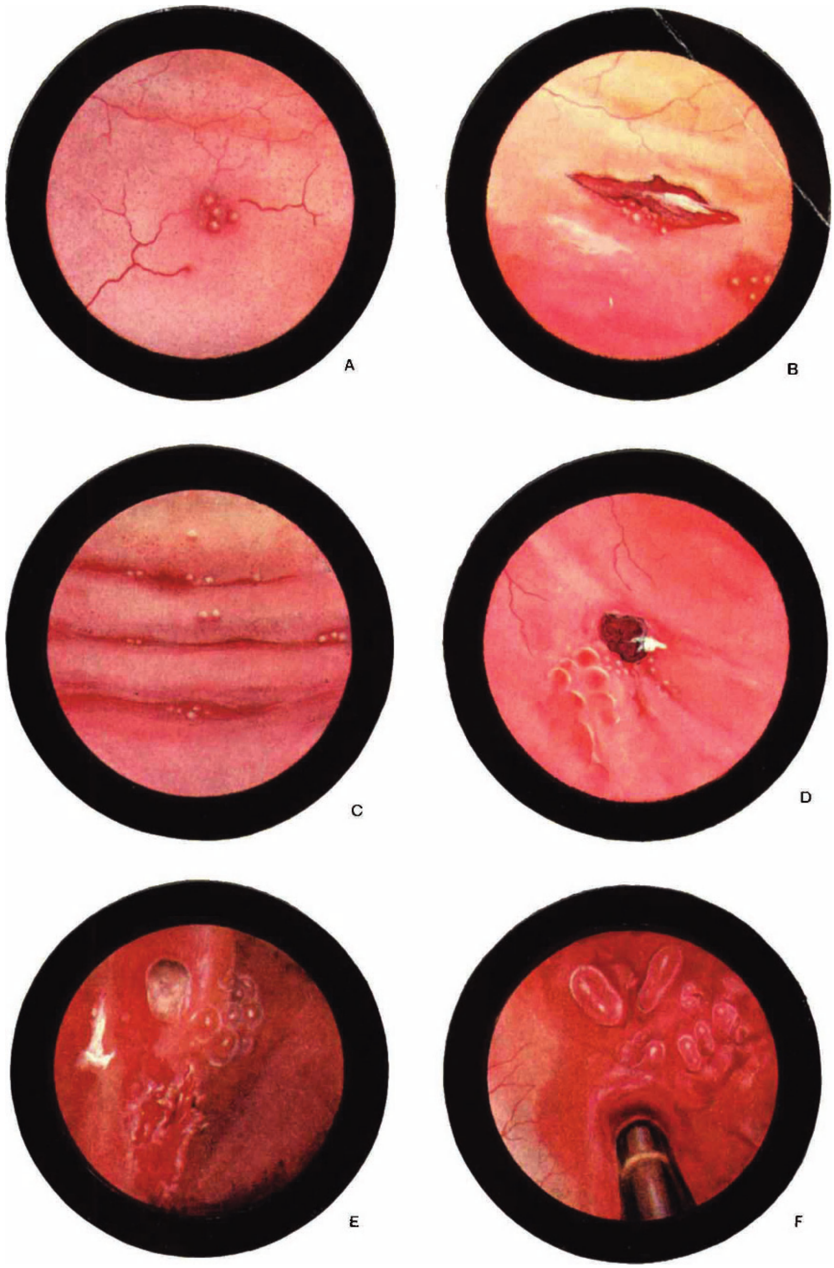
The relationship of tubercles to the blood-vessels is generally intimate. A solitary tubercle may be perched on a large vessel, or more frequently at the junction of two vessels, and according to Marion and Heitz-Boyer multiple lesions may be seen like granules situated along the ramifications of a branching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

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

PLATE IV.

TUBERCULOSIS OF THE BLADDER



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 78. 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 83 and *Fig.* 61).

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 240) 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 only; the middle section is rarely involved. Strictures, therefore, occur in the upper and lower thirds of the tube and not in the middle zone. 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 two possible methods of obtaining information concerning the function of the opposite kidney: (1) *Chromocystoscopy*; (2) *Ureteric catheterization.*

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.

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 XX.

Pyelography.—The subject of pyelography in renal tuberculosis is discussed in Chapter XXI, but it may be here noted that this investigation should not be employed save in cases where there is great difficulty in the diagnosis, and even then the surgeon should be prepared to proceed to nephrectomy immediately.

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 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.

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 during the last decade.

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). *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 eventually undergo ulceration.

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 antisyphilitic 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 co-exist, 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.—The *earliest* cystoscopic findings are those caused by the presence of the ova in clumps immediately subjacent to the mucosa. The appearance is figured in *Plate V* E, page 112. 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 80 ; 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 V* 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. 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).

Papillomata.—These 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. Epithelioma is a common lesion, and 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

PLATE V.

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.

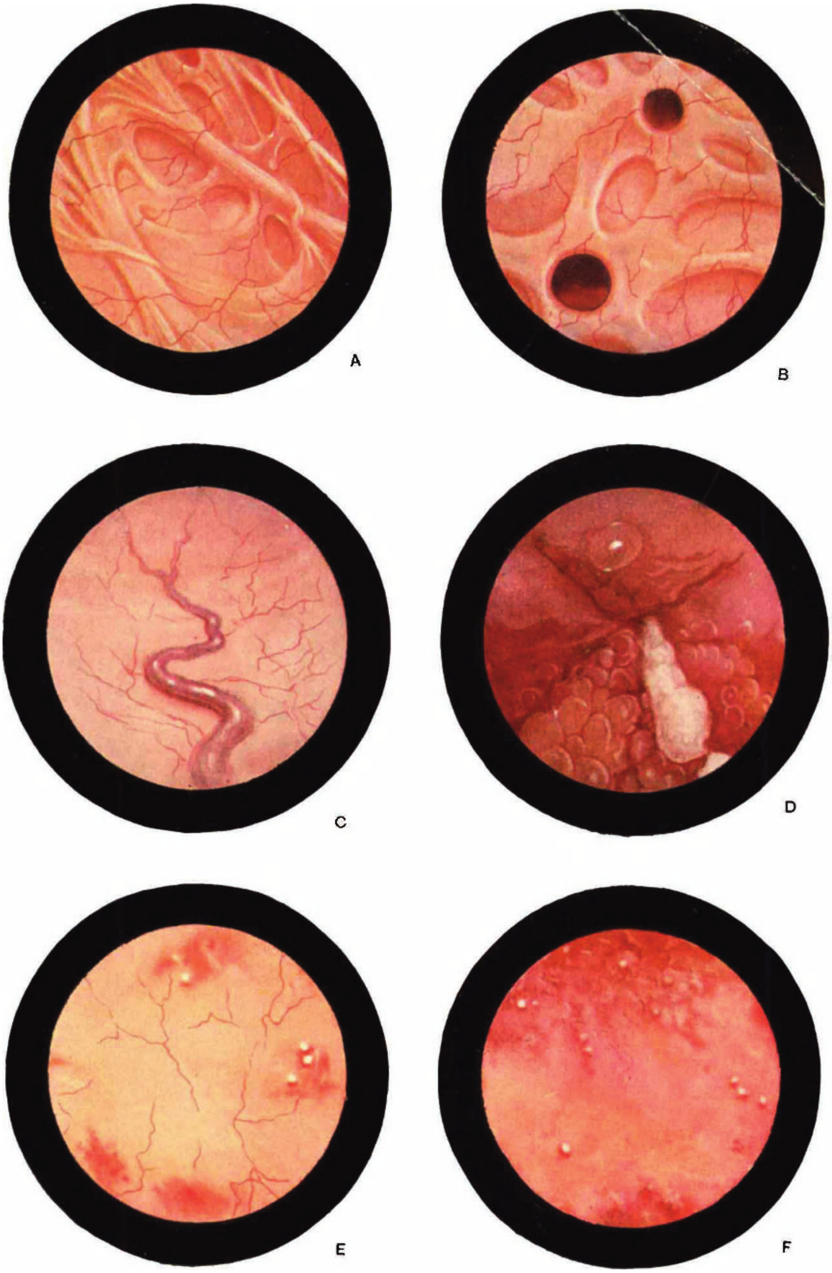
bands may rise on the wall. These may be transitory, some appearing as others disappear. Under a number of conditions these muscular ridges become more evident, and the bladder is then said to be trabeculated.

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

PLATE V.

MISCELLANEOUS BLADDER CONDITIONS



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 114).

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 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 retrotrigonal 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 further 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.

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.

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.

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. Whether the condition is of congenital or acquired origin is a vexed question. One thing, however, is certain

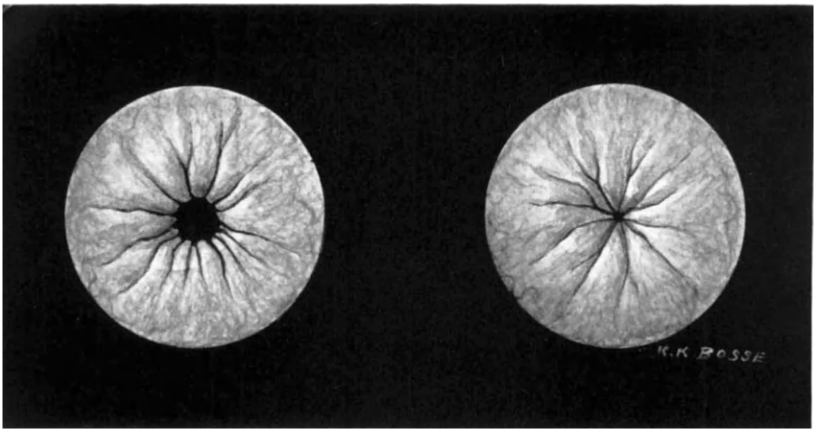


Fig. 64.—Cystoscopic appearance of diverticulum open and closed, demonstrating sphincteric action of orifice. (*Hyman.*)

Fig. 65.—Demonstration of size of two vesical diverticula by cystography (*see page* 117).

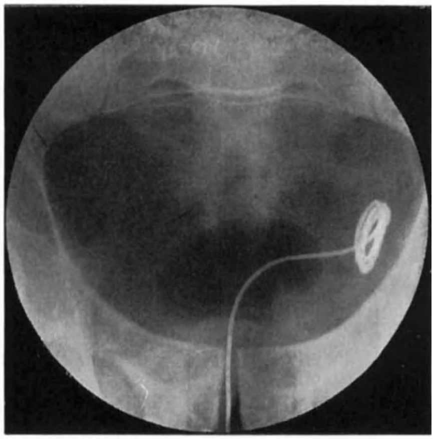


Fig. 66.—Shadow-casting bougie paid into cavity of diverticulum, where it has curled itself up. (*Gilbert Thomas.*)

—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 excentrically placed or hourglass 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 ($1\frac{1}{2}$ 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.

Cystoscopic Appearances.—The cystoscopic appearance is that of a hole cleanly punched out of the bladder wall (*Plate V* 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, 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.* 64). 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.* 67). 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.

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

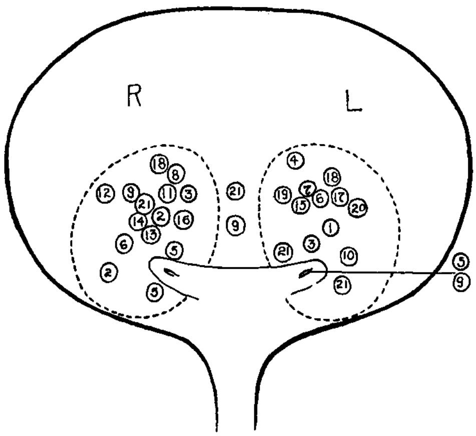


Fig. 67.—Graphic representation of the relative position of diverticular orifices in 21 cases. Cases Nos. 2, 3, 5, 6, 9, 18, and 21 have multiple diverticula. The only instances in which the base was involved are in two of these (9 and 21). A ureter opened into a diverticulum in only two instances, and again both were cases (5 and 9) with multiple sacs. (*Hinman.*)

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 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.* 68) (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 was the first in 1911 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. 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 latter may, however, be overlapped and obscured by the former. 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 (*see Fig.* 65). 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.

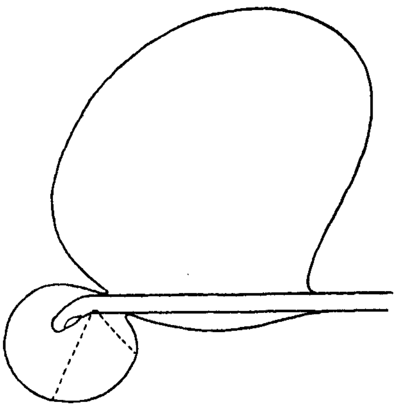


Fig. 68.—Cystoscopic examination of the interior of a diverticulum.

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 (*see Fig.* 66). 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 Targett). The size of the opening bears no relation to that of the diverticulum. An opening which will barely admit a crow quill may 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 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, in the bladder, or in both

(*Fig.* 69). 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 157). 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.

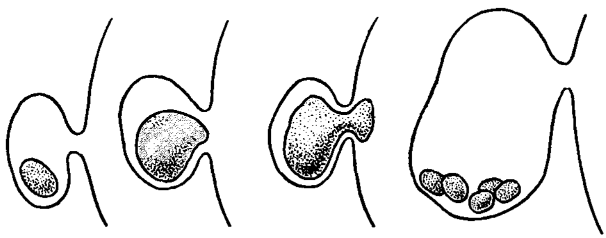


Fig. 69.—Stones in diverticula (various types).

The technique is similar to that employed in freeing a stone from the lower end of a ureter (page 224).

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 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 VI* c, page 126. In another 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.

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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* A lecture delivered at the Salford Royal Hospital to a post-graduate class contained the material which is embodied in this section. It was published in the *Brit. Med. Jour.*, 1921, April 30, and is reprinted here by kind permission.

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 XII* A, page 232; *see also* page 231) 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. *Fig.* 70 shows a large vesical papilloma removed suprapubically.

To recapitulate, it has been shown that hæmaturia is frequently

VESICAL PAPILLOMA

Fig. 70.—Operation specimen of very large vesical papilloma removed suprapubically.

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MULTIPLE VESICAL PAPILLOMATA

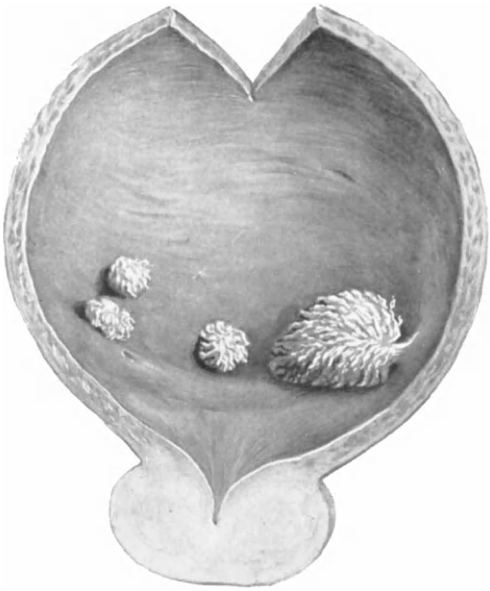


Fig. 71.—Multiple papillomata of the bladder.

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 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 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 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

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

when this was done a pair of lesser '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 twenty 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 133–135.)

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 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 VI A. They eventually acquired a phosphatic crust and were crushed by the cystoscopic rongeur and evacuated.

Occasionally the hæmorrhage for which one is consulted is excessive, and I have known 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 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

PLATE VI.

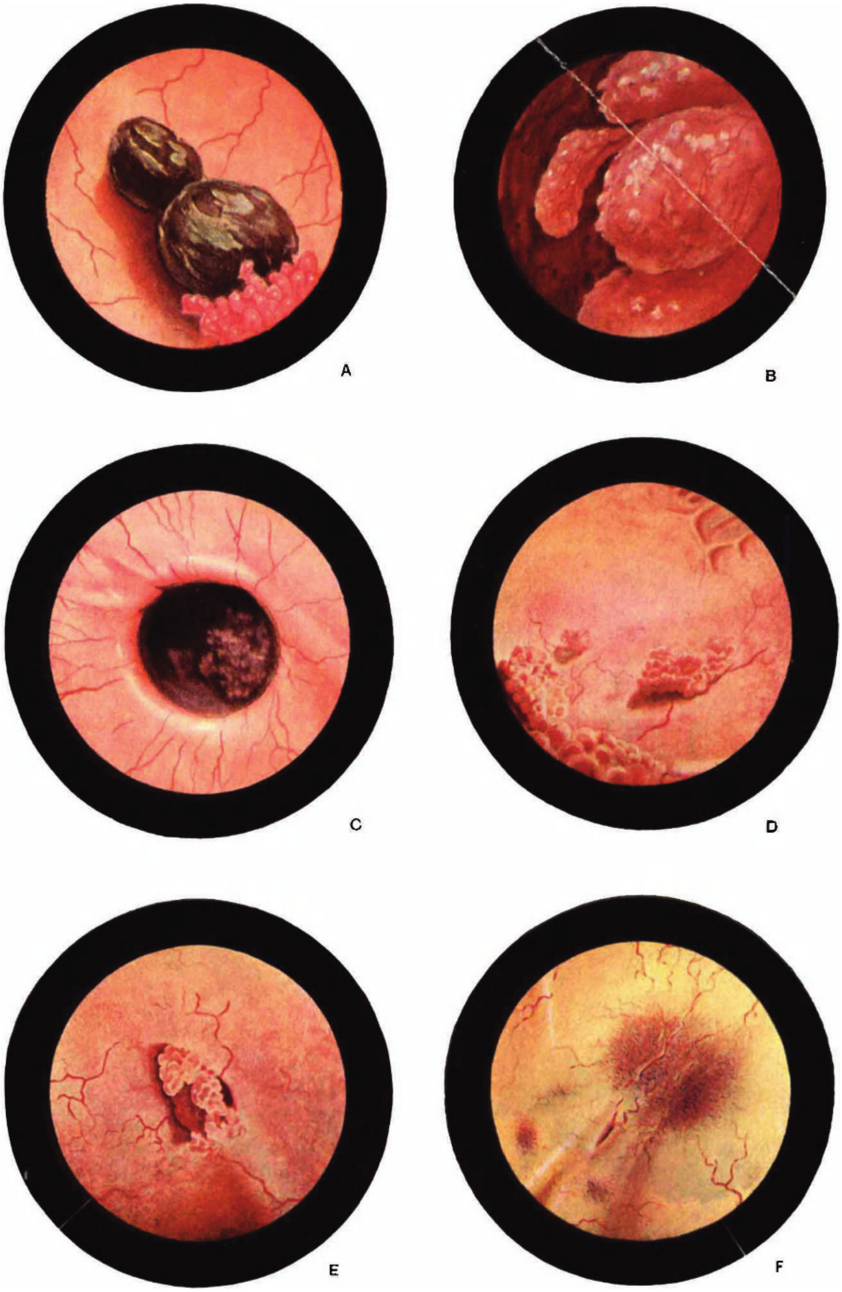
A, Two blood stones resulting from profuse hæmorrhage from the vesical papilloma of which a portion is seen. B, Close view of a portion of a papilloma occurring in an infected bladder ; the villi are swollen and there is some phosphatic deposit on their surfaces. C, Papilloma originating in a diverticulum 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. 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.

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. 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

PLATE VI.

BENIGN TUMOURS OF THE BLADDER



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 VI* F shows a capillary nævus which arose in the neighbourhood of the left ureter.

TUMOURS OF EPITHELIAL ORIGIN.

Tumours of epithelial origin fall into two main categories: (I) *Villous papilloma*—(*a*) *Benign*, (*b*) *Malignant*; and (II) *Nodular* (*malignant*).

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. Some 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 VI* D, and *Fig.* 71). 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 a similar evolution 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 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 the growth will be judged by its appearance.

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 VIII* A, page 142. 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, 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.

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 following table will serve to refresh the memory :—

	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

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. One's attitude to open operation may be correspondingly modified. I think that in doubtful cases the patient should be given his chance with perurethral diathermy.

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.* 72*a*–72*e* will assist the student in understanding the following description.

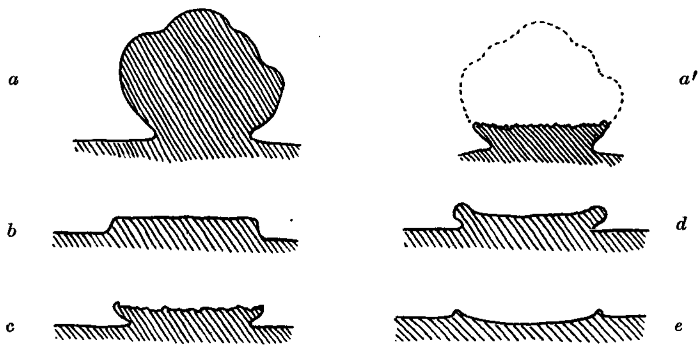


Fig. 72.—Types of nodular carcinoma. For description, *see* text.

The tumour shown in *Fig.* 72*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.* 72*b* is not very dissimilar to that of *Fig.* 72*a*, but forms a flattened plaque, projecting little or not at all into the bladder and, resembling a hard chancre in appearance. Its margin 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.

The growth in *Fig.* 72*c* probably arises from that in *Fig.* 72*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.* 72*a*′), leaving a flat but ragged fibrous surface of necrotic tissue (*Plate VII* 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.* 72*a* and recedes as it approaches its base of attachment to the bladder.

Fig. 72*d* presents the appearance typical of an ulcerated epithelioma (*Plate VII* F). 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.* 72*e* shows the same condition as *Fig.* 72*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.

PLATE VII.

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.

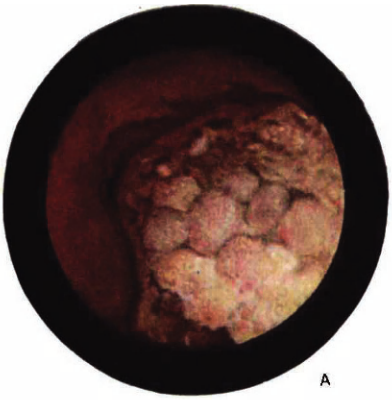
The growth shown in *Fig.* 72*a* is probably the least and that in *Fig.* 72*e* the most rapid, whilst the others show an intermediate malignancy. The vesical mucosa surrounding the neoplasm may be healthy and normal, or may be puckered and infiltrated. Frequently there is surrounding œdema apart from infection. Cystitis is very common.

Removal of a Part of the Growth for Microscopical Inspection.—It is possible, with the cystoscopic rongeur (*Fig.* 73) to remove a portion of growth for microscopical investigation. When dealing with *villous growths* we should be compelled to satisfy ourselves with a superficial portion, the base being inaccessible. As this does not give any real assistance in the microscopical diagnosis of malignancy, and as its removal is a risky procedure involving danger from hæmorrhage and dissemination, it is not to be recommended.

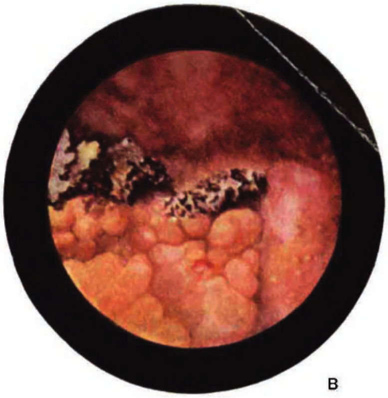
I have used the method on occasion in investigating a *nodular growth* the appearance of which was not distinctive. It is a satisfactory procedure and devoid of risk. It should terminate the cystoscopic

PLATE VII.

MALIGNANT GROWTHS OF THE BLADDER



A



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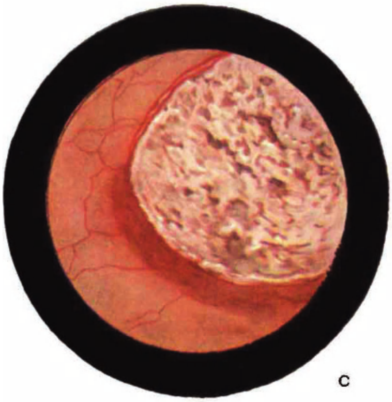

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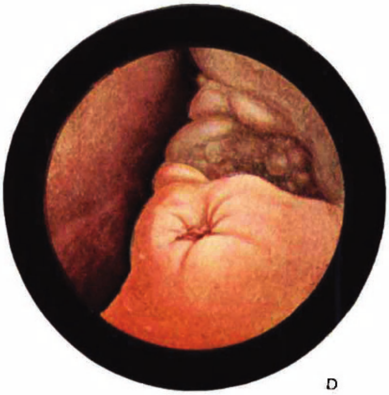


D

E

F

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 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

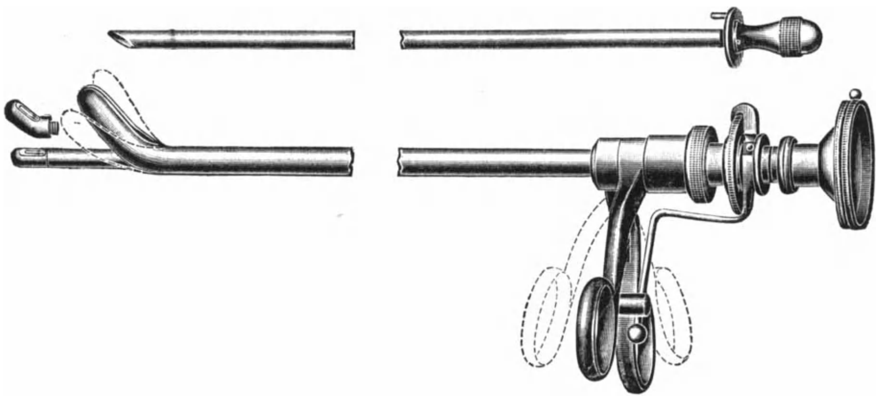


Fig. 73.—Cystoscopic rongeur.

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.* 86, page 151) and their size indicated. Their destruction will precede that of the main tumour at the first session of diathermy.

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.* 74 to 77 will assist in demonstrating the ways in which the size of the papilloma affects the cystoscopic examination.

Fig. 74 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. 75 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

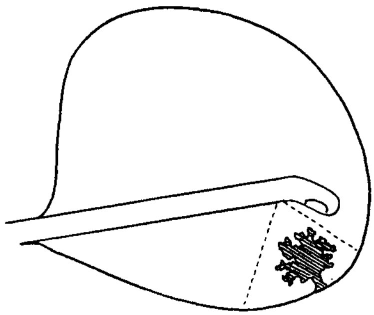


Fig. 74.

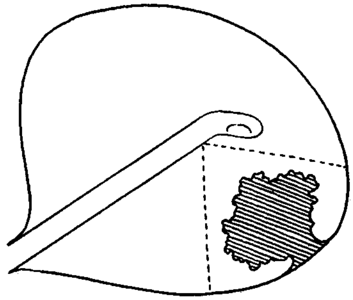


Fig. 75.

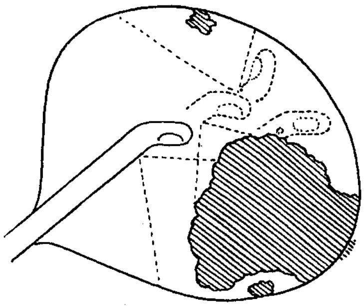


Fig. 76.

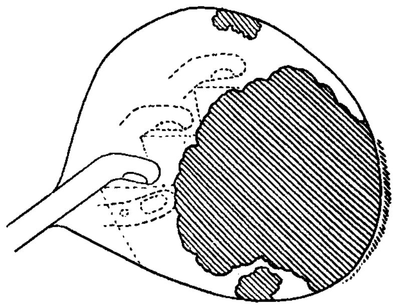


Fig. 77.

Figs. 74–77.—To illustrate the effect of the size of a papilloma on cystoscopy. For description, *see* text.

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. No secondary buds are figured. A papilloma of such size would be destroyed with ease in about two sessions of diathermy.

In *Fig.* 76 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.* 76 and 77, 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.* 76 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.* 77 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.* 74 and 75 there is no invasion of the submucous coat. This has occurred in *Figs.* 76 and 77. The question of treatment in growths of this size will be discussed later (page 144).

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 owing to its vascularity, 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.* 78). It was for this purpose that Swift

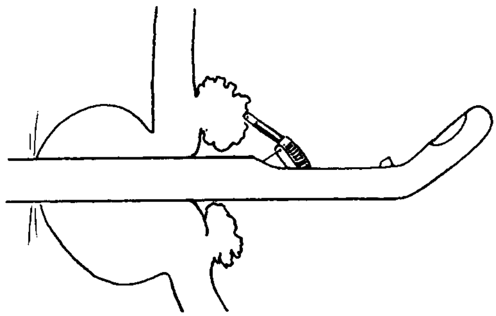


Fig. 78.—Treatment of papilloma covering the meatus by means of the retrograde cystoscope.

Joly introduced his retrograde instrument. Apart from it treatment would have to be by open operation.

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 150.

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.

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.

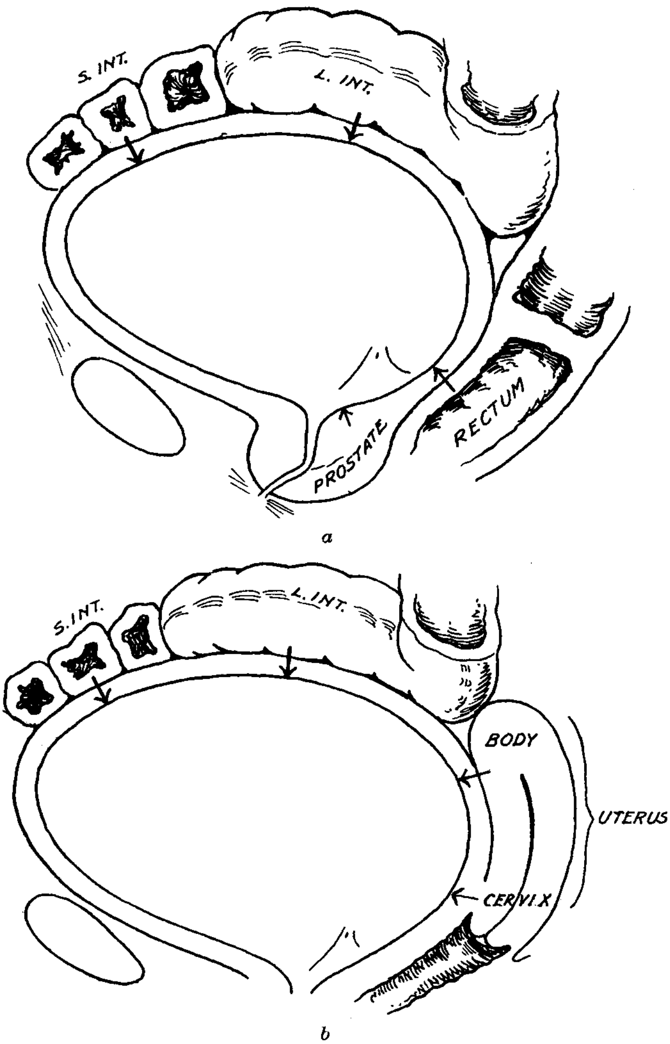


Fig. 79.—Points of invasion of the bladder by carcinoma arising in the various contiguous structures. *a*, Male ; *b*, Female.

Neoplasms Arising Outside the Bladder.—Such growths encroach on the viscus at its nearest point (*Fig.* 79) ; 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.

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 147). 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.

Diverticula.—Not infrequently diverticula are the seats of neoplasms (*see* page 119) both villous and nodular. A beautiful example is portrayed in *Plate VI* C, page 126. 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. Allusion to the method of treatment adopted for this growth is made later (page 148).

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 78). 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 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.

Tumours arising in Other Organs.—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 VII* D, page 132). The position of the involvement varies with the anatomical origin of the neoplasm, which may be uterine, vaginal, prostatic, intestinal, etc. At a later time fistulæ—the vesicovaginal 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 V* D, page 112. The whitish purulent material seen in the centre of the picture flowed into the bladder during cystoscopy and became more abundant on suprapubic pressure.

Tumour cells may be implanted in the bladder from a papilloma of the renal pelvis, and occasionally one originating in the ureter may project into the bladder, as shown in *Plate VI* E, page 126.

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 VII* F, page 132), described on page 90, 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 VI* A, page 126). *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 111).

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 143. 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 transurethral 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 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 distention of 8 oz. should be employed. Lesser quantities are inconvenient, giving too little space, whilst over-distention may be provocative of bleeding. The inflamed bladder may, of course, decline to take this quantity, and on the other hand large bladders may be induced to take consider-

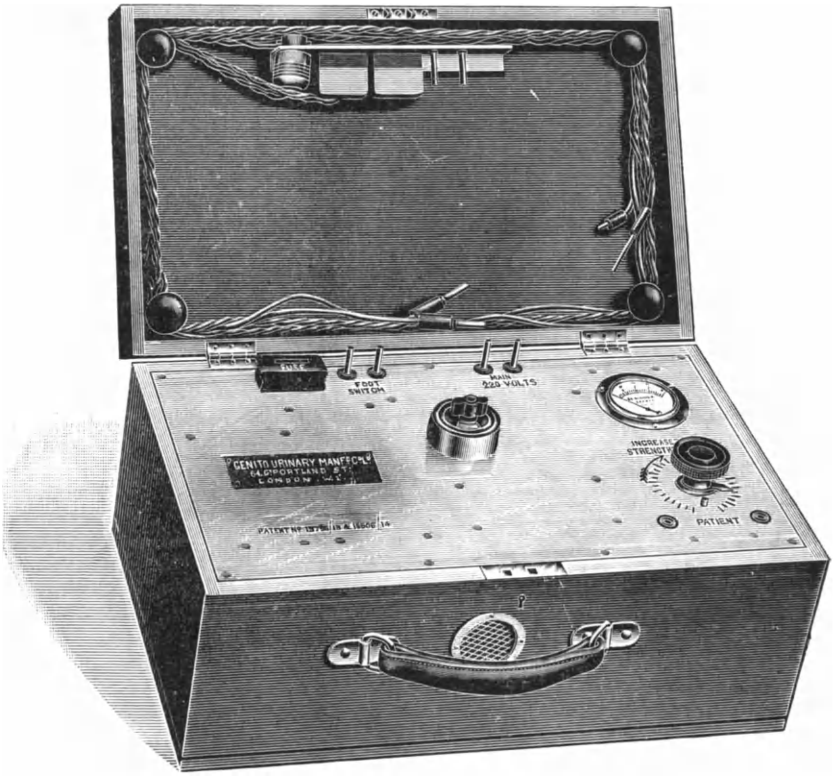


Fig. 80.—Diathermy machine.

ably more, but such an amount should be employed only after failure to manipulate the cystoscope with less fluid, as over-distention 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.* 80). 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.* 81). The pad of the inactive electrode is soaked in saline solution. The active electrode is sterilized by immersion in antiseptic

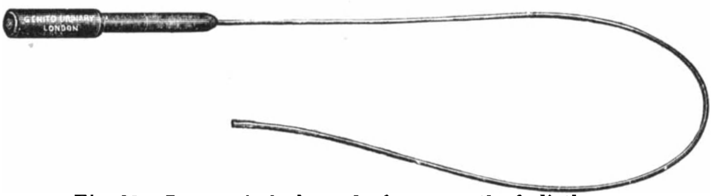


Fig. 81.—Intravesical electrode for perurethral diathermy.

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.

PLATE VIII.

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.

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 safety. A Universal machine which is 'earth-free' may, however, be

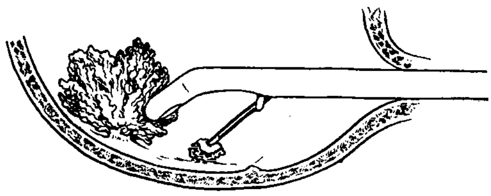


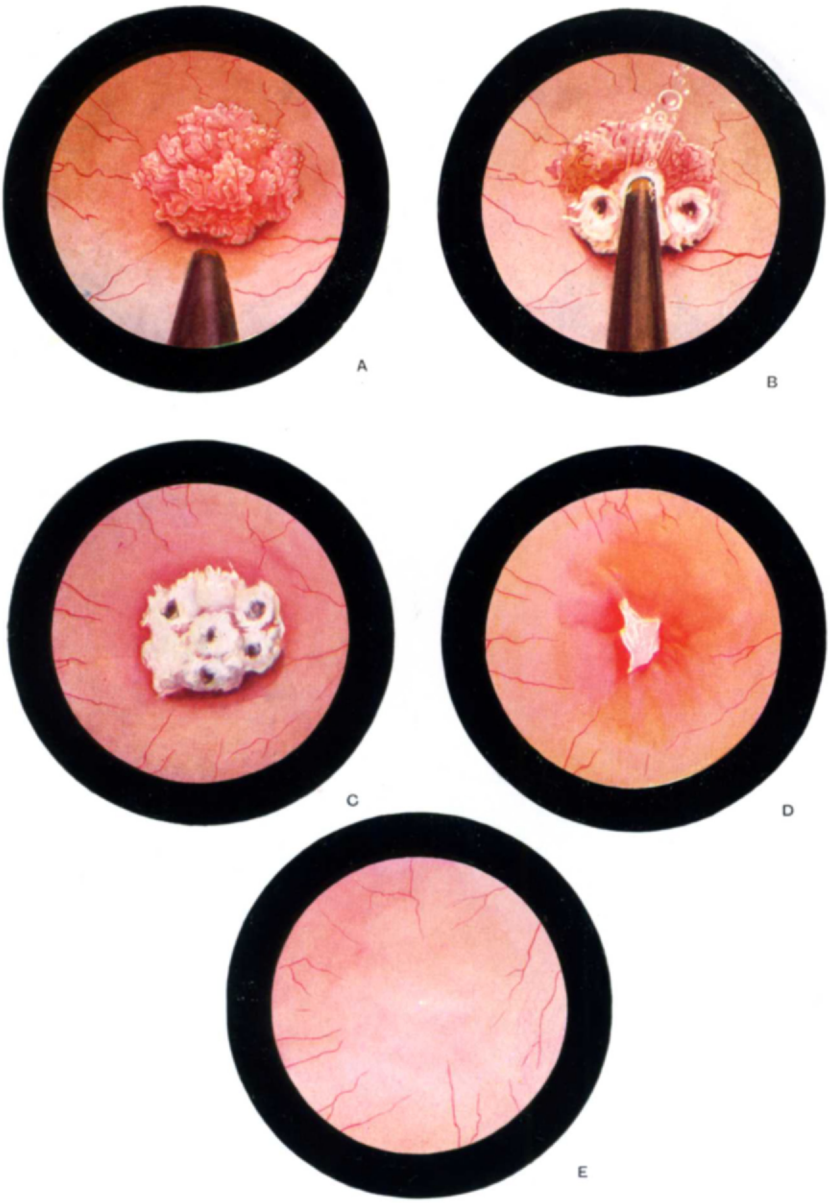
Fig. 82.—Treatment of vesical papilloma begins with secondary growths if any are present.

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 are accessible (*Fig.* 82). Their situation is known, for it was charted

PLATE VIII.

PERURETHRAL TREATMENT OF VESICAL PAPILLOMA



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 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 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.

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 VIII* 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 147). 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. As the individual surgeon's experience matures, however, increasingly large tumours will be submitted to diathermy. In any case it is well to give a first or probationary sitting, as thereby the size of the tumour may be reduced to such an extent that treatment will be more easily conducted 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 continue the application under better conditions. Thus, certain tumours which at first sight appear to be unsuitable for transurethral treatment may ultimately be destroyed. It is always difficult to forecast the results of such probationary treatment, but the extent of the alternative open operation is such that it should be avoided if there is any hope of success with perurethral measures.

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 lesser 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 147).

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.—As in ordinary surgical work, so in bladder fulguration, American and Continental operators have forsaken general for local anæsthesia, whilst most of those who have written in this country appear to use general anæsthetics. I have no hesitation in falling in with the latter. Treatments lasting for upwards of three-quarters of an hour cannot reasonably be given to conscious patients. By relying on local anæsthetics the surgeon severely limits the length of his applications, whilst the cauterization of the tumour base will cause pain, and may be shirked.

The results are reflected in the average number of treatments accorded to patients in this country as compared with America. American surgeons speak of giving fulgurations numbering into the teens to a single patient. My own maximum is six, and very rarely do I exceed three or four. I consider that these figures amply justify the use of a general anæsthetic. Even when dealing with a small bud, which is quickly destroyed, a general anæsthetic should be employed. The papilloma itself is insensitive, but not so the bladder wall surrounding its base. Cauterization of the latter will be evaded on a conscious patient and recurrence *in situ* risked.

Period in Hospital.—The patient's stay in 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. If the complete destruction of the growth at the last sitting is in doubt, he returns to the ward. But if the burning was carried down to the mucosa, the examination can be conducted in the Out-patients' Department.

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. The safeguard against interpreting it wrongly is the knowledge that it was not there when treatment began; 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 appears neoplastic but really results from his own treatment. 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, 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.* 83*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 devitalize the cells. This tissue, which appeared unchanged at the

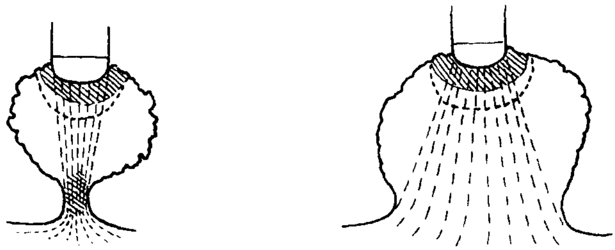


Fig. 83.—Diagrammatic representation of the course of the diathermic current in papilloma with: *a*, A small pedicle; and *b*, A broad pedicle.

time of the treatment, has died and disappeared at the end of three weeks (*Fig.* 84).

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.* 83*a*) and its devitalization is always a possibility.

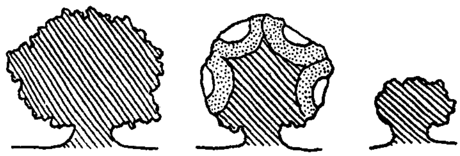


Fig. 84.—Illustrating effects of diathermy on a papilloma: *a*, Original growth; *b*, The apparent destruction at end of session; and *c*, The appearance presented at a subsequent sitting.

bility. Presumably the unexpected total disappearance of tumours is thus explained. *Fig.* 85 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 VI* C, page 126), 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.

Figs. 83 *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 VIII* E, page 142). 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.

Fig. 85.—Piece of papilloma passed per urethram fifteen days after diathermy. (*Natural size.*)

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 when he returns to consciousness.

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 the 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.* 86) 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.

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

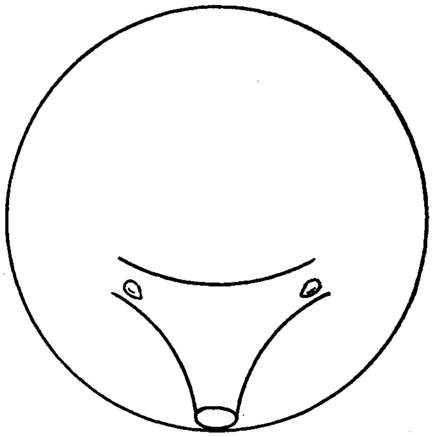
VESICAL PAPILLOMA. FOLLOW-UP RECORD.

Name .... *Address*	*Sex*.......... *Age*..........	

SIZE

NUMBER

PROGNOSIS



HISTORY

REMARKS

(Heading of the back of Record.)

Instructed to return	Returned	Treatment and Remarks

Fig. 86.—Record book for bladder tumours.

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.

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 are 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 (*Fig.* 91) 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.* 87, 88). 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

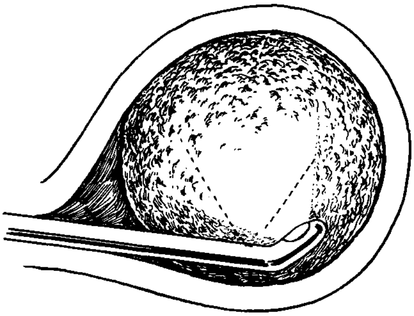


Fig. 87.—Cystoscopy in a case of large vesical calculus.

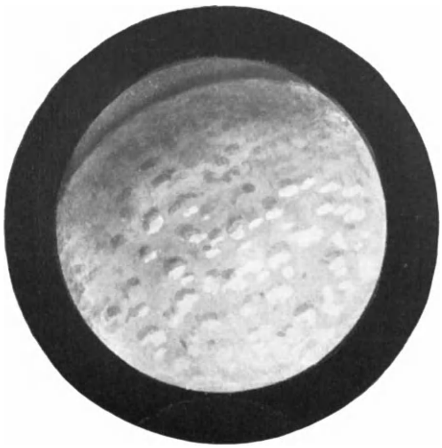


Fig. 88.—Margin of stone shown in *Fig.* 87.

Fig. 89.—Actual size stone seen in *Plate XI* D, page 214.

Fig. 90.—Vesical and urethral stones which articulate.

Fig. 91.—Vesical stone. The shadow is unusually high and was constant in position in several plates. Its position was due to its displacement by a very large prostate.

Fig. 92.—Jaws of cystoscopic rongeur approaching a small friable calculus.

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 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.

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 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 IX* A). They may be small or of medium size, but are occasionally very large.

Oxalate Calculi.—Such stones are very easily distinguished (*Plate IX* B). 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 by 1⅓ in. They have a rich dark-brown colour, though they may be almost black. Their surface is uneven. Sometimes this irregularity takes the form of flattened bosses (mulberry calculus), at others the exterior bristles with spikes (star calculi). The oxalate calculus, by 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 IX* 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 VI* A, page 126, illustrates two blood stones following severe hæmorrhage from a papilloma.

PLATE IX.

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.

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 IX* 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.

PLATE IX.

VESICAL CALCULI

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 XI* D, page 214, came out of the ureter shown in *Plate XI* C. Its actual size when withdrawn from the bladder by Bigelow's evacuator is represented in *Fig*. 89, page 155. 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).

4. **Position and Mobility of the Stones.**—A calculus may be free in the bladder, or fixed.

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*. 90, page 155). Such stones are, of course, unsuitable for cystoscopy. Alternatively they may be primary in the urethra and fungate into the bladder.

Stones in Diverticula.—These may be single or multiple. They may be small and occupy 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 excentric position demands cystoscopic inquiry. A stone has been observed fixed in the lower end of a patent urachus (Dykes). (*See also* page 118.)

Prostate.—Fixed stones also occur behind the prostate. Here they are often multiple (*Plate IX*, E and F). Urinary stagnation and decomposition are the predisposing causes. *Fig.* 91 shows a stone which rested on the upper surface of a very large gland, the shadow therefore occupying an unusual position.

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 XI* C, page 214). Their treatment will be discussed in Chapter XVIII.

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.

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 IX* D**, taken during a lithotrity, shows some partially crushed fragments on the bladder floor. As seen here, there are invariably some small bloodclots 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.

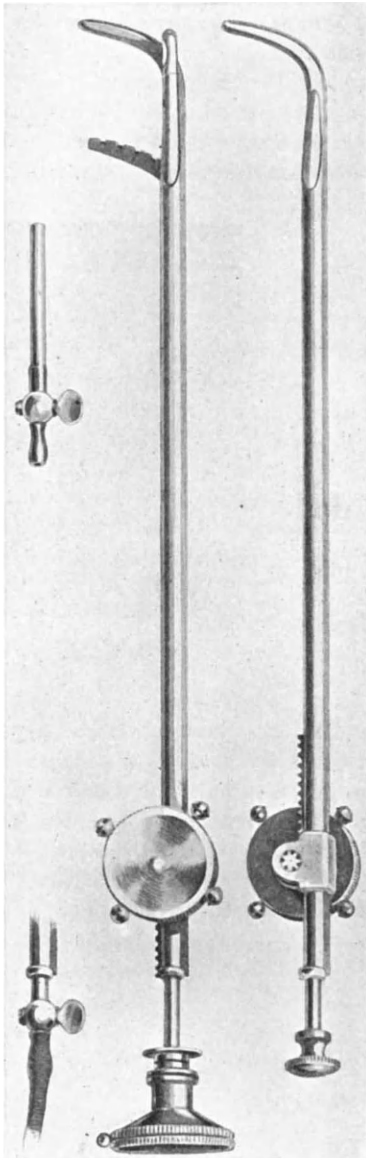


Fig. 93.—Canny Ryall's cystoscopic lithotrite.

Some septic bladders are regular stone factories, and when cleared reform 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.* 93, 94) 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.* 73, page 133) is less suitable than the above-mentioned instrument, but may be used to break up stones

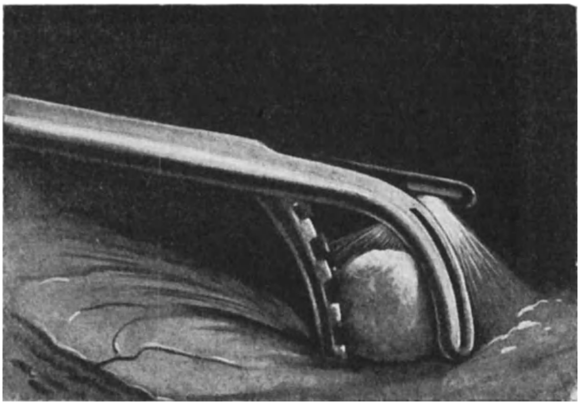


Fig 94.—Canny Ryall's cystoscopic lithotrite grasping a bladder stone under inspection.

which are very soft and friable, particularly phosphatic ones (*see Fig.* 92). It should not be employed for harder ones, as the jaws might bend and be difficult to extract from the bladder. Those who 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 XI* E, page 214), 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.

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).

Pointed articles—for instance, needles, surgical and otherwise—occasionally perforate the bladder. *Plate XI* F, page 214, 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). 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 (Day).

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 159).

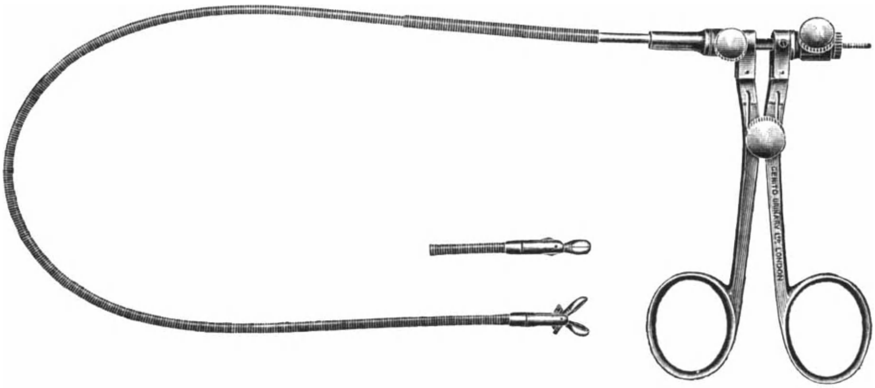


Fig. 95.—Buerger's forceps.

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.* 93 and 94, pages 159, 160) or rongeur (*see Fig.* 73, page 133) 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.* 95 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 distention 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.

Other instruments capable of grasping and withdrawing objects found in the bladder are the cystoscopic rongeur (*Fig.* 73, page 133), and Canny Ryall's cystoscopic lithotrite shown in *Figs.* 93 and 94, pages 159, 160. 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.

This condition has been known under several different titles, such as 'ballooning of the ureter', 'prolapse of the ureter', etc. The term 'ureterocele' is probably the best. *Plate X* C, E, page 176, give a good impression of the appearances presented cystoscopically, and *Fig.* 96 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 lesser translucent cysts (Thomson-Walker). In the case from which *Plate X* 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.* 96, 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 X* 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.

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 distention 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.

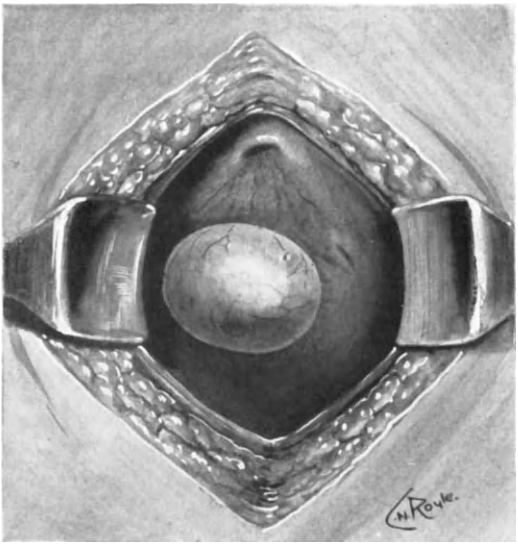


Fig. 96.—View of ureterocele at operation. Note the small orifice of the ureter situated to the inner side of the cyst, and compare with the size of the right ureteric orifice.

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. 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.* 97), 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. Dilatation has also been seen in post-mortem specimens, and severe hydronephrosis is sometimes encountered.

The cyst is produced by mechanical distention. 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.

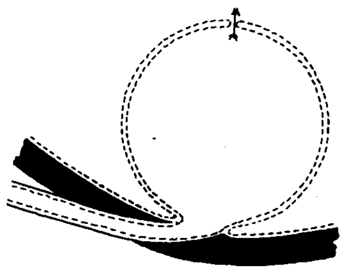


Fig. 97.—Diagrammatic representation of a ureterocele.

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 259, 260). 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 newborn. Stones have been observed in these cysts, and this fact has been used as an argument in favour of their acquired origin, it having been considered that they were an etiological factor. They probably result from urinary stagnation.

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 and been snipped off by gynæcologists, who have not recognized the condition with which they were 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 distention.

Treatment.—This may be undertaken by open or perurethral methods. *Fig.* 96 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 over as large a surface as possible by means similar to those employed in the treatment of a papilloma. *Plate X* D, page 176, 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. Complete ureteric obstruction has been known to occur from this cause.

CHAPTER XIV.

VARIX AND MALAKOPLAKIA OF THE BLADDER.

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 V* c, page 112. 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 extra-vesical tumours.

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. It never gives rise to symptoms, with the exception of hæmorrhage, and its presence 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.

" Microscopically a plaque consists of a mass of cells immediately beneath the epithelium which has disappeared over the summit of the mass. The cell mass does not invade the muscle. The cells comprising the mass are very large and usually contain only one nucleus, but in some cases more than one is present. Besides the nucleus many of these cells contain one of more rounded bodies of size varying up to about twice that of the nucleus : these are the inclusions of Michaelis-Gutmann bodies. . . . Masses of coliform bacilli have been found in the masses in many cases. Tubercle bacilli have been repeatedly looked for, but it is doubtful if they have ever been found in a true case of malakoplakia."

CHAPTER XV.

PROSTATIC HYPERTROPHY.

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 evacuated. 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 176, 177.)

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.*

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 aspect 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.

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 bulges 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 recess.

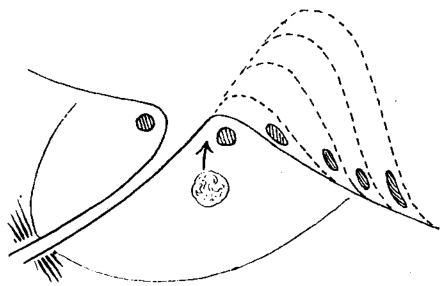
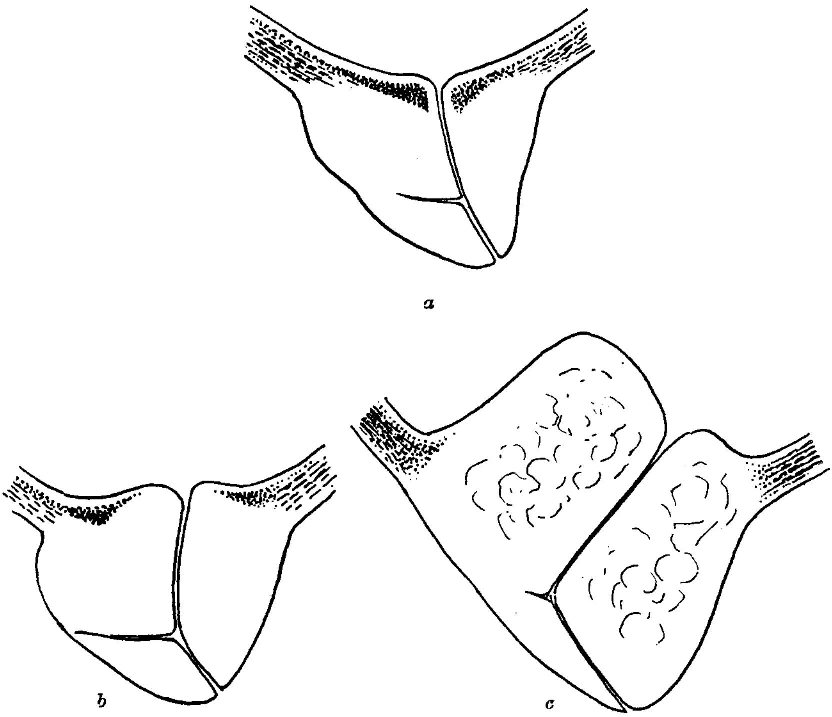


Fig. 98.—Diagrammatic representation of the way in which a prostatic adenoma advances.

Intravesical Changes.—But another important factor enters into the elevation of the vesical floor, and especially that of the meatus. Growth progresses most freely in the section between the urethra and the common ejaculatory ducts. It soon approaches the urethra and in doing so replaces the submucous tissue and peri-urethral plain muscle, so that it comes to lie immediately subjacent to the mucosa. Continuing this process it approaches the internal meatus from below, and, displacing the sphincter (*Fig.* 98), it becomes an intravesical structure, covered only by a thin layer of mucosa, which has probably been dragged up with it from the urethra in its progress.

The advance of the gland as it pushes itself into the bladder is represented diagrammatically in *Figs.* 99 *a*, *b*, *c*, where it will be seen that with each increase in its size the sphincter is rolled further and further back. It is eventually divorced widely from the meatus and comes to lie below the level of the orifice in a position where it cannot possibly exert any sphincteric control.

The central and posterior portion of the gland is the one where change is most marked, 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, advances into

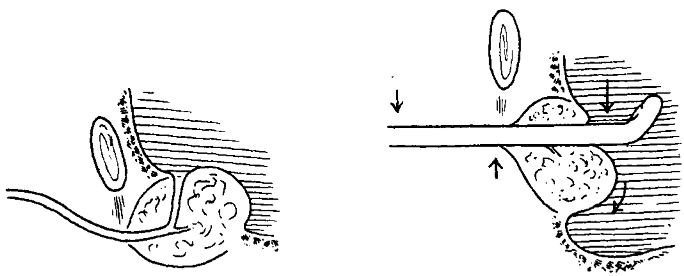


Figs. 99.—*a*, Normal relations of vesical sphincter to prostate, etc. *b*, *c*, Alterations produced at vesical neck by increasing degrees of prostatic hypertrophy.

the meatus, the neoplasm first becoming submucous, and then proceeding to curl outwards the sphincteric musculature. The anterior region is the one least involved, and indeed there is generally no intravesical bulge at this point (*Fig.* 98).

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 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 a case in which the lateral lobes were enlarged and the middle one quite unaffected, though this is very rare. The floor of the urethra was continued into the trigone on the same plane, and by elevating the cystoscope into the cleft between the two hypertrophied lobes it could 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 *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 increment would preclude the use of the ordinary cystoscope, and special instruments have been made with the object of overcoming



a *b*

Fig. 100.—*a,* Urethra in prostatic hypertrophy. Note increase in the curve of the prostatic urethra as compared with the normal shown in *Fig.* 45*a,* page 51. *b,* Urethra in prostatic hypertrophy after introduction of cystoscope. Marked retroversion of prostate causing exaggeration of the retroprostatic pouch.

this difficulty. They are, however, unnecessary, as 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.* 100). This becomes increased in the ordinary type of hypertrophy, owing to the development of the middle lobe. The angle may 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.* 100). 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 (*see Fig.* 99).

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.* This is due to the close approximation of the adenoma to the mucosa, it having displaced the submucous and muscular coats, as before stated. Its vascularity is most marked where the glandular enlargement is furthest advanced, and it is therefore best developed posteriorly (*Plate X* A) and least anteriorly. It determines the occurrence of hæmorrhage during instrumentation, unless great gentleness is exercised.

Effects on the Urethral Meatus.—In the foregoing description of the way in which the adenoma encroaches on the bladder, it has

PLATE X.

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.* 96, page 166). F, The left ureteric orifice corresponding to a severely infected kidney. The orifice is dilated, surrounded by bullæ, and there is intense cystitis.

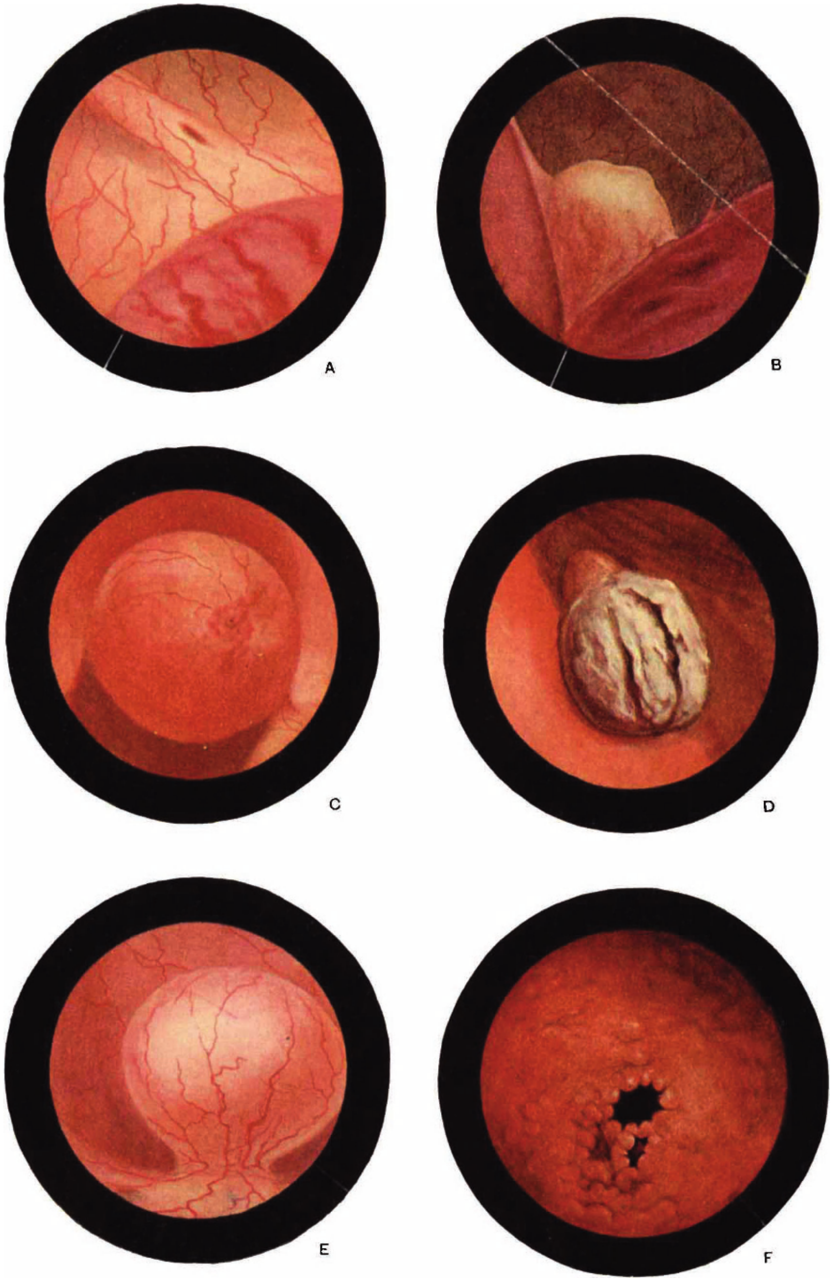
been shown that the internal opening is : (*a*) Elevated, both actually and also in reference to the base of the bladder ; (*b*) Displaced anteriorly ; (*c*) That the sphincter is dilated and dislodged by the growing gland, which usurps its position at the meatus ; (*d*) The adenoma is overlaid by a 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 182.

PLATE X.

PROSTATIC HYPERTROPHY. URETEROCELE. PYONEPHROSIS



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 44). 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 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 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 48). 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 47.

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 distention 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 distentions. 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 distention 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

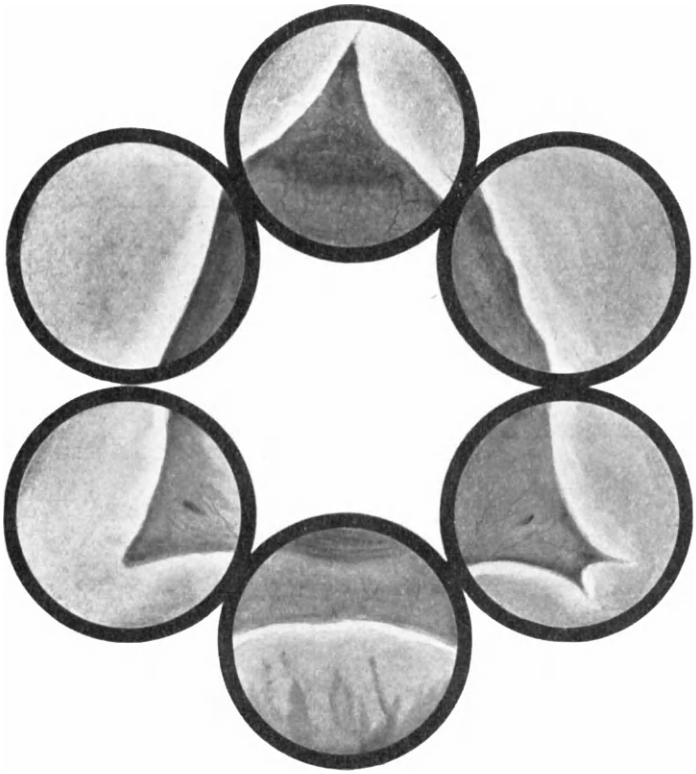


Fig. 101.—Series of cystoscopic fields showing collectively the contour of the *vesical* aspect of an enlarged prostate. (Cf. *Figs.* 54, 55, page 60.)

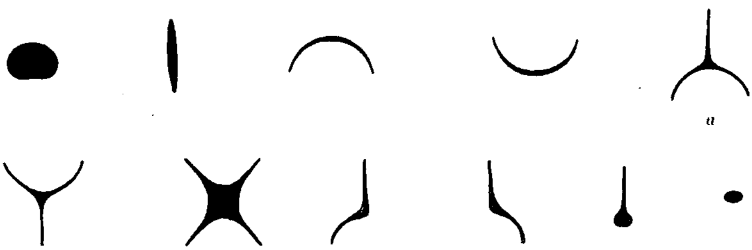


Fig. 102.—The first figure represents the outline of the normal meatus; the remainder show the possible changes which the orifice may undergo in prostatic hypertrophy. (*Redrawn fram Young.*)

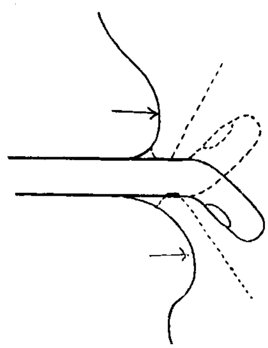


Fig. 103.—Cystoscope examining prostatic hypertrophy appreciates increase of the gland occurring towards the bladder cavity.

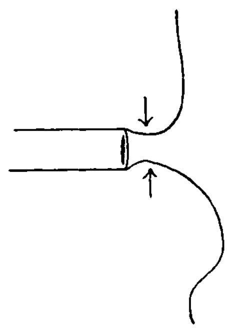


Fig. 104. — Urethroscope examining prostatic hypertrophy appreciates increase of the gland taking place towards the lumen of the urethra. (Cf. *Fig.* 105.)

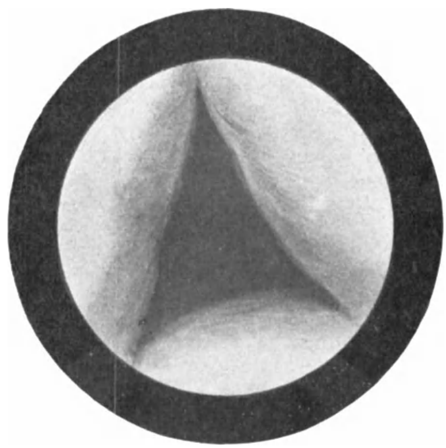


Fig. 105.—Internal meatus in prostatic hypertrophy seen through the posterior urethroscope. (Cf. *Fig.* 104.)

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.* 54, page 60), 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.* 101). 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.* 102. 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.* 102 (*a*) (*see also Fig.* 101). 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 X* B, page 176). 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.

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.* 107), and is therefore in less close apposition. Its colour is deeper than that of the bladder except when the latter 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.

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.* 103). Those occurring transversely require a urethroscope or a retrograde cystoscope for their recognition (*Figs.* 104 and 105).

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 further 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 175). 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.* 108). Suggestions for uncovering it to some degree have been made on page 178. Stones and growths and the mouths of diverticula, etc., may be overlooked when sheltered in this retreat.

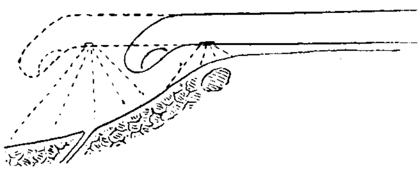


Fig. 106.—Showing that in the normal condition it is not possible to see the prostatic margin and ureter in the same field.

In the normal individual it is never possible to bring the edge of the meatus and the ureter into the same field (*Fig.* 106), 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.* 107, 108). 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 188).

It very rarely happens that we desire to catheterize the ureter in prostatic hypertrophy, but when the occasion does arise it will 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

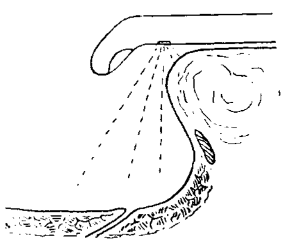


Fig. 107.—Showing that in prostatic hypertrophy it may be possible to see the prostatic margin and ureter in the same field.

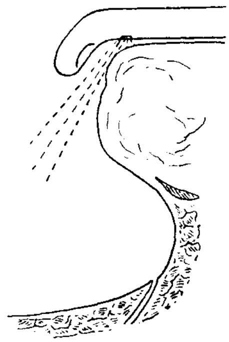


Fig. 108.—Showing that the ureter may be hidden by a very large gland.

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 230). In the presence of cystitis the dilatation of the orifice may be masked by the œdema of its lips.

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 said before, 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 IX* E, page 156, which also demonstrates the manner in which the gland hides objects in the pouch. Occasionally a stone forms in a diverticulum (page 118).

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 overlying 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.

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.

CHAPTER XVI.

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

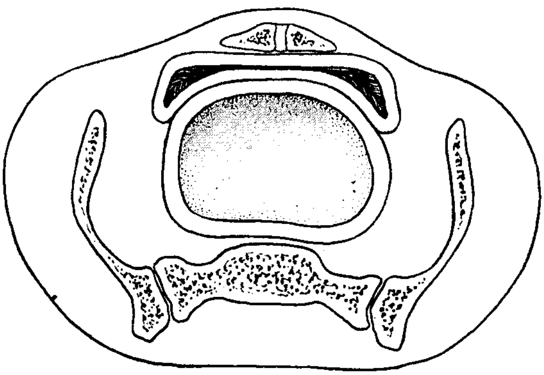


Fig. 109.—Distortion of the bladder by pregnant uterus near term.

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.* 109). 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 segment of the bladder on which the ureteric orifices open 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

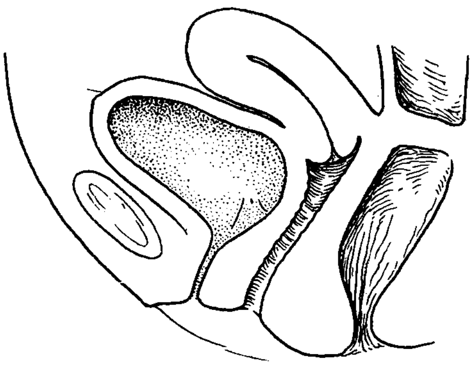


Fig. 110.—Normal relations of bladder and female adnexa.

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.* 110.

Retroversion and Retroflexion.—In these conditions the uterus is bent over backwards so that the cervix indents the vesical wall (*Fig.* **111**). It comes into relationship at the level of the interureteric bar and the 'bas fond'. Here a median elevation is produced, so that

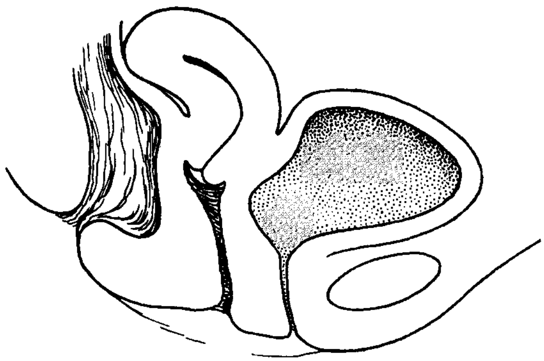


Fig. 111.—Effect on the bladder of retroflexion of the uterus.

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.* **112–114**) may be slight or may be so extreme that the greater portion of the bladder

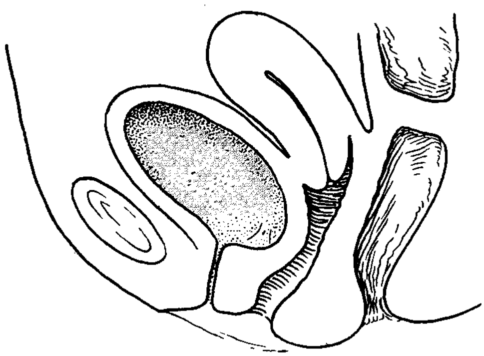
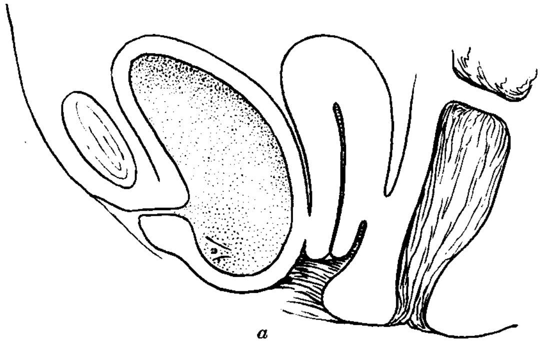


Fig. 112.—Effect on the bladder of a slight degree of uterine prolapse.

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.* 112) 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



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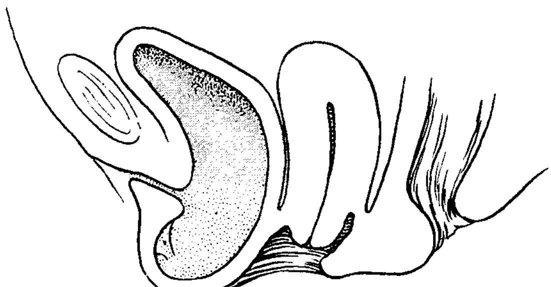

b

Figs. 113, 114.—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 181).

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.* 114) 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 distention 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.* 115). 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 bladder should come under frequent observation in these diseases for the purpose of ureteral catheterization. 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.

The indications for interference in uterine cancer rest almost

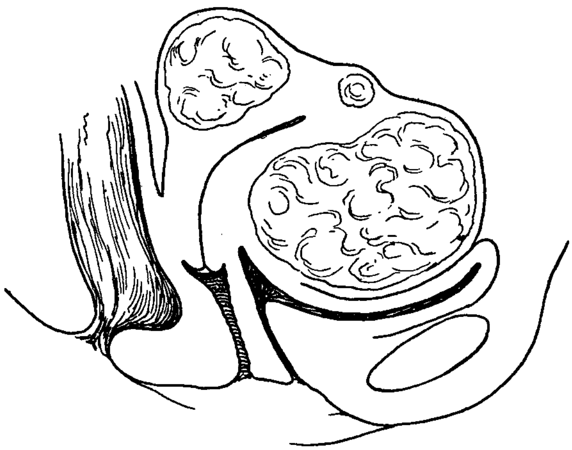

Fig. 115.—Effect on the bladder of uterine fibroids.

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. This investigation can be undertaken at the time of the ureteric catheterization. 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 similar type to that observed in enlargement of the uterus by fibroids. This distortion is usually of slight degree.

2. The earliest signs of invasion are increased vascularization and œdema of the vesical mucosa at the spot which overlies the neoplasm. This increases in degree, and in due course

3. A bud of carcinoma appears and gradually spreads (*Plate VII* D, page 132). 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.

4. When ulceration is marked, perforation and formation of a fistula into the genital passages occur.

In Chapter X the appearances presented by vesical carcinomata are more fully described. 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 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.

CHAPTER XVII.

URETERIC CATHETERIZATION.

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

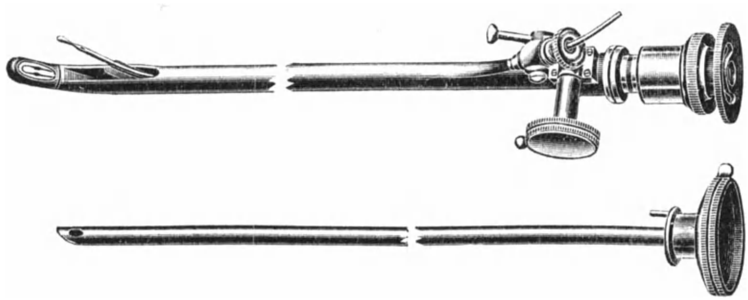

Fig. 116.—Single catheterizing cystoscope.

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.

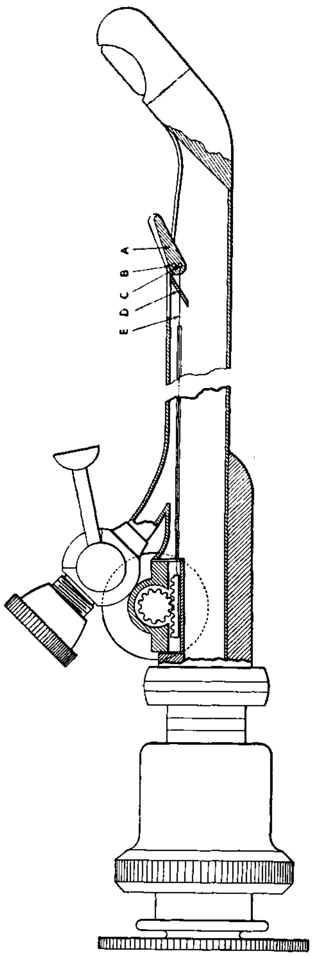

Fig. 117.—Single catheterizing cystoscope. A, Albarran lever; B, Pin on which the lever works; C, Pinhole through which the wires pass—pushing in order to lift the lever, and pulling to lower it; D, Sloping guide to direct ureteric catheter towards the lever; E, Wire connecting lever with rack.

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.* 116, 117).—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.

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.

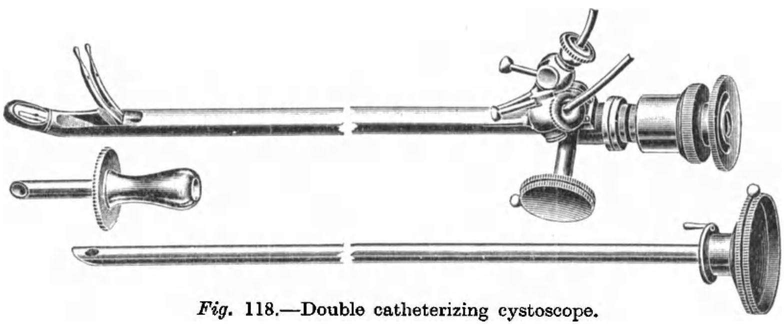

Fig. 118.—Double catheterizing cystoscope.

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.* 118).—This differs from the single model in that the catheterizing parts are duplicated throughout. The catheters may or may not be 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.* 119) several excellent modifications are adopted, and the cystoscope has become deservedly popular.

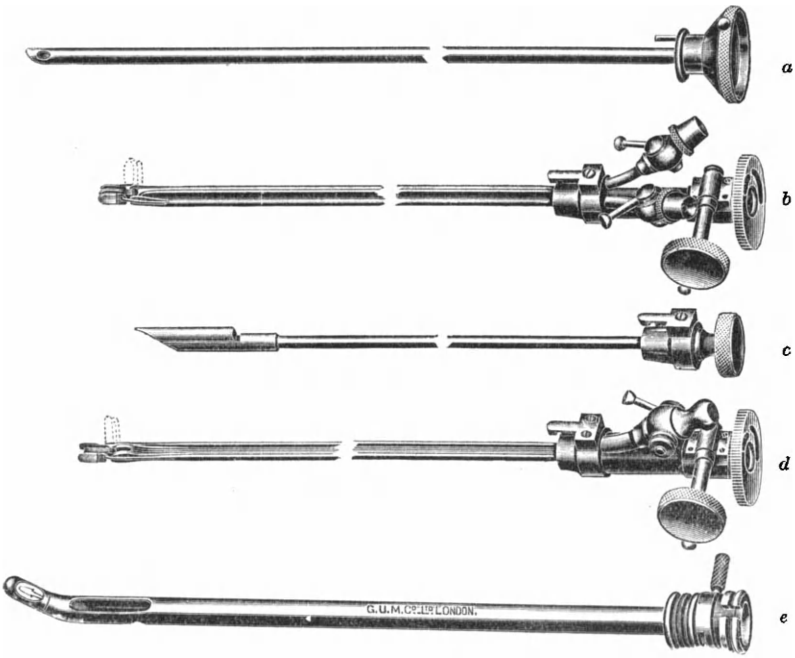

Fig. 119.—Swift Joly's catheterizing and operating cystoscope. *a*, Telescope ; *b*, Double catheterizing attachment ; *c*, Obturator ; *d*, Operating attachment ; *e*, Sheath.

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.* 120).

Fig. 120.—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.* 121). 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.

Mr. 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

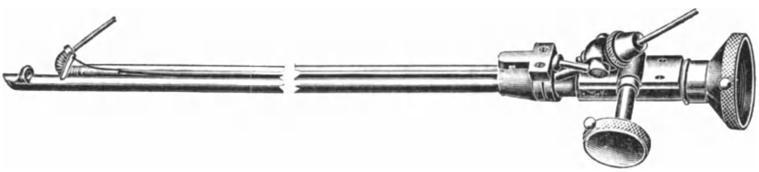

Fig. 121.—Telescope and operating attachment of Swift Joly's retrograde cystoscope for examination and fulguration of the internal meatus,. Note double-reflecting prism.

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.

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.* 122. 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.

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).

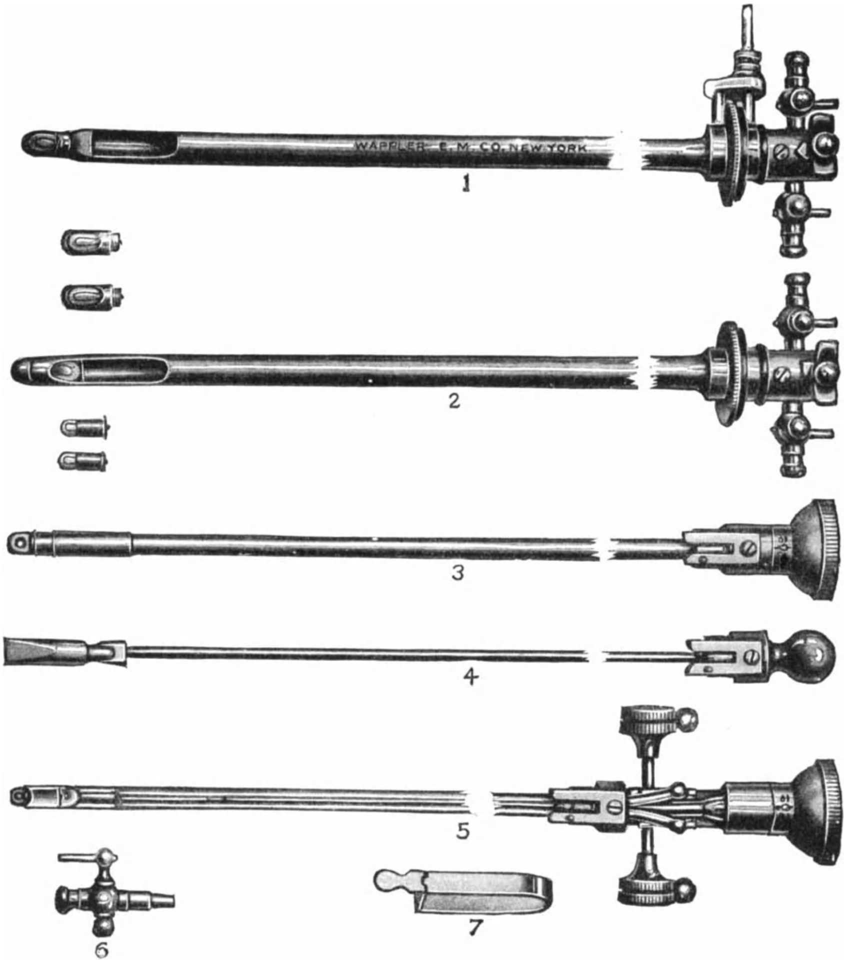

Fig. 122.—Brown-Buerger combination cystoscope. 1, Concave sheath and lamps; 2. Convex sheath and lamps; 3, Telescope; 4, Obturator; 5, Telescope combined with catheterizing apparatus; 6, Stop cock for irrigation; 7, Catheter clip.

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-distention, and therefore a small catheter which leaves plenty of room for leakage alongside it will be selected.

Fig. 123.—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.* 123). 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 & 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.* 130, page 209) 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.

The sterilization of the *interior* of the catheter is more 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 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. 124.—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.* 124 will be found useful, as it is universally adaptable to any syringe or

Fig. 125.—Ureteric catheter syringe.

catheter. The syringe shown in *Fig.* 125 may be employed with it, or with the tapering nozzle seen in *Fig.* 140, page 255. 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.* 126, and this is the most 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 instru-

ment 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 one of the nozzles shown in the illustration. Some paraform tablets are placed in a depression in the floor of the sterilizer and some

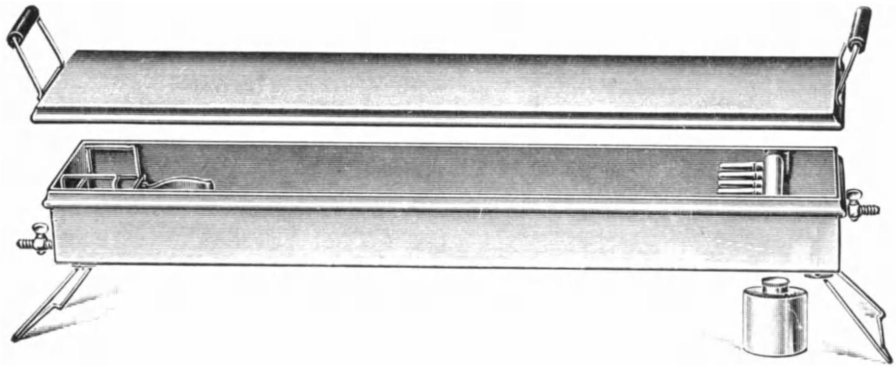

Fig. 126.—Ureteral catheter sterilizer.

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 these it reaches the cavity of the sterilizer, and here acts on the exterior of the instruments. The sterilization obtained by this method is

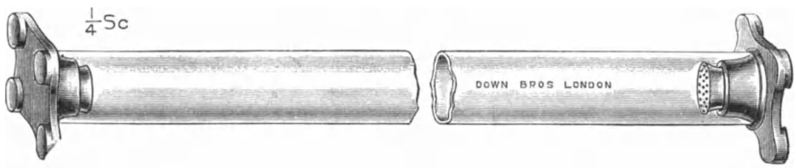

Fig. 127.—Glass catheter tube, for storage and sterilization of ureteric bougies and catheters, with formalin container at each end.

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.* 127**). The catheter box (***Fig.* 128**) 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.

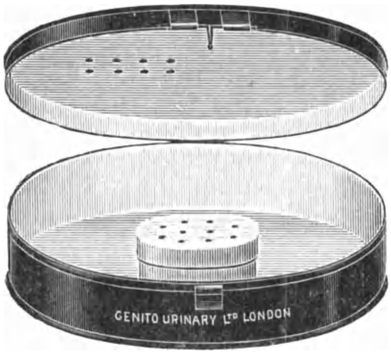

Fig. 128. — Everidge's catheter box for ureteral catheters, with formalin container.

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 41).

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

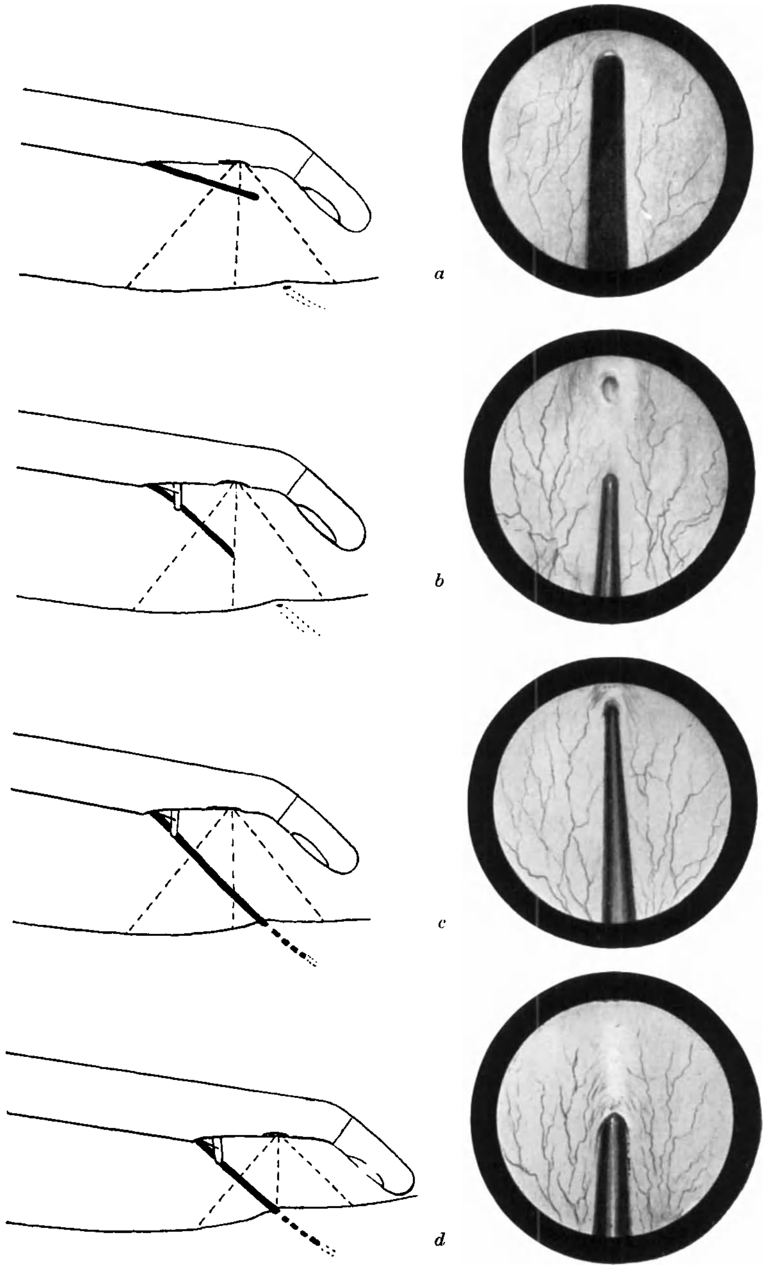

Fig. 129.—To illustrate the technique of ureteric catheterization.

[*To face page* 203

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 58 and 68. (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.* 129*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 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.* 129*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 208). 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.* 129*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.* 129*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 211), 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 further 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 below this it is generally 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 XV).

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 XVI, 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 further 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. 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 observations would then of course be made in renal examinations.

The ureter may be actually *absent.* A very careful and prolonged search should be made before deciding that this is so, especially when the bladder is diseased, and indigo-carmine should be employed to assist in its identification before the search is abandoned.

One of the commonest minor abnormalities to be observed is an exaggeration of the little salient on which the ureter normally emerges. It requires greater precision on the part of the operator to hit off an orifice so situated. The catheter must dip straight home without fouling the vesical floor. A skilled cystoscopist does not find this difficult, for he has accustomed himself to entering the ureter cleanly as a routine, so that when catheterizing across a septic bladder he may introduce the least possible quantity of contamination into the ureter. A puffy condition of the ureter of inflammatory origin may give rise to a similar elevation. An extreme degree of flexion should be given to the catheter in these cases by means 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 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

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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.

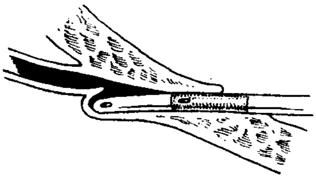


Fig. 130.—Ureteric catheter caught in a fold of mucous membrane.

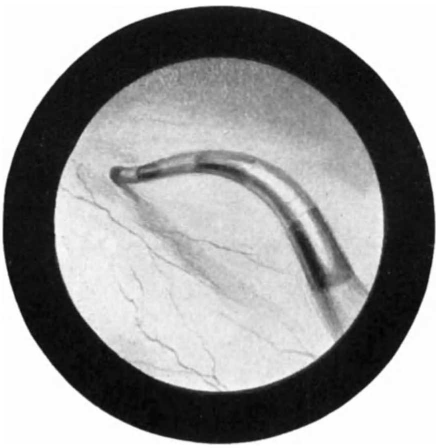


Fig. 131.—Catheter obstructed in ureter: intravesical portion bends up.

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* 130). The intravesical segment is then seen to become arched (*Fig.* 131). 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 :—

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 distention 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-distention 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 generally 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. Perhaps it is even better in these cases to use a rubber catheter for lavage and reserve the cystoscope until the bladder has been rendered as aseptic as the circumstances will allow. 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.

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 distention 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 XVIII.

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, 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, occurring in one of every five subjects over 30 years of age. They are usually rounded, though occasionally oval. They are often multiple, rarely larger than a pea, and have good and homogeneous density and sharply-cut margins. They occupy the pelvic area (vesico-prostatic 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 one infected case in the writer's experience the ureter prolapsed into the bladder like an everted coat-sleeve and appeared as a tower-like structure, the orifice being situated at the summit.

Hæmorrhages occur around the meatus (*Plate XI* 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.

PLATE XI.

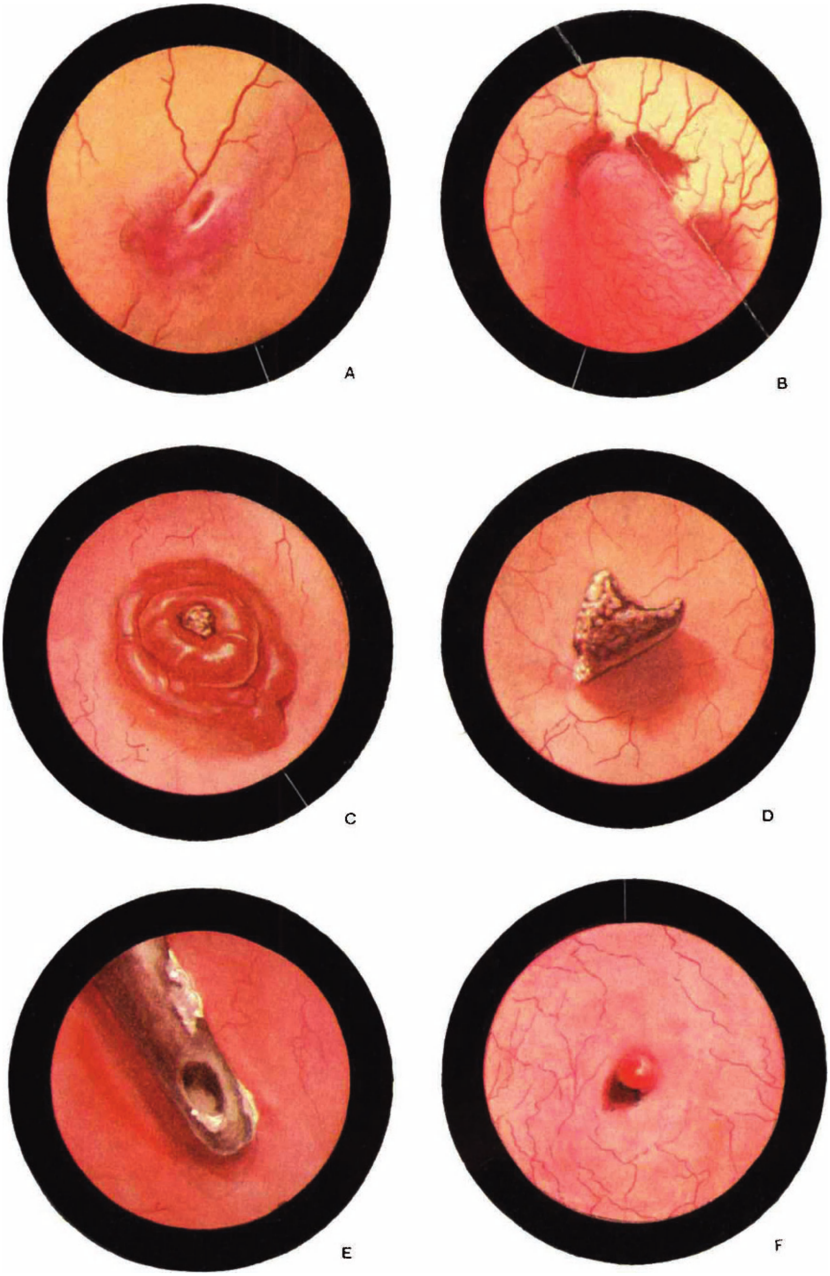
A, Stone descending ureter. Hæmorrhage subjacent to orifice. B. Ureteric stone, ecchymoses around ureteric bar. Orifice small, and slightly œdematous trigone prominent. C, Stone presenting at orifice. A rampart of œdematous mucosa surrounds the orifice, which is slightly everted. D, The same stone seen 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.

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 XI* C). When the stone escapes into the bladder cavity its presence there will be obvious cystoscopically (*Plate XI* 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

PLATE XI.

STONES DESCENDING THE URETER. FOREIGN BODIES IN THE BLADDER



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. The swollen 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* is usually diminished. When the duct is completely occluded no liquid can escape, and ineffectual muscular efforts will be witnessed. The absence of efflux is made more striking if indigo-carmine is issuing from the opposite ureter. 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. Generally it is 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.

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 233). The worm-like stream shown in *Plate XII* B, page 232, 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, when its intravesical portion will be seen to curl up (*see Fig.* 131). 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 208). 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 ear-piece 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 surface 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, junr., 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

Fig. 132.—Two stones in ureter. Relation of shadow to ureter made evident by opaque bougie.

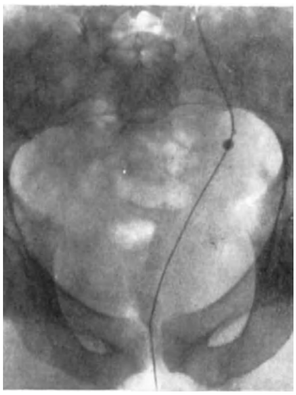


Fig. 133.—Opaque bougie in ureter. Portion of the stone has been chipped off by bougie and lies ¼ in. above the main stone.

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.* 132, 133). 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. 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.

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.—When a ureteric catheter is used, 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. 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. 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 Marion and Culligan have each recorded instances of the same phenomenon occurring in the renal pelvis.

Accentuation of the Stone Shadow.—When a faint indeterminate radiographic shadow is seen in the line of the ureter it can be accentuated by the introduction around it of colloid silver or silver iodide 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, though some urologists nowadays consider that these drugs are objectionable. They need be used, however, only in small quantities. Recently Girling Ball has exhibited plates showing a similar phenomenon produced by sodium bromide. In this case it appears probable that the stone is enveloped in a membrane which absorbs and retains the bromide solution.

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, but it may be said, without fear of contradiction, that at the present time far too much open surgery is practised.* The following factors will influence the choice : (1) The size of the stone ; (2) The time it has been impacted ; (3) Its position ; (4) The condition of the kidney ; (5) 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 or date stone will have a reasonable chance of success, whilst still larger ones have been evacuated under dilatation. Spiculated stones descend with greater difficulty than smooth ones.

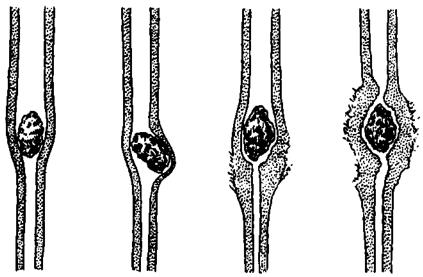
2. *The Time the Stone has been Impacted.*—Calculi which have been impacted at one spot for a long time may be surrounded by periureteral thickening and have a subjacent stricture, and this latter may be indicated by the ureterogram. It is often quite easily overcome by dilatation. The possibility of diverticulation can also be suspected by careful inspection of the ureterogram, and 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.* 134** illustrates various ureteric states associated with the presence of a stone in its lumen.

3. *The Position of the Stone.*—The higher the stone lies in the ureter, the more accessible it is to open operative treatment. Calculi at the ureteropelvic junction should be submitted to pyelotomy. Stones placed deeply in the pelvis are very inaccessible. Conversely, those in the lower ureter are eminently suitable for cystoscopic removal, though the ones in the upper reaches also generally yield to catheter manipulation, and this should be tried unless the stone is of

* 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.

large size. Judd says that cystoscopic technique is 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. Bugbee believes that 75 per cent of all patients will be relieved of their calculi by these means. Stones in the lower ureter are generally of small size, the larger ones being found in the proximal ureter.

4. *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, etc., and on this or other account will require removal, when the two conditions will probably be best treated simultaneously by open operation.



a *b* *c* *d*

Fig. 134.—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 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. 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.

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.), oxycyanide of mercury (1–3000), flavine (1–1000 in aqueous solution), or mercurochrome (1 per cent in normal saline).

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 encouraging the extrusion of the calculus. I find that a calculus rarely moves so long as the catheter is *in situ*. Before withdrawal the ureter spould 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

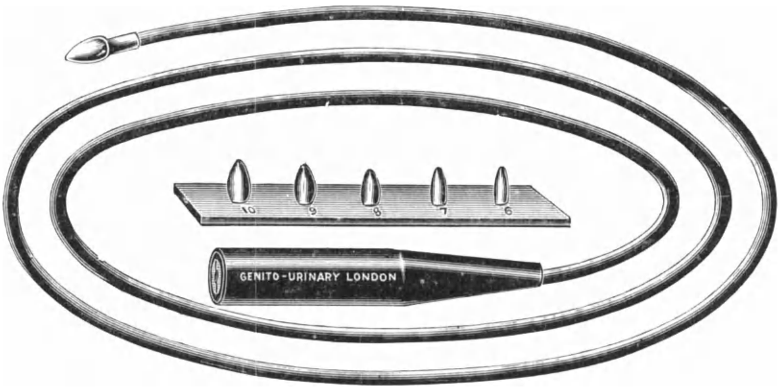


Fig. 135.—Buerger's dilating olives.

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.

Graduated Metal Olives.—Buerger has introduced graduated metal olives for dilatation of the ureter (*Fig.* 135). 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 exercised 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 distention 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.* 136) similar in principle to the straight Kollmann's urethral dilator and manipulated from the exterior by a cable. It is specially useful in the intra-

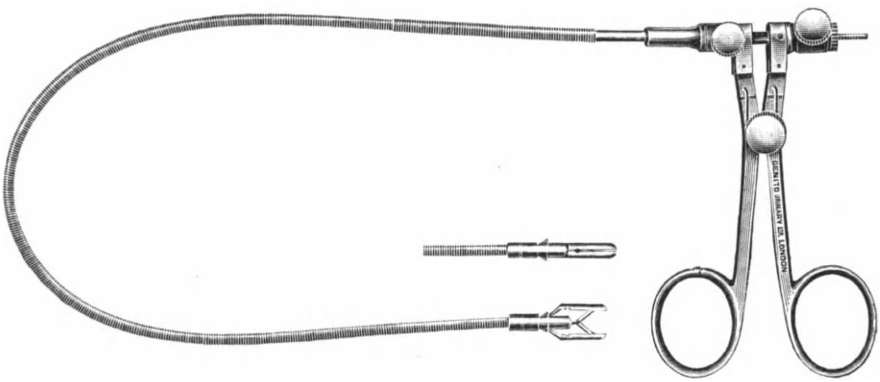


Fig. 136.—Bransford Lewis's ureteral dilator.

vesical 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.

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.* 137 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

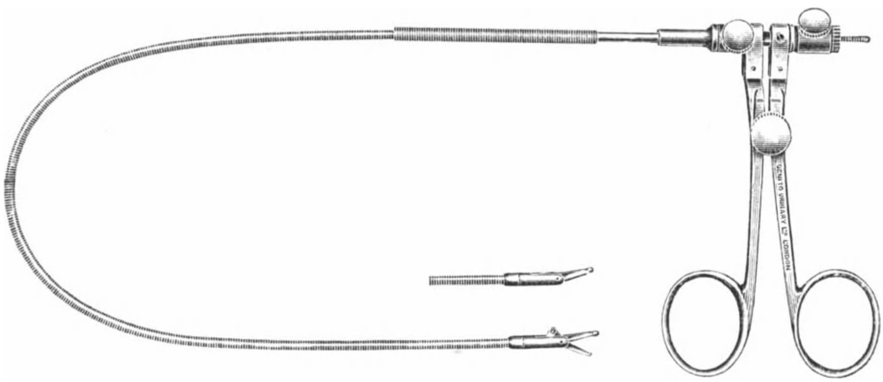


Fig. 137.—Buerger's scissors for use with operating cystoscope.

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. Hæmorrhage soon clouds the vesical medium, so that if the first or second incision is inadequate, further progress may be impeded.

Diathermy of the anterior wall of the intravesical ureter is easy, and the extent of the incision is under more accurate control than is the case when cutting instruments are employed. As hæmorrhage is absent the operation can be performed deliberately. When the stone actually presents at the opening (*Plate XI* c, page 214, and *Fig.* 138), 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. A week or more is required for the separation of sloughs, so that the stone is not so immediately liberated as when the scissors are employed. For this reason, when dealing with urgent cases, especially with calculous anuria, it is inferior to incision with the scissors.

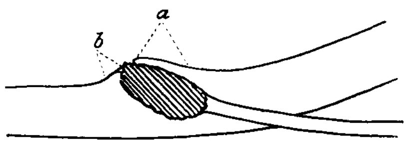


Fig. 138.—Sites for application of electrode when a stone impacted at the meatus is being released by diathermy. *a* is the usual and more important position.

Extraction by Ureteral Forceps.—Forceps (*see Fig.* 95, page 163) 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 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.

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 may tap a distended cavity, but quite frequently 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 XIX.

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 the succeeding chapter methods of examining the renal function will be described. Pyelography, which is closely related to these subjects, will be dealt with in the final chapter.

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 will be the next and final resort. The description will consider: (I) *Changes in the meatus itself*; (II) *Changes in the efflux.*

I. CHANGES IN THE MEATUS.

Congenital Abnormality.—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 XX) 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 XII* E). The relationship of a double orifice to duplication of the upper tract will be discussed in Chapter XXI. 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 ureteropyelography (*Fig.* 153, page 257).

Congenital Diminution.—Orifices of less than usual size have been noted in the chapter on the normal bladder (*Plate II* A, page 68). 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 ureteropyelitis, 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 76).

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 XII* 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 VI* E, page 126, 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.

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 Hœmorrhage.—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.

PLATE XII.

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.

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.

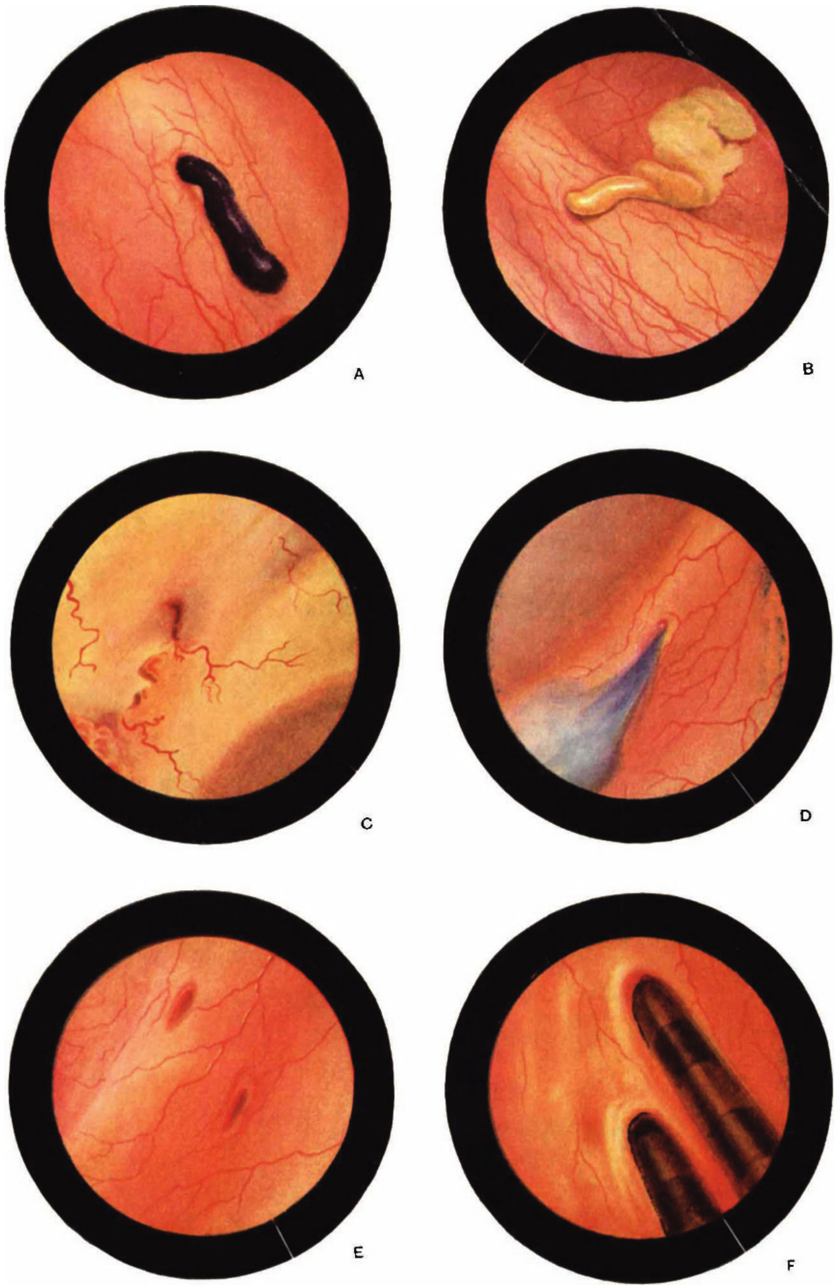
3. Clotting may take place in the ureter, producing the worm-like coagula sometimes found in the urine. Such a clot is occasionally seen in process of being extruded from the ureteric meatus (*Plate XII* A). It is a deep purplish-red comma-shaped body hanging from the orifice, but if its expulsion is 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,

PLATE XII.

THE URETER IN VARIOUS CONDITIONS



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 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 XII* 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) *Pyelography*.

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 most 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 XXI).—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 two examinations are related and complementary, and their results must be reviewed together. 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 XX.

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. As the cystoscopist is responsible for this work, he must be acquainted with the various tests, so that their description falls appropriately within the covers of this work.

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.

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 two sets of excretion tests in common use at the present time : (1) Those depending on the elimination of substances occurring in our normal metabolism ; and (2) The 'dye tests'. Of the former I shall describe one, the urea-concentration test, and of the latter two, the indigo-carmine and the phenolsulphonephthalein tests.

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.

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 phenolsulphonephthalein 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. It can be obtained in sealed sterile ampoules of 10-c.c. capacity, from Messrs. Mottershead & Co., Manchester.

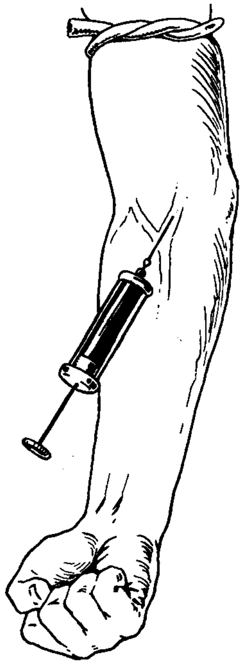


Fig. 139.—Injection of indigo-carmine into a vein.

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 excentric 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.* 139) 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. 7 c.c. are used for adults, and lesser quantities for younger subjects.

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 XII* D, page 232). 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.

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 3½-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.

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—1¾ to 4 minutes.

When phenolsulphonephthalein is used in the estimation of total renal function the test is a quantitative one. The urines excreted

* 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.

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 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,

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* Marrack, however, states that blood can be removed by precipitation with zinc chloride.

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 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.

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 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, this blood-urea test seems to give the best evidence which the circumstances will allow.

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 235) 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.

CHAPTER XXI.

PYELOGRAPHY.

Pyelography is the name given to the demonstration of the renal pelvis by radiography after filling it through a ureteric catheter with a solution opaque to the X rays. It has many uses, giving information about the shape and position of the renal pelvis which cannot be obtained by any other means. 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, being particularly developed by Braasch in America and Papin in France. The former has had unequalled material for investigational work, and to his efforts and writings more than to those of anyone else is due our present knowledge of the pyelographic appearances in health and in disease.

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 it 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 possibility of pelvic distention 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 pyelography. Its features and importance will be discussed later (pages 257 et seq.).

3. Alterations in the shape of the pelvis may be due to :—

a. Mechanical distention of the pelvis due to obstruction at the ureteropelvic junction or at a lower level. The cause may be intrinsic or extrinsic.

b. 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.)

c. 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.

d. 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. Intramural shadows become partially or completely obliterated by the superimposed shadow if in the pelvis, whilst if in the parenchyma they will have their relationship to the pelvic shadow exhibited.

TECHNIQUE OF PYELOGRAPHY.

It is 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, and the details of the ureteric catheterization are performed as described in Chapter XVII. It is customary to employ a small ureteric catheter, one not larger than a No. 5, as an additional precaution against over-distention of the renal pelvis, so that the fluid may easily regurgitate along the side of the catheter and escape. 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 less than a minute. 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 distention of the pelvis. Only by personal attention will proper distention 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.

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 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 distention (*see* page 254) and to expose films frequently. Pain should be inconsiderable, but if it is complained of, a hypodermic injection of morphia may be administered in the wards following the examination. The writer never undertakes pyelography on out-patients, as it is undesirable that they should travel or be exposed to cold for some time after the operation.

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 becoming 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, 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 best 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.

Method of Injection.—In the early days a number of accidents, including some fatalities, were reported, due to over-distention 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-distention, 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 is a safe operation if the pressure of the injection is kept within strict limits. 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 distention is inadequate, more fluid is employed. Over-distention 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.* 125, page 200, may be employed in conjunction with the conical nozzle (*Fig.* 140) or the universal fitting (*Fig.* 124, page 200). 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. 140.—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 calyx with little deviation, but more commonly this line is broken by a double curve first outwards and then upwards, so that the calyx, though more or less parallel to the ureteric line, is more externally placed. The lower border of the pelvis diverges rapidly from the mesial, sweeping over with a regular and shapely curve into the lowest calyx. The outer margin receives the middle calyces.

Variations in the Normal Pelvic Contour.—These depend chiefly upon the respective extent to which the calyces and the pelvis proper are developed. Three principal types may be described :—

1. *Type A.*—In the first and most usual type (*Figs.* 141–144) the triangular outline of the pelvis is well marked, receiving above the upper calyx; below, the lower; and at a point near its centre, one or more shorter calyces.

It is convenient at this point to describe the appearance of the calyces. These have been divided by Braasch into major and minor. The *major* or primary calyces 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 calyx which curves outwards and downwards.

When long these calyces are seen to be slightly constricted at their middle, but when short they are generally stout and have parallel margins.

Two or three *minor* or secondary calyces cap the extremity of each primary calyx, 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 calyces 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 calyces face as above, but additional cups are present looking inwards and upwards in the case of the upper pole, inwards and downwards in the case of the lower, to drain the extremities of the gland. The minor calyces 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 distention. 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.* 145–147) the familiar funnel-shaped pelvis has been encroached upon by an unwonted development of the major calyces, and in well-marked instances (*Fig.* 150) the pelvis proper ceases to exist. There is then an upper and a lower calyx, and the condition differs only in degree from that known as duplication of the renal pelvis. The pelvis is Y- or T-shaped, the middle calyx opening into the upper or lower branch, or occasionally at the angle between the two. 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.* 148) the pelvis proper is more developed and absorbs the major calyces so that the minor calyces open directly into the pelvis itself.

These three types are selected in order to facilitate description, but it must be remembered that intermediate varieties are constantly observed.

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

Figs. 141–144, *Type A*, show the *standard type* of normal pelvis. *Figs.* 145–147, *Type B*, where a more marked development of the major calyces has reduced the size of the pelvis proper, so that it approximates in type to the bifid pelvis seen in *Fig.* 150. *Fig.* 148, *Type C*, Pelvis well marked ; major calyces absent, and minor calyces open direct into the pelvis.

Examine each pyelogram for the fine contour of the minor calyces seen best in *Figs.* 141, 144, and 148, and for calyces occupying the sagittal plain and, therefore, seen end-on—e.g., lower middle calyx of *Fig.* 144 and some calyces in *Fig.* 148.

In *Figs.* 142 and 145 the ureter has been bowed inwards by the catheter, and in each figure note that the catheter has entered the upper calyx, whence it has obtained its purchase.

Fig. 141.—*Type A.* Representative example. Note long upper calyx only faintly outlined, and also the delicately formed cups.

Fig. 142.—*Type A.* Calyces evenly distributed. The ureter has been bowed inwards by the catheter, which has entered the upper calyx.

Fig. 143.—*Type A.*
Pelvis of simple form. Middle calyx single.

Fig. 144.—*Type A.* Major calyces strongly represented. Middle calyx double and obviously foreshortened. Fimbriated minor calyces.

Fig. 145.—*Type B.* Pelvis proper small. Upper and lower major calyces large. Two middle ones open into latter. Ureter displaced inwards by catheter.

Fig. 146.—*Type B.* Pelvis small. Calyces branch freely.

Fig. 147.—*Type B.* The pelvic outline in this figure must be distinguished from shadows thrown by gas in the colon.

Fig. 148.—*Type C.* Minor calyces open almost directly into the pelvis proper and they are deeply cupped. The shadow of the pelvis overlies that of the last rib.

Fig. 149.—Horseshoe kidney. Pelves close to mid-line, somewhat low, definitely dilated. Note presence of calyces on inner side of ureter. (*Mr. Jocelyn Swan.*)

Fig. 150.
Normal pelvis, but tending strongly to duplication.

Fig. 151.

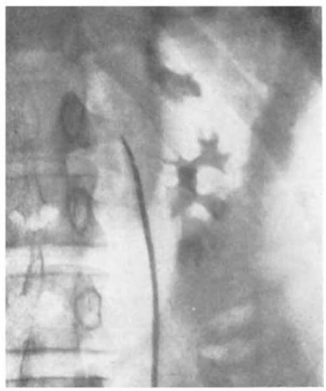

Fig. 152.

Figs. 151, 152.—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.* 151), and later the upper pelvis was filled through catheter which appears in the pyelogram (*Fig.* 152). Note small size and rudimentary appearance of upper pelvis.

Fig. 153.—CYSTOGRAM. Great distention of bladder in boy, age 10. Regurgitation into left ureter and renal pelvis, which are much dilated. Subsequent pyelography of right kidney gave picture seen in *Fig.* 148. Nephrectomy (left): recovery. (*Mr. Cyril Nitch.*)

Fig. 154.

Mobile kidney. Slight distention of pelvis.

Fig. 155.—Low-lying kidney, non-mobile, probably defective ascent. Hydronephrosis. Strong band of tissue separates intrarenal from pelvic distention.

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 calyx, and the ureter becomes bowed in an antero-posterior direction (*Figs.* **142**, **145**). 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 calyces as a rule present their full length to the rays, but frequently the middle one is foreshortened (*Figs.* **144**, **148**, **152**). The middle calyx is normally shorter than the other two, and by such foreshortening this feature is accentuated. Occasionally the extremities of the calyces 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.

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 calyces, whose development is very variable. These latter may reach in the upward direction as high as the 11th rib. The extremity of the lowest calyx rarely descends below the transverse process of the 3rd lumbar vertebra in health.

CONGENITAL ABNORMALITIES OF THE KIDNEY.

Congenital abnormality may take the form of: (1) *Displacement* (*dystopia renalis*); (2) *Horseshoe kidney*; (3) *Duplication of the renal pelvis, ureter, and kidney.*

1. **Congenital Displacement.**—Pyelography is undertaken in congenital displacement of the kidney either as a part of the routine investigation of urinary trouble, when the organ is found in some unexpected position, or it is used as a method of establishing the nature of a lump which is suspected to be a misplaced kidney. Frequently the catheter does not reach the pelvis because of the circuitous course taken by the ureter, but the injected fluid usually finds its destination and demonstrates the position of the kidney.

The following brief description of renal embryology will serve to indicate the situations in which dystopic organs may be found. The kidney may fail to migrate from its place of origin. Primarily formed in front of the sacrum, it may remain there, constituting the pelvic variety of dystopia. One or both organs may be found in this position, and when double they generally retain the fused condition. The pelvis faces forwards and the ureters emerge anteriorly and descend in front of the parenchyma of the fused lower poles and the inferior extremity of the pelvis. If the kidney ascends, but yet remains united at its lower pole (horseshoe kidney), its relationship to the ureters is maintained. Either kidney in its ascent from the sacrum may halt in any position short of the normal one. It may then be found in the iliac, lower lumbar (*Fig.* 155), or other position as the case may be. The left kidney more frequently fails to reach its destination than the right. The two organs remaining fused may ascend on the same side of the spine; one ureter as a rule then crosses the mid-line to reach the misplaced gland.

2. **Horseshoe Kidney** (*Fig.* 149).—This condition is best diagnosed by bilateral pyelography. The two pelves are then found to be closer than usual to the mid-line, to lie at a lower level than normal and to be misshapen. They are frequently dilated. The ureter, as above stated, passes in front of the united lower poles and in so doing may come to overlap the lowest calyx. Calyces found on the inner side of the ureter should arouse suspicion of a horseshoe kidney and are an indication for bilateral pyelography if surgical interference is contemplated, though there is a tendency nowadays to avoid bilateral simultaneous pyelography.

3. **Duplication of Organs.**—Duplication of the renal pelvis (*Fig.* 150) is the slightest form of duplication and may occur in association with an otherwise normal kidney, a fused, or a double kidney. In the downward direction the duplication may stop short of the ureter or be extended to involve that tube. If the ureteric duplication is partial, it is referred to as a 'bifid ureter'; if complete, as a 'double ureter'.

Pelvic duplication "varies in degree from an abnormal elongation of the upper calyx to two distinct and widely separated pelves" (*Figs.* 151, 152) . . . "When the pelvis is duplicated completely, the lower pelvis is usually larger and more completely formed. The upper pelvis is usually smaller, has fewer calyces, and is often rudimentary. This disparity in size occurs so frequently that if, in the course of routine pyelography, the outline of the pelvis is unusually small and high-lying, duplication of the pelvis should be inferred, and attempts made to outline the lower pelvis. . . . With duplication of the pelvis of one kidney a tendency towards duplication or unusual increase in size is usually apparent in the other." (Braasch.)

When the *ureter is bifid*—that is, double only in a portion of its extent—it is impossible to surmise its condition apart from pyelography. Here the catheter may pass as far as the bifurcation and there be arrested, or it may select one of the ureters and proceed to the corresponding renal pelvis. It will generally be found that the solution outlines both pelves. In the case where the catheter has progressed beyond the junction the fluid in its return flow down the ureter prefers to regurgitate by the second channel rather than to find its way along the lower ureter which is already partially filled with the catheter.

Duplication of the ureter in its whole course (*double ureter*) is demonstrable by meatoscopy (*Plate XII* E, F, page 232), unless one of the ureters is misplaced. If two ureteric openings are found in the bladder, it may be presumed that there are two complete ureters and two renal pelves, for in no authentic case has the ureter been found bifid in its lower extent and single in its upper. Catheterization of each ureter combined with pyelography will display the pelvic outline and show if it is normal or not. When one orifice is misplaced—for instance, in the urethra—it can sometimes be satisfactorily catheterized and a pyelogram obtained (Papin). In complete duplication it will be found an invariable rule that the ureter draining the upper pelvis is inserted as the lower one at the bladder. In the ureterogram they are seen to effect a double crossing, one of which occurs immediately above the bladder and the other in the upper lumbar region.

The presence of a normally situated orifice must not be taken as evidence of the presence of a kidney, for in some cases the latter is absent. The orifice would then be motionless and no carmine would be excreted at it on chromocystoscopy being tried. Pyelography would fail to outline a renal pelvis.

Congenital malformation of the kidney is often associated with malformation in the genital system, and when one of these is discovered a look-out should be kept for the other. " In the Ballowitz collection of 213 cases of congenital defects of the kidney, the state of the genital organs was mentioned in 103, and in 73 of these (70·8 per cent) some malformation was present. Of these, 28 were male and 41 female; the sex of the remaining 4 cases was not stated. Further, the genital malformation is, almost without exception, on the same side as the renal defect." (Thomson-Walker.) Genital malformation is therefore important corroborative evidence of congenital renal anomaly.

The importance of the subject of congenital abnormality lies in the frequency with which it occurs, and the increased susceptibility of abnormal organs to disease. Separate estimations by Poirer, Pohlman, Huntingdon, and others have shown that about 3 per cent of all bodies have complete or partial duplication of the ureter. In these one or both ureters are strictured with fair frequency, and the corresponding portion of the kidney is cystic or hydronephrotic.

Robinson discovered hydro-ureter of one ureter in 24 per cent of 50 specimens of duplication. Mertz found that disease of the kidney existed in 30 per cent of 300 investigated cases of double ureter, whilst 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.

The number of cases in which congenital abnormality of the upper urinary tract is associated with disease was investigated by Botez. In 51,504 autopsy records this writer showed that horseshoe kidney occurred once in 715, whilst in 1000 operations on the kidney it occurred once in 143—that is, five times more frequently.

It will be seen therefore that congenital abnormality is important rather by reason of its complications than on its own account, and that 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.

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 calyces as seen on the radiogram will undergo modification, so that the upper and lower calyces 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 (*Fig.* 154, page 257, and *Fig.* 161, page 266). Kinks near the ureteropelvic junction may then be ascribed to adhesion between the ureter and the dilated hydronephrotic sac. Definite distention 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 distention 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 distention is often far from easy, and that therefore the importance of an accurate diagnosis prior to operation is greatly increased. Pyelography has therefore filled 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 distention 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.—If a large hydronephrosis can be diagnosed satisfactorily by symptomatology and abdominal palpation, the cystoscopist should 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* page 253), neither of which is desirable.

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 suffered such deformity as is witnessed in renal neoplasm or congenital cystic disease of the kidney (*see* page 269). 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 is arrested 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 distention 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 flow 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 (*Fig.* 164, page 266). Therefore in distending large sacs it is wise to use a solution of increased strength.

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 overdistention.

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 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 Distention 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 distentions give pronounced symptoms and are the ones where assistance is most required. Nevertheless pyelography is the only available method of diagnosis.

Small Hydronephroses.—Distention will naturally first affect the soft renal parenchyma, and later the more fibrous pelvis. Pressure atrophy therefore occurs in the neighbourhood of the papillæ and shows itself through an increase in the size of the calycine shadow.

The earliest change is seen in the cup-shaped *minor calyces*, which become decreasingly concave and are eventually flattened or even convex. The major calyx, with its distended minor calyces, thus assumes a club-shaped appearance. This is, perhaps, the most important of all early changes from the diagnostic point of view.

The next structure to be involved is the *major calyx*, 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 calyx may or may not be noted, for often atrophy affects equally the depths of the sinus and its portals—intercalycine papillæ. Later the calyces are definitely shortened.

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 ureterocalycine curve. This becomes more and more acute as the lower calyx 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 distention 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 calyces may escape distention. 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.—As distention progresses, all the features enumerated above become exaggerated, the pelvis is larger, the calyces are broader and shorter, and the ureteric insertion is more displaced.

Large Hydronephroses.—As before stated, pyelography is generally unnecessary for those cases which can be diagnosed by 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. When it is undertaken the solution used should be of increased strength in order to allow for its dilution by the residual urine. Little or no pain is caused by the distention 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 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) (*Figs.* 164, 165; and *Fig.* 155, page 257).

In the *pelvic* type the enlargement occurs chiefly outside the renal sinus (extrarenal type). The pelvis is greatly enlarged and is usually more or less rounded (*Fig.* 162), though it may retain its triangular contour (*Fig.* 163). 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) (*Fig.* 153, page 257). The pelvis may be little or not at all dilated, whilst the parenchyma is greatly reduced in thickness. It may take the form of a single smooth-walled cavity, but more commonly the pyelogram shows a central cavity into which open numerous secondary loculi (*Fig.* 166), exhibiting an undulating or more deeply scalloped external border, in correspondence with the 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.* 164, 167).

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 evidence; 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

Note the enlargement of the pelvis proper, the broadening of the major and the obliteration of the minor calyces. The effects are felt irregularly, one calyx yielding more than its neighbours. In every plate the upper and lower calyces show distention more than the middle one. *Fig.* 159 is not fully distended with solution. This pelvis prior to dilatation was probably shaped like *Type B* (*see* page 256 and *Figs.* 145–7). Compare the shapes of these pelves carefully with those in *Figs.* 141–8. In *Figs.* 160 and 161 the catheter is arrested at the ureteropelvic junction and the pressure of its tip has distorted the channel. Examine for back-flow down ureter, best seen in *Figs.* 160 and 161, and observe the irregular distention resulting from peristalsis. In *Fig.* 161 the pelvis is low-lying and the distention was due to this. In *Fig.* 157 the tip of the catheter is seen in the upper calyx, and the ureter is slightly bowed. In *Figs.* 160 and 161 pyelectasis is more advanced than in their predecessors.

Fig. 156.—Dilatation slight but unquestionable. Chief evidence is the clubbing of the calyces.

Fig. 157.—The tip of the catheter is seen in the upper calyx, and the ureter is displaced.

Fig. 158.
Upper calyx mainly affected.

Fig. 159.—Pyelectasis evident but pelvis not fully distended with solution.

Fig. 160.—Distention uniform and of medium severity. Minor calyces completely effaced.

Fig. 161.—Upper and lower poles much dilated. Middle calyx unaffected.

Figs. 160 and 161 show the catheter arrested at the ureteropelvic junction, and ureteric regurgitation. Observe the peristaltic wave.

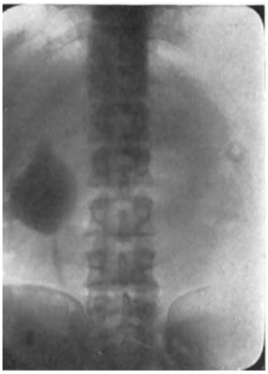

Fig. 162. — Hydronephrosis due to aberrant vessels. Pelvic type. Calyces clubbed but still well formed. (*Mr. Cyril Nitch.*)

Fig. 163. — Hydronephrosis, pelvic type, due to ureteric obstruction low down. Triangular contour retained.

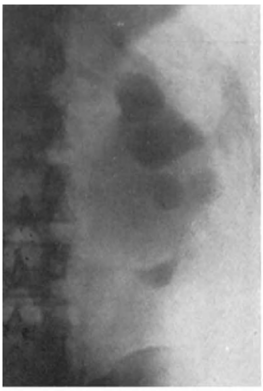

Fig. 164. — Hydronephrosis of mixed type and congenital origin—pelvis and calyces both much dilated. Pelvis could not be emptied prior to injection of solution, which has incompletely mixed with the contained urine, and has outlined the rounded upper calyces distinctly, but the pelvis and lower calyces less well.

Fig. 165. — Hydronephrosis of mixed type. Catheter has only entered the ureter a short distance. (*Mr. Jocelyn Swan.*)

Fig. 166.—Hydronephrosis in which the rounded calyces are well seen but the pelvis is not obvious.

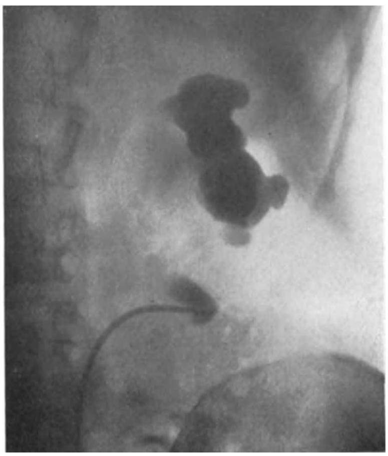

Fig. 167.—Hydronephrosis of large size incompletely filled.

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.* 168). 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.

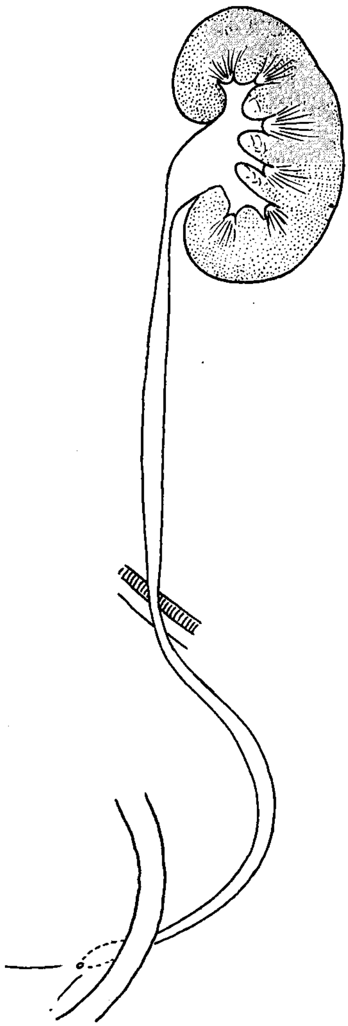

Fig. 168.—Diagrammatic representation of the variations in width of the normal ureter.

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 (*Figs.* 160, 161).

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. 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 (*Figs.* 160, 161). The ureter, as a result of either of these accidents, may be foreshortened and appear to be strictured.

The most usual site for obstruction is the ureteropelvic 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 its consequences will be limited to that branch and to the corresponding portion of the kidney (partial hydronephrosis).

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 calyces, pelvis, or sometimes by the 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. A medium of strength greater than usual should therefore be employed to allow for its dilution. 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.

The writer has avoided pyelography in urinary tuberculosis, and regards it as a dangerous and undesirable examination. The diagnosis should be made by other means, which are discussed in Chapter VI. The 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 as far as possible. (2) The ulcerated papillæ allow easy access of the pyelographic 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 distention. (3) The trauma caused to a severely diseased organ would appear to be a ready method of disseminating organisms.

Pyelography 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 with the stage and type of the disease :—

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. 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. 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 number.

4. When the ureter becomes strictured it may be impossible to outline the pelvis at all, or the appearance may be that of a pyonephrosis.

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 concave shadows on the pyelogram (*Figs.* 169–171). 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 (*Fig.* 170). A considerable development of cysts in the upper pole of the kidney may displace the pelvis downwards, whilst a similar increment at its lower end may modify the course of the ureter.

The condition is invariably bilateral, as can be demonstrated by taking a pyelogram of the second organ. The two pyelograms should not, however, be made simultaneously. The 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 calyces and later proceeds to deal similarly with the pelvis itself. A few calyces or a portion of the pelvic shadow may therefore be missing from the pyelogram. In due course more calyces, and perhaps the whole of the pelvis, disappear. Coincident with this obliteration of calyces and pelvis, elongation or retraction of other calyces in the remainder of the gland occurs. These elongated calyces are 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 calyces 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 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.*175) and cause a filling defect suggesting a neoplasm. When the tumour becomes impacted in the pelvic outlet a hydronephrosis may be produced.

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 (*Figs.* 172, 173). 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. Rarely they also cause deformity of the pelvis, but

Fig. 169. — Polycystic kidney (right). Flattened and elongated pelvis.

Fig. 170.—Left kidney of same patient as *Fig.* 169. Disease more advanced here. Note the long curved shadows, each probably related to the convexity of a cyst. (*Mr. Cyril Nitch's case.*)

Fig. 171.—Polycystic kidney.

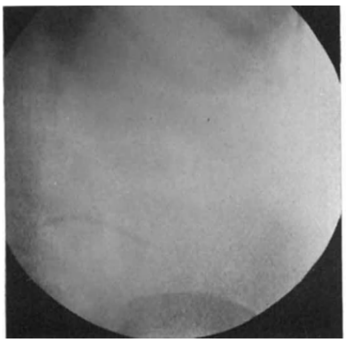

Fig. 172.

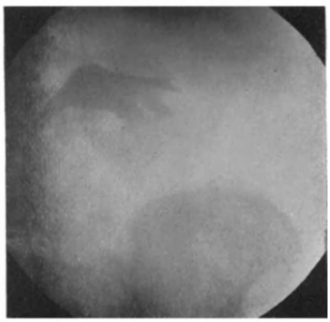

Fig. 173.

Figs. 172, 173.—New growth of *upper* pole of kidney. In *Fig* 172 the catheter is bowed down and finishes close to iliac crest. *Fig.* 173 was taken after injection of solution. Observe the low position of pelvis due to its displacement by superimposed growth. It is abnormal in shape. Its upper margin is convex owing to encroachment of the tumour. The catheter occupies uppermost available calyx. (*Mr. Jocelyn Swan.*)

To face page 270]

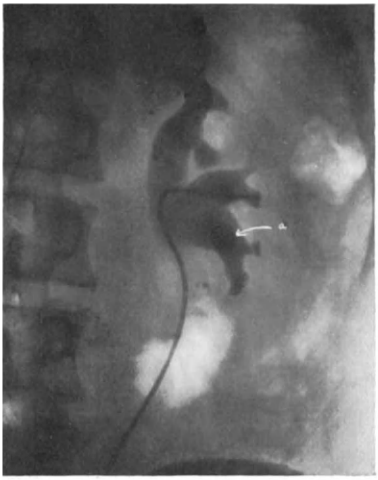

Fig. 174.—Hydronephrosis due to stone blocking the ureteropelvic junction. The stone (*a*) has been displaced by the catheter into lowest calyx, but at operation was at pelvic outlet.

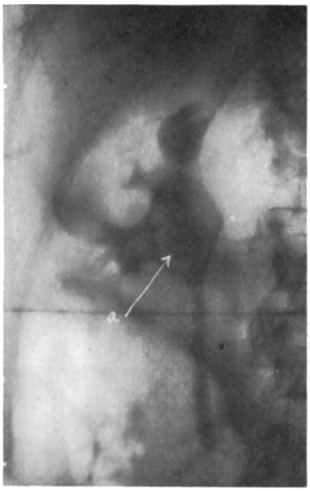

Fig. 175.—Stone in the renal pelvis (*a*). The pelvis was filled with pultaceous material, probably changed blood, and this accounts for the irregularity of the pelvic shadow, which has a vacuolated appearance. It illustrates the effect on pyelography of foreign material in the pelvis.

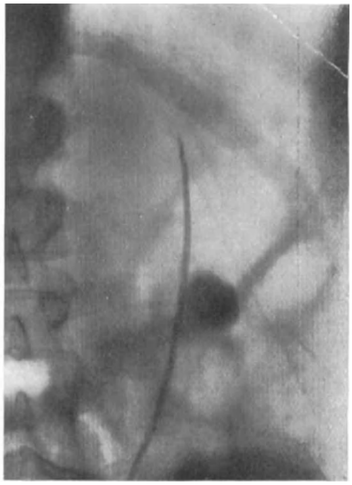

Fig. 176.—Rounded shadow lying low in renal area. Catheter passes close to it, but its tip is seen to have passed 2½ in. beyond it.

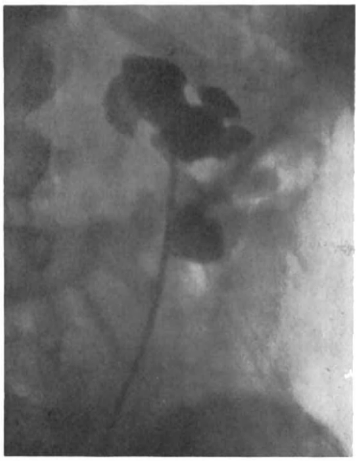

Fig. 177.—Same patient as *Fig.* 176. Solution has been injected. It outlines the upper calyces only and they are dilated. Stone shadow occupies position of lower calyces and no solution has escaped past it to the parenchymal aspect. Stone is therefore impacted in lower calyces and this was confirmed at operation.

Fig. 178.—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.

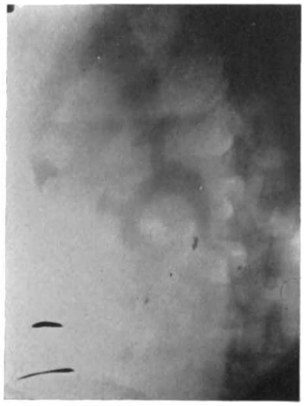

Fig. 179.—Case of shrapnel wound of the loin. Renal crises. Four foreign bodies are seen in the radiogram, two of which are situated in relation to the upper ureter. The ureter is distorted by them. Crises relieved by liberation of the ureter.

Fig. 180.—Numerous spherical shadows in left flank, probably small renal calculi.

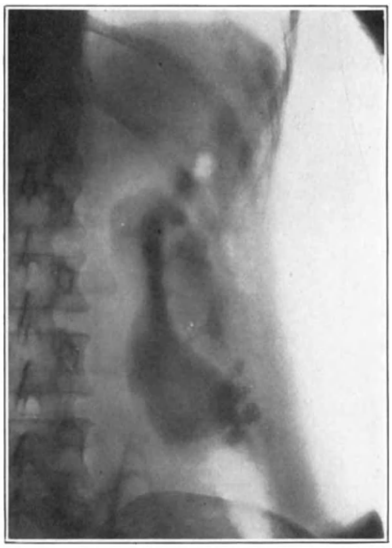

Fig. 181.—Shows that they are arranged around a large hydronephrotic sac which is, in this pyelogram, only partially filled.

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.

Many shadows, however, in the neighbourhood of the kidney are of uncertain origin, and pyelography offers great assistance in their interpretation (*Figs.* 176, 177, 180). 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 calyx, 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, 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.

If the shadow is that of a *urinary stone*, it may lie in the renal pelvis, in a calyx, 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 it occupies a calyx, 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 stone is separated from that of the pyelogram but lies within the shadow of the renal outline. The distance between the former two 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 calyx distention is limited to the area of kidney drained by that particular calyx, but as the stone is generally tightly impacted, the solution does not reach this distended cavity, which is therefore not shown on the pyelogram (*Fig.* 177). 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. When the stone is situated in the pelvis there is generally some distention of that cavity which may be of minor extent or may have progressed to the formation of any degree of hydro- or pyonephrosis (*Figs.* 174, 175, 178, 181).

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.* 181), nephrectomy may be forecasted, always presuming that the other kidney is proved to be healthy.

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 218). Sometimes a pelvic stone which throws a weak shadow on the radiogram may, on pyelography, cause a light patch within the area of the pyelographic shadow.

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