

the bladder should be washed daily in order to retard calculous deposit upon the nucleus. Dr. Douglas, of Rondout, N. Y., in cutting a patient to extract a piece of glass, fearing that pressure with his forceps might splinter it in the bladder during extraction, devised the ingenious expedient of covering the blades of his forceps with soft molasses candy, knowing that if any of this substance was left in the bladder it would melt and pass away. The device was fully successful.

## CHAPTER XXX

## ANATOMY, PHYSIOLOGY, AND EXAMINATION OF THE URETER

THERE are many diseases of the ureters, such as simple and tubercular ureteritis, renal colic, and stone in the ureter, that are too intimately bound up with the diseases of the kidney to be dealt with separately. They can only be touched upon in this section of the work, but will receive more generous mention with the kindred maladies of the kidney. As a matter of fact, the chief interest of ureteral surgery centres about the various operative procedures, exploratory and plastic, to which they are subjected, and to these the subsequent chapters will be chiefly devoted.

## ANATOMY

The ureter is the excretory duct of the kidney. It is a fibro-muscular tube beginning as the funnel-shaped neck of the renal pelvis and terminating at the lateral angle of the trigone of the bladder. There is normally one ureter for each kidney. Each ureter is from 35 to 40 cm. (14 to 16 inches) long. The ureter is, when empty, a closed tube like the urethra. Its physiological calibre is that of a cylinder about 0.3 cm. ( $\frac{1}{8}$  inch) in diameter. The lumen of the ureter is slightly constricted at three points: (1) A distinct narrowing at a point about 2 cm. from its upper extremity, (2) a slight narrowing where it crosses the brim of the pelvis, and (3) a muscular constriction at its entrance into the bladder.

**Structure.**—The ureter is composed of 3 coats: the fibrous, the muscular, and the mucous.

The *fibrous* external coat runs continuously from the fibrous envelope of the kidney and its pelvis to the bladder. It is a tough, glistening, elastic tissue.

The *muscular* coat consists of an external longitudinal and an internal circular layer of smooth muscle. It is well developed in both the ureter and the pelvis of the kidney. In the calices it thins out



to a few stray fibres. At the vesical extremity of the ureter its muscle pierces that of the bladder and is continued as a band of fibres running along each edge of the trigone. Thus there is one band joining the two ureters (interureteric muscle) which sometimes raises a distinct transverse fold in the mucous membrane, while another thinner band of fibres runs from each ureter towards the neck of the bladder. The ureter possesses no proper sphincter. Its power of resisting regurgitation from the bladder is due to its oblique course through the muscular wall of the bladder, and to the constriction of the bladder muscle, which automatically closes the ureteral orifices as it contracts to force the urine into the urethra.

The *mucous membrane* of the ureter is smooth and thrown into longitudinal folds when the organ is collapsed. The epithelium consists of several superposed layers, the deeper ones conical or ovoidal, the superficial ones cuboidal or flattened. Though some expert microscopists claim to be able to distinguish the epithelium of the pelvis of the kidney from that of the ureter, most conservative observers confess their inability to make such a distinction, and do not even venture to assert that any given cells in the urine come from any part of the ureter or its pelvis unless the presumption is confirmed by other signs, notably the presence of renal casts and albumin.

**Relations.**—The ureter lies immediately behind the peritoneum throughout almost its whole length. It is firmly attached to this structure so that when the peritoneum is detached from the parietes it carries the ureter with it. When this dissection is performed by the finger the ureter may be identified as a cord interrupting the smooth yielding surface of the peritoneum within 3 cm. ( $1\frac{1}{2}$  inches) of the spinal column. In the abdomen the ureter lies upon the psoas muscle and crosses the genito-crural nerve. It is in turn crossed by the spermatic (or ovarian) vessels. On the right side it lies close to the vena cava. At the brim of the pelvis it crosses the common iliac vessels at or near their termination. Thence it plunges down in a fold of peritoneum (posterior false ligament of the bladder), passes under the arch of the vas deferens, and lies external to it, entering the bladder wall close above the seminal vesicle and about 2 cm. from the median line. Thence it runs 2 cm. obliquely forward and inward through the bladder muscle and beneath the mucous membrane, and emerges at the angle of the trigone 3 cm. from its fellow and the same distance from the urethral orifice.

**Topographical Anatomy.**—The ureter, like the kidney, can very rarely be felt when in a normal state. When tender or enlarged, however, in a thin subject it may be traced almost from the kidney

to the brim of the pelvis. In fleshy subjects it can only be felt at this latter point—viz., at the outer edge of the rectus muscle on a line joining the anterior spines of the ilia. Tenderness at this point can always be distinguished by palpation, and if the patient is not overfat an enlarged ureter can be rolled between the finger and the iliac artery. In the female pelvis the ureter is readily felt through the vaginal vault almost up to the pelvic brim. But in the male it is only in exceptional cases that tenderness or enlargement at the lower extremity of the ureter can be appreciated by rectal touch in the region just internal to the base of the seminal vesicle.

### PHYSIOLOGY

The ureter transmits the urine from the kidney to the bladder partly through the force of gravity, but chiefly by its peristaltic action. Waves of contraction run along it quite as they do along the intestine, and as each wave reaches the bladder the ureteral orifice becomes slightly raised and tumefied, emits a little jet of urine, and then sinks back again. This is perhaps the most picturesque phenomenon observable through the cystoscope. The contractions of the two ureters are quite independent and not often synchronous. They recur irregularly every five, ten, or twenty seconds. Exceptionally the intervals are much longer.

Like the bladder, the ureter is insensitive to touch unless inflamed. But, like the bladder, it is extremely sensitive to distention—witness the agonizing pain of renal colic. Whether those obscure cases of renal colic attending the passage of concentrated crystalline urine (p. 631) are due to distention or to simple scratching of the ureteral walls it is impossible to say. Dr. Bryson has recently advanced the theory that pain of the upper third of the ureter is radiated to the kidney, pain of the middle third to the abdomen, and pain of the lower third to the bladder and urethra. While this may often be the case, I cannot accept the conclusion that the vesical pain of renal origin, which so often mystifies the most expert, is always due to an irritation at the lower end of the ureter. I believe that this pain is often due to a disturbance purely in the renal pelvis without any implication of the ureter.

### EXAMINATION

The methods of examining the ureter are reducible to two: (1) Palpation; (2) urethral catheterization and its various modifications.



## PALPATION

The ureter may be palpated through the abdominal wall, through the rectum (the vagina in the female), or through an exploratory incision (p. 637).

**Abdominal Palpation.**—It is practically impossible to distinguish tenderness in the upper part of the ureter from tenderness in the kidney itself, and any ureteral swelling in the loin is overshadowed by the associated renal enlargement. In feeling for the ureter through the abdomen deep palpation is first employed at the point where the ureter crosses the pelvic brim. If the rounded tube can be made to slip under the finger here it may sometimes be followed, especially if tender, up the outer border of the rectus for a short distance; but unless greatly distended it becomes quite lost to abdominal palpation a few centimetres above the umbilicus.

**Rectal Palpation.**—When ureteral stone is suspected, rectal palpation should always be employed on the chance that a stone impacted in the lower end of the duct may thus be diagnosed. It is noteworthy that in one of Bishop's<sup>1</sup> cases a stone that could not be felt by vaginal touch was palpable through the rectum.

The ureter is felt for just above the seminal vesicle, about 1 cm. from the median line.

**Vaginal Palpation.**—As the ureters curve upward, outward, and backward around the cervix from the trigone of the bladder, they are readily palpable through the vaginal vault when diseased, and may also usually be felt when normal. The trigone of the bladder terminates at a point on the anterior vaginal wall about 2 cm. below the cervix. Each ureter may be traced outward and backward from this region as a firm cord. Recognition of the normal ureter by palpation requires considerable skill.

## URETERAL CATHETERIZATION

It is interesting but quite unnecessary to dwell upon the various measures that have been suggested in former years for the purpose of collecting the urine of each kidney separately. Surgeons have long been awake to the utility of such a proceeding, and many very ingenious methods have been devised for obstructing one ureter while allowing the urine to flow freely from the other. The sum of them all was failure. The next step was to introduce a catheter directly into one or both ureters by means of some kind of a cystoscope (the attempt at catheterization without cystoscopy having

<sup>1</sup> Edinburgh Med. J., 1889, vi, 47.

proved futile). Latest has come Harris's ingenious device for dividing the bladder into two reservoirs from each of which the urine of one kidney may be drawn separately. We need only concern ourselves with these last two devices—catheterization and segregation.

The ureteral catheter may be introduced by means of the so-called optical cystoscope (p. 330) or through the straight tube employed by Kelly. The latter apparatus is not generally applicable in the male and therefore merits no consideration here, although it may be said, by the way, that for simplicity and cleanliness it far surpasses the other method. In the female I always employ Kelly's tubes. Dr. Chetwood has fitted the lamp of his urethroscope to this instrument, and I have found the modification most useful.

For ureteral catheterization by the optical cystoscope patient and instrument are prepared as for cystoscopy, though general anesthesia is usually preferable here. The *choice of instruments* must lie with the surgeon. The three instruments most in favour at present are those of Casper, Albarran, and Nitze. I have employed Casper's instrument; but though it has several points of superiority, the optical apparatus is so poor that I prefer Nitze's new modification of Albarran's cystoscope (Fig. 123). Even this leaves much to be desired, and an improvement upon it will doubtless soon appear; but for the present it seems the best we have. A detailed description of the instrument is unnecessary. The manipulation of its simple mechanism can only be learned by practice.

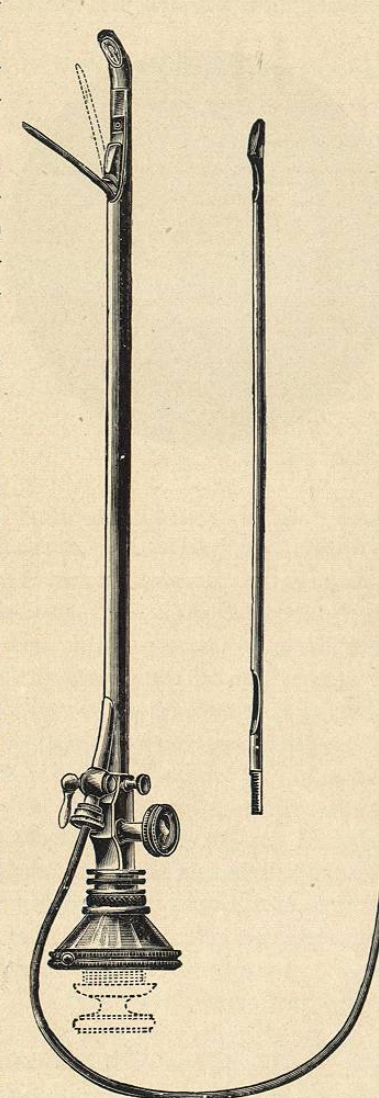


FIG. 123.



**Technic.**—*To find the ureteral orifice* is the first point. As this is the most difficult part of the operation it should be undertaken with the utmost care and precision. The cystoscope is introduced

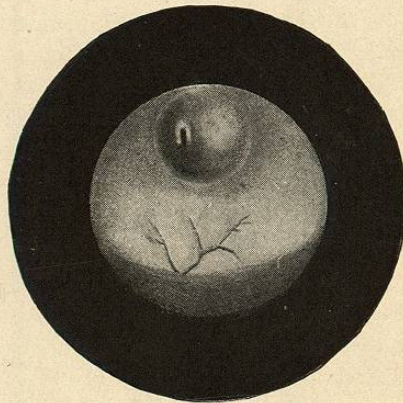


FIG. 124.—(NITZE.)

(p. 332) and its beak turned directly downward. The light is then turned on and the instrument adjusted by pulling it out or pushing it in until the dark circle of the neck of the bladder intrudes upon the field of vision. It is then slowly rotated to an angle of  $30^{\circ}$  to  $45^{\circ}$  from the perpendicular. During this procedure the surgeon watches attentively every portion of the mucous membrane that comes into view. The mouth of the ureter may project prominently and unmistakably, or it may be quite invisible. Sometimes it appears as an oblique slit in the mucous membrane (Fig. 124), sometimes as a gaping crater. It may be flat upon the bladder wall or it may be distinctly elevated on a little mound. One of its most striking characteristics, one that often calls attention to it, is its intermittent muscular contraction which accompanies the ejection of a little jet of urine. When the surgeon spies a point that he suspects is the mouth of the ureter, but of which he is not certain, he has only to wait until he sees the little slit gather itself together and eject the urine (Fig. 125), and by this he recognises it definitely. At the same time he will note whether the jet consists of limpid urine, of cloudy pus, or of dark blood.

It may be no easy matter to find the ureteral orifice. If it is not found after a short search of ten minutes or so, the cystoscope may be extinguished and withdrawn and a greater quantity of fluid introduced on the chance that the orifice may have been hidden by a fold of mucous membrane. But, whatever difficulties may be encountered, they must be overcome by methodical gentleness. The operator who allows himself to become flurried is lost. There must be no haste,



FIG. 125.

no aimless wandering about. If the ureter is to be found at all, it will be met with very near the neck of the bladder and not more than 2 cm. from the median line. It is useless to wander over a wider field.

*To introduce the catheter* may be impossible; but, as a rule, this depends solely upon finding the ureteral orifice. I have said that the finding of the ureter is the most difficult part of the operation, because when the ureter is once found and the cystoscope properly placed in relation to it, the catheter may then be introduced perfectly well unless there is some physical peculiarity of the case that makes the operation impossible. In other words, if the operation is possible at all its success depends more upon the discovery of the ureter and the proper position of the cystoscope than upon anything else. The position of the cystoscope should be such that the ureteral orifice is brought as near as possible to the lens. For this purpose the shaft of the instrument must be turned towards the ureter. Unless this is done the operation is incredibly difficult.

With the instrument thus closely approximated to the ureter, the catheter (which has been previously tested to prove that its lumen is clear) is pushed slowly into the cystoscope until it appears inside the bladder. The little director (if the Nitze instrument is used) is then elevated a trifle and the catheter again pushed forward. If it tends to pass beyond the ureteral orifice the director is turned up more sharply, or the instrument is withdrawn a trifle, and so by a series of trials, with the cystoscope always as near as possible to the ureteral orifice, the catheter is finally introduced. Success is not yet certain, but the difficult part of the task is now accomplished. The catheter is gently impelled onward until it has been introduced about 5 cm. into the ureter. This is far enough for a ureteral catheterization; for other purposes it may be necessary to introduce it further. The lamp of the cystoscope is extinguished and the instrument slowly extracted, great care being taken not to disturb the catheter. In order to avoid pushing the catheter too far into the bladder it is well to make a characteristic scratch upon it before beginning to extract the cystoscope, in order that there may be some means of knowing the exact point at which it should be fixed. The catheter is tied in like a filiform bougie and its end is carried into a small sterilized bottle which it is convenient to attach to the patient's thigh by means of adhesive plaster.

If the urine flows freely it should require not more than two hours to collect 25 c. c. of urine, which is all that is needed for the purposes of examination.



**Urine Segregation.**—I abstract a description of this instrument and its employment from the writings<sup>1</sup> of its inventor, Dr. M. L. Harris, of Chicago.

The chief part of the instrument (Fig. 126) might be described as a twin catheter, the shaft of which is inclosed in a metal sleeve. Each half of the double beak may be rotated outward independently. To the outer extremity of each half glass bottles may be attached to receive the urine, and a rectal lever is held to the shaft of the catheter by means of a fulcrum and spring. The whole instrument may be sterilized by boiling.

Anesthesia is obtained by injecting into the rectum—

R Antipyrin.....	1 gramme
Tr. opii.....	1 c. c.
Water.....	90 c. c.

This solution produces anesthesia of the floor of the bladder after thirty minutes, which time is employed in preparing for the operation.

The anterior and the posterior urethra are successively washed, and the bladder irrigated until the fluid returns clean. Then 60 c. c. of a 5% solution of suprarenal extract is injected into the bladder and allowed to remain there ten minutes. This is then drawn off, the bladder washed once more, and 15 to 20 c. c. of a 2% cocain solution is injected and allowed to remain in the bladder for six minutes.

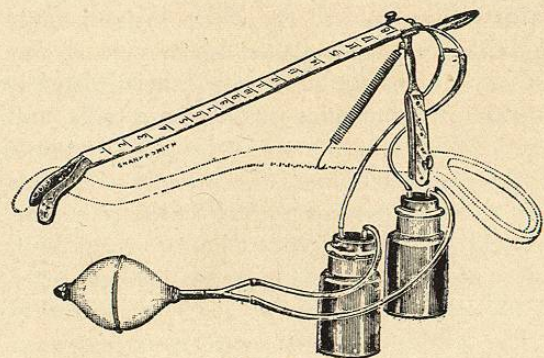


FIG. 126.

This is drained off, the bladder irrigated once again, and the patient is ready.

With the patient lying on his back, his knees drawn up, the lubricated catheter is introduced very gently until its beak is well within the bladder. During this time the outer ends of the catheter are attached to a short circuit of rubber tubing. The fulcrum crutch is attached to the shaft of the catheter some 2 or 3 cm. from its outer

<sup>1</sup> J. of the Am. Med. Ass'n, 1898, xxx, 236. Med. Record, 1899, lv, 457. Annals of Surgery, 1900, xxxii, 149.

extremity. Now the rectal lever is lubricated and introduced into the rectum. It is attached by the fulcrum and spring and carefully held in the median line (it has a tendency, before the catheter is turned down, to slip off sideways). Finally, each half of the catheter is rotated gently downward through an arc of 120°, or thereabouts, until it is felt to rest gently upon the floor of the bladder (too great a pressure might occlude the ureter). The whole instrument is then gently withdrawn until it rests against the neck of the bladder. The shaft of the rectal lever should now be in a line with the patient's body, the catheter inclined obliquely. With the instrument in this position, the end of the rectal lever projecting between the two catheters elevates the floor of the bladder into a ridge on each side of which is a pocket, each pocket drained by a separate catheter. The short-circuit tube is now removed and the fluid in the bladder allowed to drain off. It may be necessary to wait a few minutes until the instrument becomes filled with urine. Each curved tube is then attached to its own bottle; the straight tubes are connected again by the short-circuit tubing after the flow of urine has been started by a few gentle squeezes of the aspirating bulb. Vigorous aspiration is only harmful. It causes hemorrhage by sucking the mucous membrane into the instrument.

The instrument must usually be left in place for thirty minutes in order to obtain enough urine to examine. Harris estimates the normal functional capacity of the kidney at 0.16 c. c. of urine per minute per kilo of body weight. This is an average estimate as the urine descends intermittently. After the desired amount of urine has been obtained, the catheters are folded back, the rectal lever detached, the instrument extracted, and the operation closed by a final washing of the bladder.

**Advantages and Disadvantages.**—In attempting a comparison between the ureteral catheter and the urine segregator it must be remembered that the latter has a much more restricted range of usefulness than the former. The urine segregator has no therapeutic uses while the ureter catheter has many. The instruments can only be compared in the field of diagnosis. Even in this field comparison is not easy, for the surgeon who is accustomed to using the ureteral catheter will obtain better results from it, while he who is familiar with the segregator will find this the more useful. In general it may be said that the segregator is by far the easier instrument to use. Yet this is not said in order to encourage a careless handling of the instrument, for carelessness is more likely to cause the operator to fail than any other one thing. Two errors may be committed. The instrument may be so clumsily arranged that the watershed is not