A Short Account of the Anatomy of the Ureter

The ureter is a hollow, muscular organ, approximately 25 cm in length that originates in the renal pelvis behind the hilus. It runs into the retroperitoneal cavity in almost what could be called a straight line, into the lumbar tract along the anterior side of the psoas muscle, behind the mesocolon and to the side of the gonadal vein. At the entrance to the pelvis, it crosses anteriorly over the common iliac vessels and then runs laterally to the internal iliac vessels before finally curving medially to be crossed by the deferent duct in males or by the uterine artery in females. Finally, it shows up in the inferolateral wall of the bladder.

The anatomical image immediately connected to the course of the ureter is the classic anteroposterior one. For an endourologist, it is of the utmost importance to always have a laterolateral image of the course of the viscera in mind that highlights the relatively accentuated and focused angle that the ureter covers bypassing the iliac vessels and the curve that brings it right into the bladder.

A full understanding of the ureterorenoscopic route inside each individual tract of the ureter may almost always help avoid any strains and/or lesions.

Another anatomical consideration to bear in mind is structure: the delicate mucosa, the muscular and the adventitial layer. The muscular layer, in particular, has different levels of thickness from top (thinner) to bottom (thicker) thus often making incomplete perforations with a submucosal tunnel in the distal tract, and avulsions or complete perforations in the proximal tract more frequent.

The same features mentioned with regard the muscular layer also justify the different possibilities of dilation of the lumen and the internal size, without dilation, that...
vary from 1–2 mm in the intramural tract to 4 mm in the pelvic tract and 5–6 mm in the lumbar tract, reverting back to 2–4 mm in the pyeloureteral junction.

**Classifications**

There is no actual standard classification for ureterorenoscopy (URS) complications which can often be found divided into temporal and seriousness criteria. We will use both criteria, thus considering complications as: intraoperative, major and minor, early postoperative, major or minor, and late postoperative, adding that to rectify any major complication often requires an open approach while minor complications may almost always be dealt with using nonsurgical procedures.

**Major Intraoperative Complications**

**Avulsion of the Ureter**

Avulsions are undoubtedly the most serious complication that may occur during an URS. Fortunately, however, they have tended to lessen over time from 0.5 to 0% [1–3], thanks, in part, to the introduction of new instruments and accessories, but perhaps also to the greater experience of the urologists carrying out the procedure.

Complications may appear anterograde, which tend to be more frequent, or retrograde and are practically always an expression of excessive traction while attempting to remove a stone trapped inside a basket [4]. They may also be the result of pressure being applied to the ureteroscope as it is being inserted into a difficult or stenotic ureter or one that is prone to muscular spasms.

This complication is more common in the proximal ureter where the muscular and mucous layers are less present [5]. However, when a ureter becomes less resistant and elastic, due to previous traumas or endourological procedures, it may be subject to avulsions in any of its segments [6]. The use of modern multiple coil baskets, that can inadvertently trap ureteral mucosa, and the distance a trapped stone has to pass through in order to reach the ureteral meatus are other possible risk factors [7].

A lesion is typically spotted when, at the end of a removal procedure, a stone in a basket appears directly inside the ureteral meatus surrounded by the detached ureter.

In other cases, where there is the slightest hint of potential damage, an ascending pyelography will confirm so, showing the complete spread of the contrast medium, without any image of the ureter or kidneys. In yet other situations again, damage may appear during the early postoperative stage when a fever, abdominal pain or pain in the side and abdominal resistance all indicate the presence of a urinoma or retroperitoneal abscess due to urinary spill. A urography or CT scan may confirm this diagnosis.

To rectify any damage would require an open procedure or laparoscopy. If the diagnosis is immediate and the patient is clinically stable, one may proceed with a ureteroneocystostomy, in the case of damage to the distal ureter, or a similar procedure to the latter accompanied by a bladder psoas hitching or by a Boari flap in the case of middle ureteral third damage, or a ureteroureterostomy on a stent in the case of damage to the proximal ureter. In more extreme cases where greater ureteral devitalization exists, more radical moves will be necessary such as the interpositioning of an ileal tract [8] or even in fact a kidney autotransplantation.

If by chance the diagnosis is not immediate or if the patient is not in a clinically stable condition, a nephrostomy will allow temporary urine drainage until such time as the final treatment can be decided upon. Factors such as age, the level and extent of the damage, renal function and also how much experience the urologist actually has may all influence or favor the choice of one procedure over another. Overall complications after re-establishing ureteral continuity are in the range of 11–53% and most of these may be dealt with performing an endoscopic procedure rather than any new open operation [9–11].

To recap then, it is important to remember to carry out all necessary precautions to avoid any such serious complication. Removal of a renal or an upper ureteral stone, without fragmenting it, is an extremely delicate procedure and should be carried out exercising extreme caution only when the diameter of the stone is particularly small and no bigger than the smallest caliber in the ureter, given that it is always hard to objectively judge this during the course of the operation. The use of nitinol tipless baskets which have a release device, plus the ready availability of an energy font for a lithotripsy, are other safety factors to be prepared preoperatively.

**Intussusception of the Ureter**

Intussusception may be defined as the enfolding of the tract of a hollow organ, most frequently the small intestine, inside another tract of the same organ. This phenomenon, for illustrative purposes, may be illustrated as a finger of a glove turned inside out.
A partial circumferential lesion in the wall of the ureter is necessary as it takes place there. Such an occurrence is rare and has been associated with the presence of fibroepithelial polyps and transitional neoplasms [12–14], while at other times it is the expression of an attempt to remove a stone trapped in a basket inside a ureter that has not been sufficiently dilated to allow so [15, 16]. Diagnosis is generally based on the suspicion of a possible lesion, on the impossibility of putting a stent in place at the end of the procedure or on immediate postoperative evidence of ureteral obstruction.

If any suspicions should arise during an operation, a retrograde pyelography will confirm the problem as it highlights the ‘bell-shaped’ aspect of the ureter [17]. Although, however, the positioning of a ureteral stent is sometimes possible and assures sufficient drainage of urine, the ischemia that accompanies an intussusception can cause devitalization of the ureteral wall concerned, with fibrotic and stenotic lesions. The most appropriate treatment would seem to be either open or a laparoscopic resection of the invaginated section followed by ureteroneocystostomy, ureteroureterostomy or ureteropyelostomy.

The use of nitinol baskets, which have a release device, is very useful for preventing complications. However, it goes without saying that sensible use of the energy of the lithotripsy and the traction on the basket also play a primary role.

**Minor Intraoperative Complications**

**Perforation of the Ureter**

Perforations are the most common URS complication, at a variable rate of between 0 and 15.4%. They appear, above all, to be the function of the size of the ureteroscope used which, in fact, goes from 15.4% per caliber of 12.5-Fr [50] to 1.7% using 8.5- to 10.8-Fr instruments [18], and to 1% with 6- to 11.5-Fr instruments [19].

In addition, the introduction of less traumatic accessories, such as nitinol tipless baskets and laser technology, which are less dangerous than electrohydraulic or pneumatic ones, seem to have determined a reduction in the incidence of perforations over time, and indeed, as may be observed in the most recent figures, their total absence [20].

In reality, however, the term perforation is a rather broad one encompassing both small punctiform lesions caused by the false passage of a guide wire or by laser fiber or closed baskets, and larger lesions caused by the tip of the ureteroscope or by the forced removal of a lithiasic fragment. On the other hand, a slight distinction between perforation and partial avulsion may be superfluous and even arbitrary when considering the fact that the subsequent treatment does not vary, i.e. the positioning of a ureteral stent for 4–6 weeks.

There is seldom need for an open procedure or laparoscopy. The greater risk factors appear to be the manipulation of impacted stones, the use of a tipped steel basket and a ureteroscopy carried out in the presence of periureteral fibrosis from previous surgery or radiotherapy.

In the case of net and punctiform perforations, it is generally possible to complete the procedure, however, where lesions are greater or where the walls are not elastic enough or appear to be worn, poor visibility of hematic stillicide or extraureteral extravasation call for the operation to be interrupted and a stent to be put in place.

Once again the advantages of having a safety guide wire appear evident, in cases such as those cited, to allow the introduction of a stent right up into the pelvic kidney. One of the complications here is the extrusion of lithiasic fragments that occurs in 0.5–2.3% of cases [1, 21, 22]: in the case of smaller lesions and uninfected stones, which may be documented from a preoperative cultural test, the fragment may be left on site and the procedure concluded with the positioning of a stent and the establishment of antibiotic therapy. In other cases, one or more fragments may remain trapped in the ureteral wall which would determine the onset of a real granuloma with possible stenosis and the need for further treatment [23, 24].

It goes without saying that the patient should be advised of such at the end of the procedure, so as to avoid any successive treatments for stones believed to be present in the urinary tract.

**False Passage**

The incidence of false passage is relatively low (0.4–0.9%) [20, 25]. It appears when an instrument or accessory perforates the mucosa, without penetrating the whole ureteral wall as it continues its path through the tunnel that it intended to create. Problems such as reduced caliber and poor mobility usually appear at the beginning of the procedure in the intramural tract of the ureter and are often determined by previous surgical or radiotherapy procedures or by an involute course for prostatic hypertrophy. Other times the lesion may occur in an effort to bypass an impacted stone in any of the ure-
teral tracts using a guide wire or a basket. Suspicion of a lesion arises when the guide wire goes up in a very uneven way or when it does not go round the pelvis as it should do. Suspicions may be confirmed by carefully introducing an angiographic catheter and injecting some contrast medium to confirm the exact position of the guide in the pelvis or alternatively to show the submucous extravasation.

The procedure, generally speaking, may be concluded, recurrences are substantially absent, but it would be prudent to leave a stent in place for 1–2 weeks. If, however, a small initial lesion is not detected, in that case the introduction of a ureteroscope into the submucous tunnel could provoke more serious lesions causing occlusion and total necrosis of the ureter [26].

**Abrasions**

A certain level of mucosal traumatism is to be expected in every ureteroscopic procedure, at which time non-physiological forces are applied to the delicate ureteral epithelium.

In the case of a singular series, the incidence of slight mucosal damage varies by 24%, using 9.5- to 11.5-Fr instruments, and by 6% using 6- to 7.5-Fr ureteroscopes [27]. Any potential abrasions may cause slight bleeding or edema that could therefore make the procedure somewhat more difficult to carry out. In the early postoperative period, edema and possible clotting could determine transitorily ureteral obstructions. In general, the procedure is concluded without any ulterior problems. The precision required when carrying out this maneuver, which is naturally hoped for in every endourological procedure, will minimize the trauma. One particularly useful precaution would be the introduction of a ureteral sheath where repeated maneuvers for entry and exit of the ureteroscope are deemed necessary.

**Malfunctioning or Breakage of Instruments**

Despite the increased miniaturization of ureteroscopes, a complete breakage of one of the instruments during a procedure is always a potential occurrence. However, today such incidences have become more anecdotal [21]. This infrequency may also be due to the fact that they are probably not always recorded. The need to suspend a procedure due to, for example, the malfunctioning of a laser font or the breakage of one of the fiber optics inside the machine is also an infrequent occurrence [28]. The breakage of any of the accessories is always however possible, especially the basket for the stone, which almost always works together with the laser fiber which when activated develops high thermal energy [29, 30].

In this circumstance, the configuration and composition of a basket play an important role. If it should happen that baskets made with a point where the coils converge tend to project towards the exterior of the stumps of a broken coil, in a downwards direction, causing ureteral lacerations when being removed [30], tipless baskets very often maintain their basic configuration. As far as composition is concerned, an elastic and flexible combination such as nitinol definitely offers greater guarantees of atraumaticity from steel.

A breakage is often identified when a stone is already lodged in the basket. In such cases it is first necessary to dislodge the stone, carrying on with laser lithotripsy [31] to then successfully proceed with removing the basket which, if it is made of nitinol, can often happen directly and cautiously, with constant visual control and with the possible assistance of a tweezers to take hold of the broken coils to keep them well away from the wall of the ureter [29]. Where this is not possible, an alternative solution would be to use a laser to complete the breakage of all the coils and in that way obtain the complete opening of the basket to then remove, first the proximal extremity and then the distal after having taken hold of its point with a tweezers and having turned it 180° inside the ureteral lumen [31].

A second possible complication, decidedly more common when the manipulation of stones took place without the stone being held in sight [32], is the trapping of a stone which is larger than the inside of the basket, which is then blocked inside the intramural tract of the ureter. In such cases, a ureteral meatotomy or a ureterolithotomy might be the only possible solution [33]. At present, the occurrence of such is rare and may be quite easily managed where a ureteroscope allows the contemporary introduction of a basket and fiber laser whilst maintaining adequate irrigation. Failing this, it is possible to use an extracorporeal lithotripsy [34, 35], even when this approach does not allow you to free any possible bundle of trapped ureteral mucosa from the basket, or even disassemble the basket, removing the ureteroscope and reintroducing it parallel to the basket until such time as it reaches the stone that may by that time have fragmented [36].

If it is true that sudden malfunctioning of instruments remains inevitable, it is however clear that accurate and programmed maintenance, a process of sterilization in compliance with recommendations and careful preservation of instruments are all ways of minimizing any of
these unpleasant events. Regarding metallic accessories, by now it appears to have been established that characteristics such as the tipless configuration, the possibility of rapid disassembly and construction in nitinol may link efficiency with atraumaticity.

**Extravasation**

Any type, size or density of ureteral lesion may be responsible for extravasation of urine, blood, medium contrast or irrigation liquid. The incidence is less than 1% [18, 25], although this figure is probably underestimated as not every author concludes his procedure with a retrograde pyelography which is the only means of confirming this complication.

The moment in an operation when a lesion occurs and the size of the lesion will determine the extent of extravasation: if minimum quantities do not determine any type of sequel, greater volumes of liquid collected may become infected and evolve into an abscess with other likely periureteral fibrosis phenomenon [37]. In a situation where it is necessary to use electrical current during an operation so requiring the use of hypotonic solutions, an event which has become much rarer since the introduction of laser, the possible systemic action of reabsorbed irrigation liquid should be considered: circulation overload, hypotension and hemolysis. In the end, if it is true that a ureteral lesion is necessary, it is nevertheless certain that adoption of high pressures of irrigation will only favor and worsen the extravasation of liquid. As in other cases, it is important to detect and demonstrate the complication introducing a contrast medium. In this case putting a ureteral stent in place is generally sufficient to supply adequate drainage.

**Bleeding**

Bleeding is a complication that happens in about 0.3–2.1% of cases [18, 20, 25] and can be caused by damage to the meatus during insertion of the ureteroscope, or calyceal damage at the moment the guide is inserted. Somewhat more seldom, the fragmentation of an impacted stone may cause mucosal abrasions and bleeding. This bleeding is almost always inconsequential and self-contained but it may however make vision, and hence the procedure itself, difficult. It may also cause pain or colic in the early postoperative stage due to the passage of clots. This last part may be avoided by putting a stent in place. Of much greater importance however is the bleeding of vascular lesions during the course, for example, of an endopyelotomy or an endoureterotomy. In this case, the source of the bleeding is a polar renal vessel or a ureteral vessel. The procedure must be stopped and the source of the bleeding blocked with a ureteral dilation balloon blown up to 24–30 Fr [38] until the moment that the selected emergency procedure starts, which very often is an arteriography with an embolization.

**Difficult Access**

In 1.6–2.7% of cases [28, 39], a ureteroscope finds it hard to pass the meatus, to run through the intramural ureter, or to reach the lesion. A reduction in size and improvements in the shape of instruments have rendered such occurrences somewhat rare, however not totally obsolete.

Some of the elements responsible for this problem might be the reduction of the inner diameter of the ureter from extrinsic compression or from stenosis, the patient having a particular anatomy, a dislocation of the meatus by prostatic hyperplasia, distal edema from an impacted stone or a prolonged muscular spasm. A correct approach to this situation would be to avoid any prolonged maneuver or strong pressure and, at all times, never to think twice about postponing the procedure for anything from 2 days up to 10 days [38, 39] after a stent has been put in place to obtain passive dilation.

**Major Early Postoperative Complications**

**Infection**

The large variability in reported incidences may, in part, be justified by the absence in the literature of a univocal definition of infection and sepsis.

To make things easier here we will define infection as a harmful colonization by an unknown species in the host organism that responds to the infection with inflammation. By the term sepsis, we refer instead to a serious medical condition characterized by a generalized inflammatory state called SIRS (systemic inflammatory response syndrome) and the definite or suspected presence of an infection [40, 41].

Even if at times the appearance of a fever following a ureterorenoscopy is a simple expression of a sterile, chemically induced inflammation of a kidney [2], it is clear that the introduction of a pathogenic agent into the urinary passage with instruments and also the manipulation of infected stones are the most common causes. The reported incidence of temperatures \(>38^\circ C\) varies between 1.2 and 6.4% [19, 25], but even without defining the temperature the incidence may oscillate between 1.3 and 6.9% [3, 18].
In terms of preventing infective type complications, whereby the need to adhere to the regulations of intraoperative sterility is evident, the position regarding antibiotic prophylaxis is less clear. An incidence of a temperature of >38°C was recorded in 22% of patients who were not put on antibiotic prophylaxis [42], but in just 3.7% of these was the presence of an infection documented.

In the presence of a positive preoperative cultural examination, it is necessary to prescribe antibiotics; however, the position taken in the presence of sterile culture is more controversial: in the case of an URS undertaken for treatment of stones, the risk of these being infected makes antibiotic prophylaxis prudent, while it is possible to abstain from this when the procedure is merely diagnostic or programmed for the treatment of neoplasia [38].

With regard to the precautions that should be taken for prevention, perhaps the most important is related to the need to avoid a situation where high pressure of irrigation determines a reflux in the parenchyma, bacteremia and sepsis. This is particularly necessary in the presence of infected urine or in the manipulation of potentially infected stones. The pressure of irrigation is a definite requirement and must be sufficient to maintain adequate visibility using one of the devices that allows us to force the irrigation for short periods of time, and in the case of longer procedures, to carry out measures such as the positioning of an endoureteral sheath or an angiographic catheter as far as the pelvis and also continuous or intermittent drainage of the bladder.

Steinstrasse

The pile-up of lithiasic fragments in the ureteral lumen is a relatively rare occurrence after an URS. Where fragmentation happens, under direct visual control, the larger fragments are actively removed and the smaller ones are often washed away during the procedure. Also, the frequent position of a ureteral stent may favor the elimination of little fragments in the immediate postoperative phase. It is recorded that the majority of asymptomatic cases in fact resolve themselves in 2–4 weeks [43–45].

The treatment therefore initially requires observation only, associated or not with an expulsive medical therapy including alaphilithic and/or cortisonic treatment [46–49]. If infections or complete obstruction are present it may be necessary to put a nephrostomy in position or to proceed with a retrograde or anterograde percutaneous URS. In the presence of one larger distal fragment, extracorporeal shock wave treatment could allow passage to the entire column [44].

Minor Early Postoperative Complications

Obstruction of the Ureter

Pain and colic are expressions of obstruction that may develop depending on the formation of clots, localized edema or ureteral spasms and behind any of these has been a certain level of minor trauma to the mucosa. The temporary positioning of a stent at the end of a procedure avoids the appearance of problems even if in this case symptoms of irritable bladder may manifest themselves. Signs of obstruction are present in 4–9% of cases [18, 20] and generally do not require any treatment other than the administration of painkillers and parental fluids. In the incidence of persisting symptoms, it would be preferable to investigate the site and the extent of obstruction by means of an X-ray examination.

Vesicoureteral Reflux

In the past, this complication correlated to a dilation of the ureteral meatus, even if the number recorded, which was between 5 and 10%, also included those patients who did not undergo dilation [22, 50–53].

A reflux of this type, sterile and in adults, has seldom determined secondary complications to necessitate treatment. The very common use of smaller-sized instruments has made this type of complication less frequent.

Late Postoperative Complications

Stenosis of the Ureter

The incidence of this type of complication is between 0.5 and 2.5% of cases [25, 54–56].

The physiopathological mechanism is likely to be multifactorial: a direct trauma such as a perforation [50, 57, 58], temporary ischemia due to prolonged use of a ureterorenoscope with an excessive-sized caliber [57], the presence of an impacted stone [59–61], and the result of a thermal trauma are the greatest risk factors.

The development of stenosis is generally a silent phenomenon. For this reason, some researchers have suggested carrying out a routine radiological study 3 months after an URS [62], while most urologists in the absence of any evident intraoperative lesion regard this recourse to be overly aggressive in consideration of the
constant reduction in time of the incidence of the complication, a direct consequence of the use of reduced-sized instruments [63–65]. Moreover, the routine use of ureteral access sheaths was considered to cause possible ischemic damage and ensuing stenosis, a hypothesis, however, which does not seem to have been confirmed [66].

A separate issue is the treatment of urothelial tumors. The current conservative treatment implies laser ablation or the diathermocoagulation of the neoplasm, a follow-up based on repeated URS, endoureteral chemotherapy or immunotherapy, and occasionally sessions of radiotherapy. The risk of developing stenosis is however higher, with the incidence as high as 16% [67–71], in which case a more prudent approach in the follow-up would seem advisable.

The treatment of stenosis requires a careful radiological evaluation of the site and the extent. Stenosis following the manipulation of stones is generally nonischemic and not very long. In these cases, either dilation with a balloon or making an endoscopic incision with laser could be considered [72]. If, however, the stenosis requiring treatment is long or recurring or even complicated by periureteral fibrosis then one needs to consider the option of open surgery: a ureteroneocystostomy with a bladder psoas hitch or with a Boari flap, a ureteroureterostomy, a ureteropyelostomy, or even an ileal tract interposition or in the most extreme cases, a kidney autotransplantation.

### Suggestions

We believe that it is worthwhile mentioning here just a few of the procedural steps that can help avoid or reduce the incidence of all of the aforementioned complications:

- Work out your own method to follow making sure it is regularly updated.
- Use a safety guide wire.
- Use a fluoroscopy.
- Take an X-ray (ascending pyelography) at the beginning of the procedure.
- Keep all the accessories that may come in handy close by, and use them.
- Have the ureteral lumen in sight during the entire procedure.

### Conclusion

Ureterorenoscopy, either semirigid or flexible, is today a safe and efficient method that enables us to deal with a growing number of pathological conditions in the upper urinary tracts in a very noninvasive way.

Reducing the incidence and seriousness of complications to a minimum is possible and requires an accurate process of prevention: the site and the volume of the pathology to be treated are always commensurate to the experience of the operator and the availability of adequate instruments. The accessories available today are quite numerous; it is necessary to know their configuration and composition to thus enable their most accurate and advantageous use in order to choose, in each individual case, the one that will yield the best results.

### References

Review


Complications of Ureterorenoscopy


