Ureteral Trauma

Updated: Feb 11, 2017  
Author: Richard A Santucci, MD, FACS; Chief Editor: Bradley Fields Schwartz, DO, FACS

Overview

Practice Essentials

Damage to ureters can result from iatrogenic injury or from external trauma, especially penetrating trauma.[1] Iatrogenic ureteral injury usually involves abdominopelvic surgery or ureteroscopy. Ureteral injuries due to external trauma are rare, as the ureter is well-protected in the retroperitoneum by the bony pelvis, psoas muscle, and vertebrae. Damage to the ureter usually results from a significant traumatic event that is almost always associated with concomitant injury to other abdominal structures. Much of the presentation and management of ureteral injuries are dictated by the severity and management of the associated injuries.

This article discusses the etiology, presentation, evaluation, and management of ureteral injuries.

For patient education information, see the Kidneys and Urinary System Center, as well as Blood in the Urine and Intravenous Pyelogram.

History of the Procedure

Ureteral trauma was first reported in 1868 by Alfred Poland, when a 33-year-old woman died 6 days after being pinned between a platform and a railway carriage. At autopsy, the right ureter was avulsed below the renal pelvis.[2] Henry Morris described the first ureteral procedure in 1904, when he performed an ureterectomy on a 30-year-old man who "fell from his van catching one of the wheels across his right loin."[3]

Etiology

While injuries to the ureter can result from external trauma, iatrogenic causes are more common. These are usually associated with abdominopelvic surgery or ureteroscopy. In addition to intraoperative injury, the ureter can be secondarily affected by postoperative fibrotic or inflammation reactions. Iatrogenic injuries are typically isolated and thus tend to present differently from those associated with external violence.

The American Association for the Surgery of Trauma has classified ureter injuries. The following is the ureter injury scale,[4] which includes the grade of injury, type of injury, and description of injury:

- Grade I – Hematoma; contusion or hematoma without devascularization
- Grade II – Laceration; less than 50% transection
- Grade III – Laceration; 50% or greater transection
- Grade IV – Laceration; complete transection with less than 2 cm of devascularization
- Grade V – Laceration; avulsion with greater than 2 cm of devascularization

With bilateral involvement, the injury is advanced one grade, up to grade III.

External trauma
Over the past several decades, the percentage of genitourinary injuries caused by external trauma in which the ureter is involved has increased from less than 1% to 2.5%. The increase in incidence may be directly related to an increase in survival of severely injured trauma patients. Increased survival from other more deadly injuries and increased use of imaging allows for diagnosis of ureteric injury.\[5, 6\]

External trauma can be penetrating (ie, gunshot wounds, stab wounds) or blunt. Interestingly, when all penetrating and blunt traumas were evaluated, the ureter was damaged in less than 4% and 1% of cases, respectively. The type of external trauma also matters; gunshot wounds accounted for 91% of injuries, with stab wounds and blunt trauma accounting for 5% and 4%, respectively.\[7\]

The relative frequency of ureteral involvement in gunshot trauma is related to the mechanism of the injury. Ballistic injuries affect the ureter in two ways. First, they may directly injure the ureter with varying degrees of severity, ranging from a contusion to complete transection. Secondly, the intramural blood supply of the ureter may be disrupted, resulting in ureteral necrosis. Microvascular studies have shown that this damage may extend as far as 2 cm above and below the point of transection, suggesting that the zone of bullet-associated ureteral injuries extend beyond what is observed grossly. Fortunately, fewer than 3% of gunshot injuries involve the ureters.

Stab wound–related injuries to the ureter are less common than those caused by gunshot injuries. Nevertheless, long-bladed weapons or stab wounds posterior to the midaxillary line should always raise suspicion for possible ureteral involvement.

Blunt trauma can cause ureteral injury from several mechanisms. These mostly involve deceleration or acceleration mechanisms with sufficient force to disrupt the ureter from either the ureteropelvic or ureterovesical junctions. Such injuries can result from a high-speed motor-vehicle collision, a fall from a significant height, or a direct blow to the region of the L2-3 vertebrae.

**Iatrogenic causes**

Risk factors for ureteral injury during open surgery include any condition with the potential to alter the expected course of the ureter, such as the following:

- Previous operations
- Bulky tumors
- **Retropitoneal fibrosis**
- Previous irradiation
- Inflammatory processes
- Ureteral duplication
- Ectopic kidneys

Iatrogenic ureteral injury may result from any of the following:

- Crushing
- Suture ligation
- Devascularization
- Electrocautery
- Cryoablation
- Avulsion
- Transection

**Gynecologic surgery**

Abdominal hysterectomy was once the most common cause of iatrogenic ureteral injury (see the image below). However, ureteral injuries can occur during any abdominopelvic surgery.
Dual injury during hysterectomy. Combination transection of the right ureter with extravasation and left ureter ligation. Image from combined intraoperative intravenous pyelogram IVP and retrograde pyelogram.

Approximately 52%-82% of surgical ureteral injuries occur during gynecologic procedures. Hysterectomy accounts for most of these cases. However, the modality used plays a role: ureteral injury occurs 1.3%-2.2% of abdominal hysterectomies and in only 1.3% and 0.03% of laparoscopic and vaginal hysterectomies, respectively.[8, 9, 10, 11, 12] The risk factors for ureteral injury in these cases include a large uterus, pelvic organ prolapse, and prior pelvic surgery.

The injury typically occurs in the distal ureter in the region of the infundibulopelvic ligament or where a ureter crosses inferior to the uterine artery, often from blind clamping and ligature placement to control hemorrhage. During laparoscopic gynecologic procedures, ureteral injury most commonly results from cauterization or clipping. Interestingly, 33-87% of ureteral injuries caused during laparoscopic surgery are not recognized at the time.[13, 14, 15, 12, 16, 17, 18]

Colorectal surgery

After gynecologic procedures, colorectal surgery is the next most common cause of iatrogenic ureteral injuries. Together, low anterior resection (LAR) and abdominal perineal resection (APR) account for 9% of all such incidences in a combined series and 67% of all general surgical injuries. The incidence of ureteral injury during LAR or APR is 0.3%-5.7%[19] and appears to be rising.[20] The left ureter is involved more commonly than the right, as it may be elevated with the sigmoid mesentery and mistaken for a mesenteric vessel.

Vascular surgery

The overall incidence of ureteral involvement during vascular surgery has been reported as 2%-4%. Ureteral injury may result from direct injury during the procedure or may present as a fistula or hydronephrosis postoperatively. Patients undergoing repeat aortoiliac surgery appear to be at the greatest risk for ureteral injury.

The incidence of asymptomatic hydronephrosis after abdominal vascular surgery has been estimated to be as high as 20%, while only 2% of cases are symptomatic. Of those who are symptomatic, 35% present within 2 months, 50% within 12 months, and 18% after 5 years.[21] Risk factors include ureteral devascularization, retroperitoneal fibrosis, radiation exposure, graft infections, graft dilations, false aneurysms, and anterior graft placement. In patients with early obstruction (< 6 mo), it tends to resolve spontaneously.

Another condition related to vascular surgery is the development of an aortoureteric or graft-ureteric fistula, which can lead to massive hematuria and vascular collapse. The risk factors for the development of the fistulae include anterior graft placement, prolonged use of a ureteral stent, compression, and obstruction.

Urologic procedures

Ureteral injuries that occur during urologic procedures are becoming increasingly common. In one series, they comprised 42% of all iatrogenic injuries.[22] The increased incidence of ureteral injuries during urologic procedures is directly related to the increased use of ureteroscopic equipment. Endoscopic procedures accounted for 79% of injuries, while open surgery accounted for 21%. Most of these injuries occurred in the distal ureter (87%).[22]
The injuries include perforation, stricture, avulsion, false passage, intussusception, and prolapse into the bladder. Risk factors for these injuries include radiation, tumor, inflammation, and impacted stones.

Injury also may be related to the equipment used, such as wires, baskets, and lithotriptors (eg, electrohydraulic lithotripter [EHL]). Ureteroscopy procedures with ureteral access sheath can also cause ureteral wall injury.[23]

Ureteral injuries during robot-assisted prostatectomies are uncommon. In a series of 6442 consecutive patients, ureteral injury occurred in three patients[24].

The increasing use of thermoablation and cryoablation for renal tumors have placed the ureter is at risk for injury. This risk is theoretically higher for lower pole and medially located tumors.

Other iatrogenic causes

Other surgical procedures that may injure the ureters include spinal surgery for disc disease, vaginal surgery for pelvic prolapse, and appendectomy.

Radiation injury to the ureter is rare. The ureter is more resistant to the effects of radiation than the bladder. The incidence of ureteral obstruction due to radiation is 0.04%, while the incidence of obstruction due to recurrent tumor is 95%.

**emedicine**

---

**Presentation**

The key to managing any ureteral injury, regardless of its etiology, is maintaining a high index of suspicion.

Most iatrogenic injuries (70%-80%) are diagnosed postoperatively. The presenting signs and symptoms may include the following[11]:

- Flank pain (36%-90%)
- Fever and sepsis (10%)
- Fistula (ureterovaginal and/or ureterocutaneous)
- Urinoma
- Prolonged ileus
- Renal failure secondary to bilateral obstruction (10%)

Other rare but reported injuries include an aortoureteric or graft-ureteric fistula, which may present as mild-to-massive gross hematuria, or a silent obstruction, which can present later as hypertension and nephrotic syndrome.

Again, with the patient's history in mind, a carefully performed physical examination may be revealing. The following findings are especially suggestive:

- An abdominal or flank mass
- Costovertebral angle tenderness
- Peritoneal signs
- Fluid drainage from the wound or vagina

In patients with external trauma, ureteral involvement may not be obvious, especially when associated with multiorgan involvement. Therefore, the diagnosis of a ureteral injury may be delayed as other critical injuries are addressed. Nevertheless, as discussed above, a high index of suspicion for ureteral involvement must be maintained.

**emedicine**

---

**Indications**

The choice of treatment is based on the location, type, extent, and timing of presentation, as well as the patient's medical history, overall condition, and survival prognosis (see Surgical therapy).

**emedicine**

---

**Relevant Anatomy**

The ureters are peristaltic tubular structures that course from the kidney to the bladder in the retroperitoneum. Histologically, they are composed of an outer serous layer, a smooth muscle layer, and an inner mucosal layer. The smooth muscle layer
consists of 2 circular layers separated by a longitudinal layer.

The ureters can be divided into 3 segments: proximal; middle; and pelvic, or distal. The proximal ureter is the segment that extends from the ureteropelvic junction to the area where the ureter crosses the sacroiliac joint, the middle ureter courses over the bony pelvis and iliac vessels, and the pelvic or distal ureter extends from the iliac vessels to the bladder. The terminal portion of the ureter may be subdivided further into the juxtap-vesical, intramural, and submucosal portions.

The ureters are at risk during open surgery because of their proximity to many abdominal and pelvic structures. They lie anterior to the psoas muscles and adhere to the posterior peritoneum. The left ureteropelvic junction is posterior to the pancreas and duodenal-jejunal junction. On the right, it lies posterior to the duodenum and just lateral to the inferior vena cava (IVC). The left ureter is crossed anteriorly by the inferior mesenteric artery and sigmoid vessels. The right ureter is crossed by the right colic and ileocolic vessels. As they descend into the pelvis, the ureters course anterior to the iliac vessels but posterior to the gonadal vessels.

In males, the ureter is crossed anteriorly by the medial umbilical ligament. Before entering the bladder, the ureter passes under the vas deferens.

In females, the ureter courses posterior to the ovary, lateral to the infundibulopelvic ligament, and medial to the ovarian vessels. It then passes posterior to the broad ligament and lateral to the uterus. As the ureter approaches the bladder, it is about 2 cm lateral to the cervix. The uterine vessels run just anterior to the ureter near the ureterovesical junction. Most commonly, the ureter is injured in the ovarian fossa near the infundibulopelvic ligament and where the ureter courses posterior to the uterine vessels.

The ureteric arteries course in the adventitia longitudinally. They are supplied by branches from the renal, aortic, gonadal, iliac, and vesical arteries. The ureteric arteries are continuous in 80% of cases. In the abdominal portion, the blood supply is derived medially, and, in the pelvis, the blood supply comes from the lateral aspect. The richest blood supply is to the pelvic ureter.

Lymphatic drainage from the ureter drains to regional lymph nodes. No continuous lymph channels extend from the kidney to the bladder. The regional nodes that serve as drainage include the common iliac, external iliac, and hypogastric lymph nodes.

emedicine

Contraindications

Contraindications to ureteral repair vary according to the specific procedure, as follows:

- Relative contraindications to a vesicopsoas hitch include small-capacity bladders (eg, neurogenic bladder, irradiated bladders) and evidence of significant bladder outlet obstruction.

- Relative contraindications to a Boari bladder flap include small, contracted, irradiated, and neuropathic bladders; transitional cell carcinoma; and previous bladder mobilization that threatens the blood supply to the pedicle.

- The absolute contraindications to transureteroureterostomy (TUU) include a short donor ureter or a diseased recipient ureter. Relative contraindications include a urothelial tumor, nephrolithiasis, pelvic or abdominal irradiation, retroperitoneal fibrosis, and ureteral injury caused during aortoiliac bypass surgery.

- Autotransplantation is contraindicated in patients who are older than 60 years and in those with underlying aortoiliac atherosclerosis or renal disease. The presence of retroperitoneal fibrosis is a relative contraindication because of the potential of venous obstruction.

- Contraindications to ileal ureteral substitution include a serum creatinine level of greater than 2 mg/dL, neurogenic bladder, bladder outlet obstruction, inflammatory disease, radiation enteritis, and hepatic dysfunction.

emedicine

Workup

Laboratory Studies

Laboratory evaluation should include the following:

- Urinalysis
- Urine culture
• Complete blood count
• Creatinine determination from the serum and drainage

Interestingly, hematuria is not a reliable finding in ureteral injuries.[25] Only 74% of cases involve gross or microscopic hematuria.[7] A failure to observe hematuria may be seen with a completely transected ureter or partial transection of an adynamic segment.

Imaging Studies

Computed tomography

Computed tomography (CT) scanning is the criterion standard for evaluating abdominal injuries due to blunt trauma in stable patients. Contrast-enhanced CT scanning is highly sensitive in detecting urine extravasation and thus can be considered the primary imaging modality to evaluate for ureteral integrity in the stable patient. However, delayed imaging at least 10-15 minutes after contrast injection must be performed to adequately evaluate for urine extravasation.

Delayed images must be obtained if the clinician has an index of suspicion because subtle findings on initial CT scanning can suggest ureteral or ureteropelvic junction injury. Findings on early or noncontrast images that may raise suspicion of ureteral or renal pelvis injury include the following[26]:

• Perinephric stranding
• Low-density fluid around the kidney and ureters
• Perinephric hematomas

Excretory urography or intravenous pyelography

Formal intravenous pyelography (IVP) is not appropriate in the acute setting. However, in patients who must undergo immediate exploratory laparotomy for a penetrating injury to the abdomen, the ureters may be evaluated with a one-shot IVP. This is performed by obtaining a single anterior-posterior abdominal film on the gurney or operating room table 10 minutes after the intravenous injection of a 2 mL/kg (maximum of 150 mL) bolus of contrast medium. The advantage of this study is that, when performed correctly, surgical intervention is not delayed, allowing for concurrent assessment of renal function and staging of upper urinary tract injuries.

Findings suggestive of an injury include the following:

• Delayed renal function or excretion
• Ureteral dilatation or deviation
• Extravasation of contrast
• Nonvisualization of the ureter

Unfortunately, this study yields a wide range of sensitivity, from 0% to 100%, with an average of 61%.[7] As a result, negative findings do not preclude the surgical exploration of the ureter if damage is suspected, but completely normal findings indicate that significant ureteral injury is unlikely. Intraoperative single-shot IVP cannot reliably exclude ureteral injury and should not be used solely for this purpose.[27]

Retrograde pyelography

Retrograde pyelography (RPG) is the most sensitive radiographic study for the diagnosis of ureteral injury. It is not always appropriate for use in the acute setting but may be used in the stable patient as an adjunct to other imaging modalities when other clinical information is needed. It has the added advantage of facilitating the placement of a ureteral stent in the same session, if indicated.

Antegrade ureterography

Antegrade ureterography is not routinely used in diagnosing ureteral injuries. It is useful in conjunction with percutaneous nephrostomy tube placement, or placement of an antegrade ureteral stent.

Magnetic resonance imaging

Cost and time has precluded the widespread use of magnetic resonance imaging (MRI) in the acute, particularly, traumatic situation. MR urography (MRU) is a more recent imaging concept in evaluating the urinary tract. In MRU, a low-dose diuretic injection is used to enhance excretion of the contrast agent gadopentetate dimeglumine. MRU sequences are generally repeated 5 and 15 min after contrast agent injection. T2-weighted sequences have been shown to be rapid, safe, and noninvasive for reliable depiction of the urinary tract while avoiding exposure to ionizing radiation and iodinated contrast agents.[28, 29]
Delayed imaging

Delayed presentation of ureteral injuries or those missed on initial presentation may be suggested by signs such as fever, leukocytosis, local peritoneal irritation, and leakage of urine from the wound. These should be evaluated with CT scanning, but RPG may ultimately be necessary.

Diagnostic Procedures

Surgical exploration of the retroperitoneum with direct visualization of the ureter is the best method of diagnosing ureteral injury. An average of 89.3% of ureteral injuries are detected with intraoperative inspection.[30]

Inspection of the ureter involves mobilization of the ureter and visualization of the entire wall for evidence of contusion, hemorrhage, or disruption. Neither blind palpation nor observation of ureteral peristalsis is a reliable indicator of a healthy ureter.

Intravenous indigo carmine or methylene blue injection is a useful adjunct with simultaneous inspection for ureteral dye leakage. Alternately, 1-2 mL can be injected directly in the renal pelvis with a 27-gauge needle and the ureter examined for leakage. This is particularly helpful in patients with hypotension in whom intravenous dye may not be excreted efficiently. The lack of dye extravasation is only guardedly reassuring, as a damaged ureteral wall may not leak immediately but may leak or extravasate later. This indicates the importance of visualization of the entire ureteral segment in question. In some cases, the dye itself may hinder diagnosis by staining local tissues and impeding visualization of the specific leakage points.

Gunshot wounds near the ureter warrant careful inspection of the entire ureteral wall for continuity, hemorrhage, and contusion. Indigo carmine or methylene blue may administered, as described above. If the bladder is already open, the dye may be injected in a retrograde fashion; otherwise, ureteral catheters may be passed up the ureter. If the catheter passes easily and no obvious defect in the continuity of the ureter is observed, a ureteral injury is unlikely.

Cystoscopy with retrograde pyelography is the best procedure for detecting ureteral injuries in the stable patient. In addition, it allows for ureteral stent placement in the same session, as indicated.

Treatment

Surgical Therapy

Management of ureteral injuries is dictated by the location, type, extent, timing of presentation, medical history, overall status of the patient, including associated injuries, and prognosis.[31]

The American Urologic Association has released guidelines on imaging and management of ureteral trauma with varying degrees of evidence strength. Recommendations are as follows[27]:

- Clinicians should perform IV contrast enhanced abdominal/pelvic CT with delayed imaging (urogram) for stable trauma patients with suspected ureteral injuries
- Clinicians should directly inspect the ureters during laparotomy in patients with suspected ureteral injury who have not had preoperative imaging
- Surgeons should repair traumatic ureteral lacerations at the time of laparotomy in stable patients
- Surgeons may manage ureteral injuries in unstable patients with temporary urinary drainage followed by delayed definitive management
- Surgeons should manage traumatic ureteral contusions at the time of laparotomy with ureteral stenting or resection and primary repair depending on ureteral viability and clinical scenario
- Surgeons should attempt ureteral stent placement in patients with incomplete ureteral injuries diagnosed postoperatively or in a delayed setting
- Immediate repair can be considered in certain clinical situations if the injury is recognized within one week (eg, injury located near a surgically closed viscus, such as bowel or vagina, or if the patient is being re-explored for other reasons)
Surgeons should perform percutaneous nephrostomy with delayed repair as needed in patients when stent placement is unsuccessful or not possible

Surgeons should repair ureteral injuries located proximal to the iliac vessels with primary repair over a ureteral stent, when possible

Surgeons should repair ureteral injuries located distal to the iliac vessels with ureteral reimplantation or primary repair over a ureteral stent, when possible

Surgeons should manage endoscopic ureteral injuries with a ureteral stent and/or percutaneous nephrostomy tube, when possible

Surgeons may manage endoscopic ureteral injuries with open repair when endoscopic or percutaneous procedures are not possible or fail to adequately divert the urine

Ureteral injuries in patients who are too unstable to tolerate surgery should be repaired in a staged fashion or, extremely rarely, with nephrectomy. If a staged repair is chosen, the damaged ureter is initially tied off with long silk ties to aid in visualization of the ureter during the second stage of the repair. The kidney is drained percutaneously, preferably in the immediate postoperative period by the surgeon, or later by the interventional radiologist. Some surgeons have placed an 8F feeding tube into the ureter and exteriorized it until the repair can be completed.

Although nephrectomy is rarely necessary, it may be indicated in cases of severe collateral and irreparable injury to the ipsilateral kidney or a severe panureteral injury, although even the most devastating ureteral injuries can usually be repaired with reconstruction.

Understanding the vascular anatomy of the ureter is crucial in planning and effecting ureteral repair. Recall that the ureteric arteries and arterioles travel longitudinally in the adventitia, with the abdominal ureter receiving branches medially from the renal, aortic, gonadal, and lumbar arteries, while the pelvic ureter is perfused by branches laterally from the iliac artery and its branches. Following the principles of ureteral repair can prevent complications such as urinary leakage leading to patient debility, nephrectomy, and, in rare cases, death.

- Carefully mobilize the ureter to preserve the adventitia (blood supply)
- Judiciously débride the nonviable tissue until the edges bleed
- Spatulate the edges and repair with 5-0 absorbable suture under magnification
- Anastomosis should be watertight and tension-free over an internal stent
- The repair must be isolated from infection, retroperitoneal fibrosis, and cancer
- The omentum or retroperitoneal fat can be used to cover the repair; this decreases the risk of fibrosis and increases the blood supply to the repair region (wrapping the repair reportedly also allows the ureter to remain unscarred and to resume normal peristalsis)
- The retroperitoneum should be drained with a gravity drain

The choice of repair will be guided by several factors: hemodynamic stability of the patient, location and length of the injury, function of the contralateral kidney, and severity of associated injuries. Surgical decision making is also influenced by any prior history of urothelial carcinoma, history of urolithiasis, radiation exposure, or retroperitoneal fibrosis.

Contusion

Although a contusion may be considered a minor injury, it can result in a stricture if left untreated. Extensive areas of contusion may even result in ureteral necrosis secondary to microvascular damage. Minor injuries can be treated with internal ureteral stenting[5], while severe or large areas of contusion should be excised and ureteroureterostomy performed.

Partial transection

Partial ureteral transections can be repaired with primary closure. This procedure should not be performed in victims of gunshot wounds. Instead, the injured segment should be resected, with 2-cm margins, and the edges reapproximated, as described above. For nonballistic injuries, the defect may be closed primarily in the Heineke-Mikulicz fashion (ie, closing the longitudinal laceration transversely in order to avoid narrowing of the lumen).

Upper ureteral injuries

Approximately 39% of ureteral injuries occur in the upper ureter. The mid ureter and distal ureter account for the remaining 31% and 30%, respectively. Location of injury and vascular integrity of the ureter dictates the choice of repair. Upper ureteral injuries can frequently be repaired with ureteroureterostomy. However, if additional length is required for a tension-free anastomosis, mobilization of the kidney may be of benefit. The kidney should be completely mobilized and rotated medially.
and inferiorly on its vascular pedicle, with the lower pole sutured to the psoas muscle. This maneuver may provide an additional 5-8 cm of length.

Ureteroureterostomy

Ureteroureterostomy involves an end-to-end repair of ureteral defects smaller than 3 cm (see image below). This is mostly performed in the upper and mid ureter. The damaged segment of the ureter is mobilized and excised, and the ureteral ends are spatulated and approximated over an internal stent to achieve a water-tight anastomosis. To minimize handling of the ureter, holding sutures may be placed on both free ends. The reapproximation of the ureters may be performed in either a running or interrupted fashion with 5-0 absorbable suture with equal efficacy.

![Ureteroureterostomy](https://emedicine.medscape.com/article/440933-print)

Ureteroureterostomy in ureteral trauma.

This procedure yields a success rate of approximately 90%. Short-term complications include urinary leakage (10%-24% of patients), abscess, and fistula. Long-term complications (eg, ureteral stenosis) are less common (5%-12% of patients). Urinary leakage from a retroperitoneal drain can be managed expectantly; drainage following ureteral repair lasts an average of 12 days.

Ureteropyelostomy

In the event of a ureteral avulsion from the renal pelvis or a very proximal ureteral injury, the ureter may be anastomosed directly into the renal pelvis.

Ureterocalicostomy

If the renal pelvis or ureteropelvic junction is damaged beyond repair, ureterocalicostomy may be performed. In this procedure, the ureteral stump is sewn end-to-side into an exposed renal calyx.

**Midureteral injuries**

Midureteral injuries can be repaired with ureteroureterostomy (see above) or transureteroureterostomy.

Transureteroureterostomy

Transureteroureterostomy can be performed to manage an extensive defect that involves the mid or upper ureter if the length for anastomosis to the bladder is insufficient. This involves bringing the injured ureter across the midline to the recipient ureter in an end-to-side anastomosis (see image below). This is achieved by tunneling the donor ureter through the sigmoid colon mesentery superior to the inferior mesenteric artery to avoid kinking. With minimal mobilization of the recipient ureter, a small elliptical opening is created, and the donor ureter is spatulated to perform an end-to-side anastomosis. A feeding tube or double-J stent should be placed from the donor kidney, across the anastomosis, and down to the bladder. This procedure yields a high success rate (97%).
Transureteroureterostomy in ureteral trauma.

Contraindications to transureteroureterostomy include a short donor ureter or a diseased recipient ureter. Relative contraindications include a history of urothelial cancer or calculi, pelvic or abdominal irradiation, retroperitoneal fibrosis, and ureteral injury caused during aortoiliac bypass surgery. Postoperatively, intubation of the injured ureter with ureteroscopy can be daunting. Importantly, this procedure risks injury to the uninjured ureter and thus should be performed only when other alternatives are unfavorable.

**Lower ureteral injuries**

**Ureteroneocystostomy**

Injuries to the lower ureter are usually associated with disruption of its blood supply from the iliac vessels. Therefore, these injuries are best repaired with ureteroneocystostomy. Numerous techniques are available for this repair. The principles of repair include debridement and spatulation of the ureter, tunneling in the bladder wall toward the bladder neck in a 3:1 ratio of tunnel length to diameter of ureter. This tunnel is best placed superior and medial to the native ureteral orifice, where the bladder wall is less mobile, to avoid kinking of the ureter. The repair should be stented and a suprapubic tube and urethral Foley catheter placed. This repair can bridge defects up to 5 cm.

Whether the repair is antirefluxing depends on the age of the patient and the severity of associated injuries. In adults, antirefluxing and refluxing procedures are associated with the same rates of renal function preservation and risk of stenosis. In adults with normal bladders, unobstructed infravesical pathways, and no urinary tract infection, reflux does not impair renal function. Various types of reimplantation procedures have been described; such a discussion is beyond the scope of this review. The reimplant may be intravesical or extravesical, depending on surgeon preference.

**Vesicopsoas hitch**

This is the treatment of choice for lower ureteral injuries that cannot be successfully repaired with ureteroneocystostomy alone (see image below). This procedure involves mobilizing the bladder and pulling it superiorly and laterally by fixing it to the psoas tendon with an absorbable suture. This technique can be used to bridge a 6- to 8-cm defect. Both the genitofemoral nerve located on the surface of the muscle and the femoral nerve deep to the muscle may be injured during this repair. In order to achieve additional length, the urachus, obliterated umbilical artery, and contralateral superior vesical artery may be divided. Ureteral anastomosis is performed medial to the hitch. Postoperative stenting for approximately 3-6 weeks is recommended, and an open anastomosis should be demonstrated radiographically prior to stent removal. This procedure yields a success rate of 95%.
Psoas hitch in ureteral trauma.

Complications include ureteral obstruction, urinary leakage, and voiding difficulties. Relative contraindications include small-capacity bladders and bladder outlet obstruction.

Boari bladder flap

For injuries too long to be bridged with the psoas hitch procedure alone, a Boari flap can be created to provide an additional 12-15 cm of length (see image below). In this procedure, a pedicle of bladder is swung cephalad and tubularized to bridge the gap to the injured ureter. The base of the flap should be at least 4 cm to avoid ischemia. It can be developed obliquely across the anterior bladder or as a spiral flap to help gain additional length. The flap can be fixed to the psoas tendon superiorly with the ureter anastomosed to the flap, which is then rolled anteriorly into a tube and closed in 2 layers. The procedure is time-consuming and is likely not useful in the acute setting.
Complications include bladder pedicle ischemia with resultant necrosis, possible stricture formation, and urinary leakage. Relative contraindications include small contracted bladders, neurogenic bladder, and transitional cell carcinoma.

**Other surgical options**

**Autotransplantation**

Autotransplantation involves relocating the ipsilateral native kidney to the pelvis; the renal artery and vein are then anastomosed to the iliac vessels, and the healthy ureter or renal pelvis is anastomosed to the bladder.

Autotransplantation offers the best results in patients younger than 60 years without any underlying aortoiliac atherosclerosis or renal disease. This may also be considered in patients with retroperitoneal fibrosis and may be useful in those with a poorly functioning or absent contralateral kidney. Autotransplantation has been associated with a loss of 8% of renal units. The authors believe that autotransplantation is less desirable than ileal ureter for massive ureteral loss. It is not recommended in the acute setting.

Totally intracorporeal robotic donor nephrectomy with autotransplantation has now been described. Only skilled robotic surgeons should attempt this complex procedure.[32]

**Intestinal interposition**

Long ureteral defects can be replaced with reconfigured colon, ileum, and appendix.[33, 34]

As with autotransplantation, ileal interposition (ie, the creation of a ureteral conduit from ileum) is inappropriate in the acute setting (see image below). When performed in the elective setting, it yields a high success rate (81%). However, this type of repair has several contraindications, including a serum creatinine level greater than 2 mg/dL, neurogenic bladder, bladder outlet obstruction, inflammatory disease, radiation enteritis, and hepatic dysfunction. If preoperative creatinine is normal, an ileal substitution has been shown to preserve long-term renal function.[35]

Complete ureteral replacement utilizing ileum in ureteral trauma.
Ileovesical anastomosis. Bladder to the left, ileum to the right.

Metabolic complications are rare in patients with good renal function and an isoperistaltic ileal segment. In patients with high-pressure bladders, dilatation of the ileal segment may lead to urinary stasis and consequent metabolic disturbances such as hyperchloremic hypokalemic metabolic acidosis. However, the segment of ileum and transit time are usually short enough to prevent metabolic complications. Bacteriuria is common but is usually clinically insignificant as long as the bladder is being adequately drained and mucus buildup secondary to the secretion from ileal mucosa is minimized.

Urinary diversion

Urinary diversion in the form of a stent and/or nephrostomy tube should be considered, when indicated. A stent aligns the area of anastomosis, prevents extravasation, prevents obstruction from edema, and provides a scaffolding around which the ureter may heal. Studies of ureteral healing have demonstrated that the mucosa has healed by 3 weeks and muscular continuity is established by 7 weeks.[36] Thus, many recommend that a stent remain in place for 6-8 weeks after a repair. Stents come in various diameters (4-8F) and lengths. The size of stent chosen depends on the diameter and length of the ureter. The height of the patient is often used to estimate the ureteral length, although this is not always accurate. A stent should fit in the ureter smoothly, without compressing the ureteral wall, which would compromise ureteral blood supply.

The appropriate stent length can be gauged from an IVP or RPG (length corrected for 10% magnification plus 1 cm) or from the patient's height and sex. The average male usually requires a 26-cm stent, while the average female requires a 24-cm stent. The type of stent must also be considered. Stents are made of different materials that have different effects on the ureter and differing biocompatibility. All stents cause epithelial erosion and ulceration. Experimental studies have shown that C-Flex (Concept Polymer Technologies; Clearwater, FL), which is a proprietary styrene/ethylene/butylene copolymer, causes less epithelial reaction and has excellent biocompatibility. Firm or hard stents may be more appropriate in patients in whom fibrosis and extrinsic compression may become an issue.

Percutaneous nephrostomy may be used for more proximal diversion if the repair is tenuous or if healing may be delayed. However, complete proximal diversion should be avoided because the flow of urine down the ureter often is needed to help promote ureteral healing. Prolonged diversion may result in a dry anastomosis that may scar. The advantage of a percutaneous nephrostomy is that it can be clamped prior to removal to assess for symptoms of persistent obstruction, and antegrade nephrostography can be performed to assess the integrity of the repair. If persistent extravasation or poor healing is evident, the nephrostomy tract that has already been created can be used to place an indwelling ureteral stent if it has not been placed previously. In the author's institution, antegrade nephrostography is routinely performed to assess the integrity of the repair. Then, the tube is clamped for several hours to ensure the patient does not develop flank pain. It is then removed.

Retrograde ureteral stent placement

An endoscopic approach with retrograde ureteral stent placement may be effective in certain iatrogenic injuries and injuries secondary to external violence. If the patient is stable, this is often the first line of treatment. If retrograde placement is unsuccessful, a percutaneous nephrostomy tube may be placed to acutely decompress the system and to potentially attempt antegrade placement of a stent.

Laparoscopic/robotic

Of ureter injuries, 75% are iatrogenic. Among iatrogenic injuries, 73% are gynecologic, 14% are general surgical, and 14% are urologic.[37] Laparoscopy for gynecologic, general, and urologic procedures is becoming the standard of care. The incidence of ureteral injuries has increased since the introduction of laparoscopic surgery.[38]
Similarly, ureteral injuries are now repaired laparoscopically with particular rise in robotic use of ureteral reconstruction.[39] There are reports of laparoscopic Boari flap, psoas hitch, and ureteroureterostomy repairs are promising.[40, 41] Initially, operative times were longer but have decreased as experience has increased. Laparoscopy, particularly with the Da Vinci, provides the advantages of less postoperative pain, less blood loss, shorter convalescence, and minimal disfigurement.[40, 42] The success rates of laparoscopic ureteral reanastomosis of a transected ureter vary from 88-100%. [17] Robot assistance for ureteral reconstructive surgery has been successful with Boari flap ureteral reimplant.[43]

The above stated principles of repair remain the same whether the method is traditional open or laparoscopic.

**Damage control**

Patients with ureteral injury secondary to external violence often have multiple associated injuries, and the patient is often critically ill. In patients with acidosis (pH < 7.25), hypothermia (35°C), and coagulopathy, avoiding a prolonged reconstructive procedure is often prudent.

Patients who are in shock and/or have peritoneal contamination may be at a higher risk for complications following repair. Tissue hypoxia and gross contamination play an important role in the pathogenesis of strictures, urinomas, fistulas, and even death.

An abbreviated laparotomy and planned reoperation is becoming a preferred form of management in hemodynamically unstable patients with trauma. The damage-control approach involves evaluating the extent of the ureteral injury and expeditiously performing a stented cutaneous ureterostomy. Some surgeons have even placed an 8F feeding tube in the ureter and exteriorized it until the second operation. The patient can then be taken to the intensive care unit for resuscitation and definitive repair can be planned for the second-look laparotomy.

An alternative technique is to ligate the ureter, leaving long silk ties to aid in visualization at the time of the second operation. A percutaneous nephrostomy is placed by the surgeon intraoperatively or by the interventional radiologist postoperatively. This damage-control approach also allows the ureter to be reexamined at the planned reoperation.

Although nephrectomy is rarely necessary, it may be indicated in cases of severe collateral and irreparable injury to the ipsilateral kidney or a severe panureteral injury, although even the most devastating ureteral injuries can usually be repaired with reconstruction.

**Delayed diagnosis**

The diagnosis of ureteral injuries caused iatrogenically and those due to penetrating trauma is often delayed. In fact, 8%-57% of all ureteral injuries are recognized late. Such patients may present with signs and symptoms of fever, sepsis, flank pain, paralytic ileus, azotemia, and anuria. Abdominal CT scanning is a useful diagnostic tool to identify the site of injury and any associated abscess or fluid collection. Excretory urography and an RPG are also excellent first studies to help delineate the injury.

The interval from injury to recognition is important and should guide management. If the injury is diagnosed within the first 7 days without a concomitant significant infection, surgical exploration and repair may be performed. Attempting repair after 10-14 days may be difficult secondary to a marked inflammatory response. In addition, the presence of an abscess, urinoma, or fistula should delay any attempt at a definitive operative repair.

In patients in whom recognition of a ureteral injury is delayed, an initial endourologic approach may be appropriate. Patients with sepsis may benefit from urinary diversion via a percutaneous nephrostomy tube or retrograde ureteral catheter. Associated fluid collections can also be drained percutaneously.

Occasionally, diversion of the urine stream with a nephrostomy or stent is the only intervention needed. Ureters without strictures heal in most patients. However, if a stricture does develop, it can be managed endoscopically with balloon dilation or endoureterotomy. Open ureteral repair can be deferred for 1-3 months while infection and inflammation subside. Despite concerns of inflammation that may be encountered during early exploration, several studies have reported early open repair with low morbidity, a low complication rate, and equally good results.[11]

Managing a ureteral injury during a vascular graft procedure is controversial and can be approached via nephrectomy (if the patient has a functioning contralateral kidney) or a primary ureteroureterostomy with isolation of the repair with omentum. While a nephrectomy may be advocated to prevent postoperative urine leakage around the prosthetic vascular graft, it may come at a cost. The mortality rate associated with renal failure during routine aortic aneurysmectomy is 3% (and up to 12% in patients with a ruptured aneurysm). Conversely, if the risk associated with ureteral repair is minimal, the vascular surgeon should complete the graft anastomosis before addressing the ureteral injury. Studies have demonstrated that primary ureteral repair without nephrectomy is feasible and does not unduly jeopardize the vascular graft if the urine is not infected preoperatively.[44]

**Follow-up**
The repair should be observed regularly for the first year to evaluate for signs of obstruction or loss of renal function. This may include IVP to delineate the anatomy and serial renal ultrasonography to evaluate for hydronephrosis.

To evaluate renal function more objectively, nuclear scanning may be helpful.

In patients with an ileal ureter, serum chemistry studies are helpful to monitor serum creatinine and metabolic derangements. Clearly, the frequency and duration of follow-up depends on the clinical setting and the long-term stricture rates associated with each procedure.

Complications

Procedures used to repair traumatically injured ureters carry a complication rate of 25%, and the specific types of complications possible depend on the type of reconstruction performed.

The most common acute complication is prolonged urinary leakage from the anastomosis. This can manifest as urinoma, abscess, or peritonitis and can be prevented by intraoperative placement of a drain in the retroperitoneum, thereby allowing both the drainage of urine and early recognition of urinary leakage from the anastomosis. If a high volume of fluid drains, the fluid should be checked for creatinine. The delayed recognition of undrained urinary leakage has been associated with sepsis, a more complicated reconstruction, and increased hospital stay.

Other complications common to all repairs may include stricture, hydronephrosis, abscess, fistula formation, and infection. The key is to diagnose the problem early and to treat accordingly.

Hydronephrosis that develops following injury repair may be managed by simply replacing a stent or dilating the strictured segment. However, management of each complication depends on the time of diagnosis and presentation. Most complications can be managed with endoscopy or reoperation.

Ileal ureter substitution may be complicated by stone formation, renal failure, infection, stricture, calculi, pyelonephritis, and associated metabolic derangements.

After ureteral repair during aortic surgery, vascular grafts can become infected, requiring vascular and urinary diversion to eradicate. The best method of treating this dreaded complication is prevention, which usually means performing a ureteral repair with omental interposition. Nephrectomy may still need to be performed if initial repairs are unsuccessful.

Complications related to prolonged stent placement and nephrostomy tubes include migration, infection, encrustation, pain, and loss of renal function.

Outcome and Prognosis

See Surgical therapy for detailed discussions of the outcomes of each procedure.

Future and Controversies

Prevention

Ureters tend to be injured during difficult open surgery or endoscopic procedures. Some injuries may be unavoidable, and the goal is to minimize such injuries. Preoperative imaging is not indicated in all cases but may be of benefit in high-risk patients. Careful identification of the ureters and their course helps avoid injury. Lasix and hydration facilitate visualization of the ureter. The ureter is often injured during attempts at bleeding control. Adequate exposure and hemostasis, when possible, also help prevent injury.

Some have advocated the prophylactic placement of ureteral catheters or stents. Advocates of this practice argue that they help the surgeon palpate the ureter and may be of particular help in laparoscopic procedures. The stents may help in recognizing an injury intraoperatively. Of particular use in laparoscopy are lighted stents, which illuminate and help identify the ureter, thereby reducing the risk of iatrogenic injury.[45, 46]
Opponents of this practice argue that, in the presence of inflammation, the stents still may not be palpable and that the presence of the stent actually may alter the course of the ureter, placing it at risk. Histologic analysis does not seem to show any evidence of thermal injury to the urothelium or any remarkable alteration in the ureteral mucosa.[47]

Complication rates associated with ureteral stent placement are 1%. Anuria secondary to bilateral ureteral edema may occur. Some also argue that ureteral stimulation may cause renal cortical vasoconstriction, leading to decreased filtration and anuria. Additionally, placement of ureteral catheters significantly adds to the cost of the procedure.

However, the prophylactic placement of stents may be useful. Nonetheless, some studies have failed to demonstrate a reduction in iatrogenic injuries. Otherwise, placement is safe and associated with few complications. It does not prevent injury but may aid in the diagnosis and treatment of an injury.

Intraureteral injection of indocyanine green (Akorn, Lake Forest, IL) and visualization under near-infrared (NIR) light allows for real-time delineation of the ureter. This technology can be helpful to prevent iatrogenic ureteral injury during pelvic surgery. During the course of robotic surgery, the NIR laser on the da Vinci Si surgical robot (Intuitive Surgical Sunnyvale, CA) is used to excite indocyanine green molecules; infrared emissions are captured by the Da Vinci filtered lens system and electronically converted to green color. Thus, the ureter fluoresces green, allowing its definitive identification throughout the entire procedure.[48]

**Future**

Many novel techniques for ureteral reconstruction after ureteral trauma have been used. Reports of buccal mucosa and biodegradable endoluminal stenting are promising,[49, 50, 51] and this approach may become a more mainstream method for treating ureteral strictures. Their use in the acute trauma setting has not been reported.

Large ureteral damages are difficult to reconstruct. The use of tissue engineering techniques for ureter reconstruction and regeneration may be possible in the future.[52]

---

**Contributor Information and Disclosures**

**Author**

**Richard A Santucci, MD, FACS** Specialist-in-Chief, Department of Urology, Detroit Medical Center; Chief of Urology, Detroit Receiving Hospital; Director, The Center for Urologic Reconstruction; Clinical Professor of Urology, Michigan State University College of Medicine

Richard A Santucci, MD, FACS is a member of the following medical societies: American College of Surgeons, International Society of Urology, American Urological Association

Disclosure: Nothing to disclose.

Coauthor(s)

**Craig B Hunter, DO** Resident Physician, Department of Urology, Detroit Medical Center

Craig B Hunter, DO is a member of the following medical societies: American College of Surgeons, American Osteopathic Association, American Urological Association, American College of Osteopathic Surgeons, Sigma Sigma Phi

Disclosure: Nothing to disclose.

**Specialty Editor Board**

**Francisco Talavera, PharmD, PhD** Adjunct Assistant Professor, University of Nebraska Medical Center College of Pharmacy; Editor-in-Chief, Medscape Drug Reference

Disclosure: Received salary from Medscape for employment. for: Medscape.

**Shlomo Raz, MD** Professor, Department of Surgery, Division of Urology, University of California, Los Angeles, David Geffen School of Medicine

Shlomo Raz, MD is a member of the following medical societies: American College of Surgeons, American Medical Association, American Urological Association, California Medical Association

Disclosure: Nothing to disclose.

**Chief Editor**

**Bradley Fields Schwartz, DO, FACS** Professor of Urology, Director, Center for Laparoscopy and Endourology, Department of Surgery, Southern Illinois University School of Medicine
Bradley Fields Schwartz, DO, FACS is a member of the following medical societies: American College of Surgeons, American Urological Association, Association of Military Osteopathic Physicians and Surgeons, Endourological Society, Society of Laparoendoscopic Surgeons, Society of University Urologists

Disclosure: Serve(d) as a director, officer, partner, employee, advisor, consultant or trustee for: AUA Journal of Urology<br>Serve(d) as a speaker or a member of a speakers bureau for: Cook Medical; Olympus, 

Additional Contributors

Allen Donald Seftel, MD Professor of Urology, University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School; Head, Division of Urology, Director, Urology Residency Training Program, Cooper University Hospital

Allen Donald Seftel, MD is a member of the following medical societies: American Urological Association

Disclosure: Received consulting fee from lilly for consulting; Received consulting fee from abbot for consulting; Received consulting fee from auxilium for consulting; Received consulting fee from actient for consulting; Received honoraria from journal of urology for board membership; Received consulting fee from endo for consulting.

Acknowledgements

Heinric Williams, MD Resident Physician, Department of Urology, Harper Hospital, Wayne State University School of Medicine

Heinric Williams, MD is a member of the following medical societies: American College of Physicians-American Society of Internal Medicine, American College of Surgeons, and American Urological Association

Disclosure: Nothing to disclose

References


