Approach to Ureteral Injuries

George E. Koch, Niels V. Johnsen

Background:

Ureteral injuries are rare and often challenging to diagnose without cross-sectional imaging. They are also often difficult to treat, as exposure can be limited and surgeons are required to have knowledge of many different reconstructive techniques to manage different types and locations of injuries. Treatment of ureteral injuries can often be delayed until patients are hemodynamically stable; temporizing measures are an option in settings where definitive reconstruction is not possible or appropriate. The vast majority of ureteral injuries are penetrating injuries and both traumatic and iatrogenic scenarios are common. Restoring and maintaining drainage from the kidney, whether externally or internally, should always be the priority, especially given the importance of renal function in post-trauma recovery and the profound resources required should dialysis be necessary.

Ureteral injuries may be subtle, and thus recognizing and diagnosing these injuries can be difficult. Delays in diagnosis and repair can lead to significant morbidity and further complicate both repair of the ureter as well as repair of associated injuries. The surgeon should have a high index of suspicion for ureteral involvement in penetrating trauma when the projectile courses near or through the retroperitoneum. Patients with high-energy blunt trauma (falls from a height or motor vehicle collisions with rapid deceleration) are also at risk for ureteral injury, but these injuries are exceedingly uncommon. Intraoperative iatrogenic ureteral injuries are often recognized at the time of the injury, and surgeons should fully evaluate not only partial or complete transections, but also ureteral bruising, discoloration or associated hematomas, as devascularization and electrocautery injuries may continue to evolve for some time after an unrepaired injury. Delayed presentations can include fever, flank pain and ileus, due to urinoma or abscess formation, and can even lead to renal failure and potential loss of the affected kidney.

Preoperatively, imaging should be used when available to stage ureteral injuries if the mechanism of injury raises concern for ureteral involvement. While hematuria may foster further clinical concern, it is generally unreliable as an indicator of injury and its absence does not rule out the need for imaging.

When CT Urography is not available, do an Intravenous Pyelogram to evaluate the collecting system. Take a plain abdominal x-ray 10 minutes after administering 2cc/kg of IV contrast. Contrast media extravasation proximally indicates a renal pelvis or ureteropelvic junction injury while a ureteral injury more distally may be identified by contrast extravasation or absence of distal ureteral opacification. The presence of hydronephrosis or a delayed nephrogram are less specific, but they may also be associated with a ureteral injury.

Urine extravasation into the peritoneum can sometimes lead to elevated serum creatinine levels due to reabsorption in the absence of true renal injury. This finding should not preclude contrasted imaging for patients who are otherwise healthy.

In many settings preoperative imaging is either unavailable or falsely negative. Surgeons should therefore explore the retroperitoneum if the mechanism and/or ballistic trajectory raises concern for ureteral injury.

Normal intravenous pyelogram taken 10 minutes after intravenous injection of contrast. The renal calyces, pelvis, ureters, and bladder can all be seen in this study. Case courtesy of Dr MT Niknejad, From the case https://radiopaedia.org/cases/85286?lang=us

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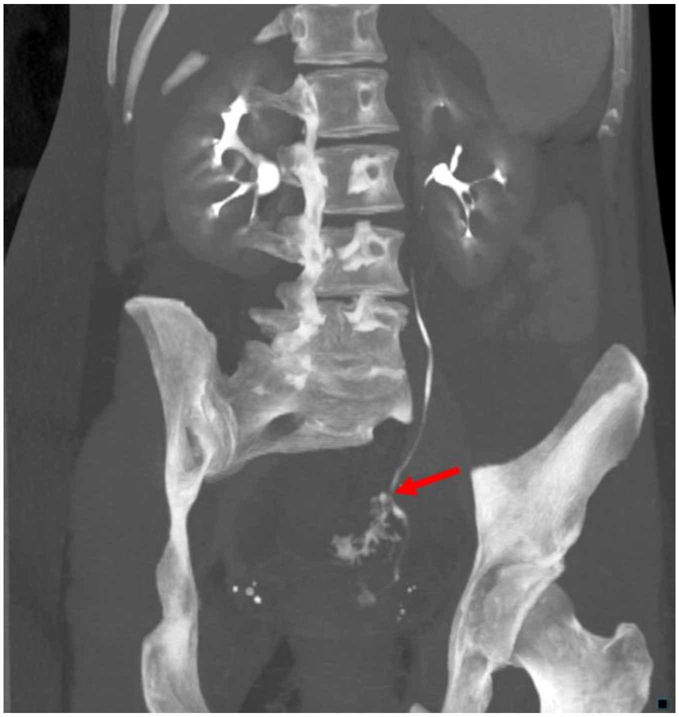
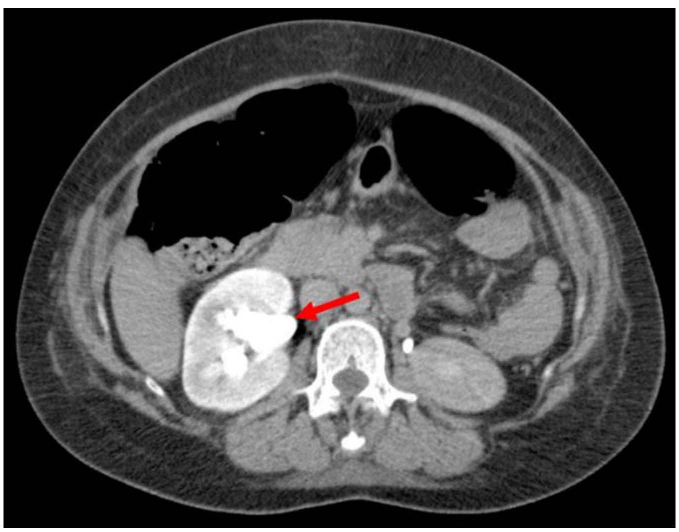


Delayed-phase CT imaging showing left distal ureteral extravasation (Red arrow.) Case courtesy of Dr Chris O'Donnell, From the case https://radiopaedia.org/cases/36562?lang=us

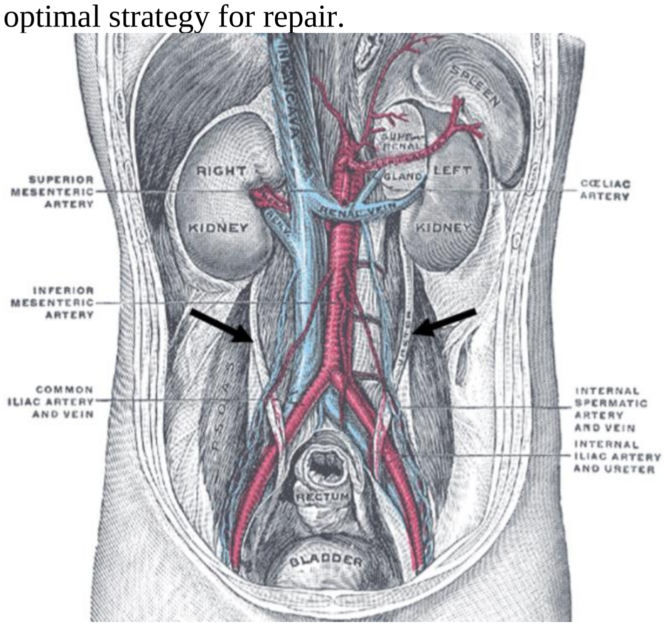


Hydronephrosis (Red arrow) and a delayed CT nephrogram associated with a distal ureteral injury. Case courtesy of Dr Vikas Shah, From the case https://radiopaedia.org/cases/55591?lang=us

In general, a retrograde pyelogram may be performed prior to surgical exploration in two cases: for patients with an endoscopic ureteral injury for whom ureteral stenting may be appropriate, or for patients with equivocal preoperative imaging whose only indication for surgical exploration is a possible ureteral injury. However, for patients who will undergo exploration for other injuries, direct inspection of the ureters at the time of laparotomy is the gold standard, and retrograde urography can be omitted. Intraoperative identification can be difficult, given the sometimes subtle appearance of a ureteral injury. In these cases, the collecting system can be pressurized by injecting saline or methylene blue directly into the ureter or renal pelvis, to help identify extravasation. This should be done with the smallest available needle. Alternatively, if the ureter cannot be identified due to surrounding tissue damage and a cystoscope is available, canalization of the distal ureter endoscopically with injection of saline or methylene blue may help identify the distal extent of the injury.

Anatomy:

The ureter originates from the renal pelvis at the ureteropelvic junction, just distal and posterior to the renal hilum. It courses caudally in the retroperitoneum along the psoas muscle, lateral to the gonadal vessels initially, before crossing medially and deep to them at the level of the aortic bifurcation. The ureter then passes over the bifurcation of the iliac vessels as it dives posteriorly to insert into the detrusor wall, emptying into the bladder at the trigone. This relational anatomy is essential to both isolating the ureter surgically and deciding upon the optimal strategy for repair.



The course of the ureters (Black arrows) in relation to surrounding anatomy.

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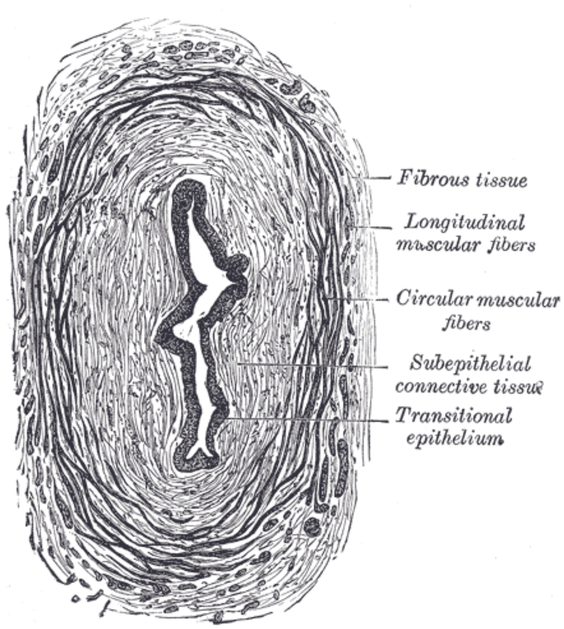
The ureteral blood supply is variable and dependent on the section of ureter being considered. The ureter is divided into three sections based on vascular supply. The proximal ureter is fed by the renal artery; the mid ureter has a variable supply including the gonadal vessels, aorta, and the iliac vessels; and the distal ureter relies on supply from the superior and inferior vesical arteries off the internal iliac. These larger arteries feed subsequently smaller branches which anastomose within the fibrous adventitia of the ureter along its entire length. Therefore, while loss of any single large vessel will not necessarily devitalize the entire ureter, careful tissue handling of the ureter and its adventitia is essential to avoid damage to these small vessels. The small caliber of the periureteral vascular arcades also requires ureteral anastomoses to be done in a tension-free manner to maintain uncompromised flow though those vessels. These vascular considerations are what often drive the choice of ureteral repair technique, with distal injuries best suited to reimplantation into the bladder (augmented by bladder reconstruction as needed), while proximal injuries are treated most frequently with primary repair.



Layers of the ureter in cross section. The fibrous adventitia houses the microvasculature of the ureter along its entire length. It is essential to appose the mucosal layer in a watertight closure.

Within the adventitia is the smooth muscle of the ureter, lined by urothelial mucosa. It is paramount that any ureteral repair, whether primary or via reimplantation, includes circumferential mucosa-to-mucosa apposition. Failing to ensure this critical step leads to urine leakage and periureteral scaring, fibrosis and stricture formation.

Principles of Ureteral Repair:

The success of open ureteral repair is dictated by five principles:

1. Selection of the appropriate repair:

Repair selection should be based on patient stability, injury etiology and location of the injury. This is due to the wide variability of patient presentations (stable vs. unstable), vascular supply along the length of the ureter (proximal, middle and distal) and the time needed to perform different repairs (stenting, primary repair and bladder reimplant).

2. Minimizing ureteral dissection:

As larger vessels feed the ureter via a network of small periureteral vessels within the ureteral adventitia, overly aggressive dissection can result in disruption of the vascular supply needed to feed the healing anastomosis. Thus, ureteral dissection and debridement should be done judiciously with the goal of removing any devitalized tissue and mobilizing the ureter no more than is needed for a tension-free, spatulated anastomosis.

3. Mucosa-to-mucosa apposition:

Mucosal apposition facilitates a watertight closure and resultant healing. Direct contact between urothelial mucosa and ureteral smooth muscle or adventitia leads to fibrosis and scarring with resultant ureteral stricture formation. Furthermore, leakage of urine from the repair can lead to a similar fibrosis as well as fluid collections and abscesses that put the patient at risk for infection and complicate future attempts at repair.

4. Tension-free anastomosis:

Ensuring both the apposed urothelium and the ureteral adventitia are under minimal-to-no tension once anastomosed protects against urine

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leakage from the anastomosis, as well as against microvascular compromise to the delicate small vessels of the apposed tissue due to mechanical stretching.

5. Adequate upper tract drainage:

Maintaining a low pressure upper urinary tract following ureteral repair minimizes the opportunity for urine to leak from suture lines, optimizing tissue healing. This should be done, at a minimum, with a ureteral stent and can be augmented with a foley catheter to reduce urine reflux along the stent. Add a nephrostomy tube for proximal decompression when a repair is considered at high risk of failing. In settings where a ureteral stent is not available, ureteral repair without a stent can be performed; however, there is likely a higher risk of leak and/or stricture formation. If upper tract drainage is not available with either a nephrostomy tube or a stent, we would recommend extended retroperitoneal drainage with a closed suction drain to minimize risk of urinoma formation and infection.

Decision Making:

The Unstable Patient:

The first consideration in evaluating a ureteral injury is patient stability. For unstable patients with a partial ureteral injury, a ureteral stent can be placed with the understanding that reconstruction can be considered when the patient is no longer critical. For complete ureteral disruptions in the unstable patient, the proximal ureter should be clipped or tied off just proximal to the injury, and a nephrostomy tube can be placed. When nephrostomy tube placement is not feasible or available, drainage may be achieved in one of two ways. First, the proximal ureter can be brought to the skin and matured as a cutaneous ureterostomy, ideally with an indwelling stent. Alternatively, a single-J or double-J stent can be placed into the proximal ureter and renal pelvis and secured with a non-absorbable suture, with the other end then brought through the skin as a drain to allow temporary urinary drainage. Finally, if patient stability does not allow for even these maneuvers, ureteral injuries can be left *in situ* for a short term (1-2 days), preferably with a temporary abdominal vacuum closure, as the majority of urine will be removed via suction (See Temporary Abdominal Closure.)

The Stable Patient

For the stable patient, ureteral injuries should be repaired at the time of identification whenever possible. In general, other intra-abdominal injuries should not preclude reconstruction for the stable patient. However, long mid-to-proximal ureteral injuries that would require extensive reconstruction, such as a creation of an ileal ureter, are generally not preferable in the acute setting and should be postponed for a later procedure.

As previously stated, the location of the injury guides the repair. Distal injuries are best reimplanted into the bladder due to the detrusor muscle's robust blood supply from the bilateral superior and inferior vesical arteries. This blood supply also directly feeds the distal ureter and is ideal for anastomotic healing and responsible for the low rate of ureteroneocystostomy strictures. The bladder can be mobilized using a psoas hitch with or without a Boari flap in order to bridge the gap to healthy ureter. These strategies can make even mid-ureteral injuries re-implantable into the bladder. For injuries that are too proximal for even aggressive bladder mobilization and reconstruction, uretero-ureterostomy should be performed. Regardless of the injury location, a ureteral stent should be placed across repairs when available and a closed-suction drain left in the abdomen.

The decision to debride ureteral tissue prior to repair can be difficult considering the sometimes competing goals of a tension free anastomosis and minimal ureteral dissection. Injury etiology should also be considered. The extent of injuries due to high-velocity weapons may not be fully apparent at the time of the operation. In such situations, we recommend slightly more extensive debridement prior to repair to ensure the health of tissue to be incorporated. These injuries include blasts, hunting or military-style rifles, and high-energy electrocautery injuries. Low energy injuries from knives, scalpels or low-velocity and caliber gunshots can be debrided more judiciously as secondary cavitation risk is less.

Delayed Recognition of Ureteral Injuries

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Given the subtle appearance of ureteral injuries, they can often be missed initially and recognized in a delayed fashion. Signs and symptoms concerning for a missed ureteral injury include flank and abdominal pain or distention, urine leakage from abdominal wounds, laboratory evidence of acute kidney injury, oliguria, hematuria, ileus and fever. Staging imaging with intravenous pyelography, retrograde pyelography or CT should be pursued. Retrograde pyelograms should be acquired if other imaging is equivocal, since ultrasonography, intravenous pyelography and CT may only show secondary signs of injury like hydronephrosis or a delayed nephrogram. For most incomplete injuries, where extravasation is present but contrast traverses the injury, a stent should be placed. This stent should be left in place for at least 6 weeks with a foley catheter remaining for at least 1 week.

For complete injuries, where contrast does not traverse the area of extravasation, or in cases when the patient will be taken back to the operating room for other injuries, open surgical repair should be attempted using the techniques outlined above. Such repairs are best done within 7 to 10 days from the initial injury. Outside of this window, a percutaneous nephrostomy should be placed if feasible, with open repair reserved only for cases with no endoscopic or percutaneous options.

Patient Follow-Up

Follow-up care for ureteral injuries is difficult to define as these injuries are rare and variable in presentation. For repairs deemed to have a high likelihood of success, drains can often be removed in the first few postoperative days as long as they remain low output. For drains with high output, measuring the creatinine level of the drain fluid can aid in the decision to keep or remove the drain in settings where this test is available. Stents can often be removed in 6 weeks. For higher-risk repairs or injuries that were treated only with ureteral stenting, retrograde pyelograms at the time of stent removal may be used to confirm appropriate healing. After stent removal, patients should be followed with ultrasound, intravenous pyelography or cross-sectional imaging in the coming months to monitor for signs of ureteral stricture. Follow-up plans should be adjusted on a patient-by-patient basis given the heterogeneity of ureteral injuries and repairs.

> Resource-Rich Settings
> CT Urography:
> Contrasted CT of the abdomen and pelvis with arteriovenous phase and a 10-minute delayed phase.
> Gold standard imaging modality for diagnosing a ureteral injury.
> Aids in surgical planning and may augment injury identification intraoperatively.

George E. Koch MD
Vanderbilt University Medical Center
USA

Niels V. Johnsen MD, MPH
Vanderbilt University Medical Center
USA

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