AUA Update Series 2020
Lesson 11 Volume 39

Calling the Urologist: Considerations in Intraoperative Consultations*

Learning Objective: At the conclusion of this continuing medical education activity, the participant will be able to identify the location of iatrogenic injuries to the urinary tract, review anatomic considerations for preventing injuries, describe diagnostic techniques for localizing and staging injuries, indicate reconstructive techniques for repair and approach passage of the difficult urethral catheter in a systematic fashion.

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***This AUA Update addresses the Core Curriculum topics of Consults & Emergencies, and Trauma; and the American Board of Urology Modules on Core/General Urology, and Neurogenic Bladder, Voiding Dysfunction, Female Urology, BPH and Urethral Stricture.**

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Release date: April 2020

Expiration date: April 2023

Key Words: wounds and injuries, wound healing, ureter, urinary bladder, urethra

INTRODUCTION

Iatrogenic injury to the urinary tract during operations within the pelvis and retroperitoneum occurs most commonly to the ureters followed by injuries to the bladder and urethra. Although most ureteral injuries occur in patients without significant risk factors,[1] the incidence of urinary tract injuries increases after prior pelvic operations, or in patients with inflammatory bowel disease, infection and extensive neoplasms causing distortion of normal surgical planes. Unrecognized congenital anomalies, such as a duplicated ureter (1 of 125 cases), retrocaval ureter and horseshoe or pelvic kidneys (1 of 400 cases), can present unfamiliar anatomy to the surgeon.[2] As minimally invasive techniques increase in frequency, the use of the various energy based tissue devices in close proximity to the urinary tract may also cause urinary tract injury in the immediate or delayed setting. Coupled with the fact that iatrogenic injury to the urinary tract can be a source of significant morbidity, a systematic approach to assessment, planning and follow-up is most beneficial in this setting. Mechanisms of injury include ligation, transection, devascularization and energy induced. Early identification of urinary tract injuries is paramount to minimizing morbidity.

As urological surgeons we are consulted intraoperatively, usually out of suspicion of urinary tract injury. Alternatively, we may be called as the operation takes an unexpected course near the urinary system in order to enhance dissection and minimize risk of injury. In contrast to the highly elective nature of our specialty, intraoperative consultations can require immediate diagnosis and management, often without any patient familiarity. As surgeons it is our goal to minimize risk or detect injury early (if it occurs) to facilitate prompt repair and prevent complications related to an undetected urinary tract injury. Anatomic considerations for preventing injuries, diagnostic techniques for localizing and staging injuries as well as reconstructive techniques, and principles of repair are presented in this Update.

COLLABORATION WITH THE CONSULTING SURGEON AND PATIENT PREPARATION

We have all faced the scenario of being highly preoccupied with our scheduled activities and getting called, "Dr. X needs a urologist in the OR." Often it is our colleagues in duress but as a consultant it is now your duty to assume "control" of the operation in order to assess, diagnose and technically correct the problem(s) present. Failure to adequately identify and/or correct a complication could lead to increasing severity or more complications, negatively impacting outcomes. We must temper our obligation to our colleague by realizing our primary obligation is to the patient.

As always, patient safety is important and an initial assessment of patient stability is essential. If the situation is a critical event (bleeding), all initial efforts are to stabilize through a coordinated effort with the participating care teams. Fortunately, in most scenarios the patient is clinically stable which provides the consultant time to perform a diagnostic assessment. **Given the unscheduled nature of these events, having a systematic and prospective approach is optimal to facilitate optimal results (Appendix 1).**

After being informed of the situation, several steps are important to review before scrubbing into the operation.[3] First, review the medical and surgical history of the patient for anything that might be pertinent. For example, it is much easier to read that the patient had undergone a prior nephrectomy before scrubbing in and trying to understand a lack of efflux during a gynecologic operation. Are there any other factors such as radiation or previous surgeries that warrant consideration? Second, are there any images available to review that may facilitate a better understanding of the anatomy or facilitate dissection? Third, other considerations to review are surgical approach (open/robotic), patient positioning and the status of a bladder catheter. All of these considerations are important as we appraise the clinical situation. I have found it easier and more definitive to invest a few minutes to retrieve items anticipated to facilitate my intervention on my own before scrubbing. It is not unusual for the consulting operating team not to be familiar with urological instrumentation and access and thus we save time by retrieving these materials on our own (Appendix 2).

When scrubbed into the operation it is best to ask the surgeon what the intended operation is and specifically what is left to be completed. Then ask the surgeon what the urological concern is, and precisely how and where it occurred as this can help expedite the sequence of repairing any urological injury. **The urologist must determine the best approach to repair the injury.** In the presence of a laparoscopic or robotic operation the urologist may rightfully choose to convert to open to facilitate the best repair.

URETERAL INJURIES

Incidence. Injury to the ureter is the most common urological complication of pelvic surgery with an incidence of 0.5% to 10%.[4-9] Ureteral injuries associated with urology procedures account for up to 70% of injured ureters, most commonly due to endoscopic techniques.[10] Gynecologic operations account for the vast majority of ureteral injuries (up to 50% in some series) in non-urology surgical cases. Surgical procedures involving the colon and rectum account for approximately 5% to 15% of ureteral injuries, most often associated with abdominoperineal resection followed by sigmoidectomy.[1, 11] Although early studies noted a trend in increasing ureteral injuries with increasing laparoscopic and robotic techniques,[12] more recent data suggest that this trend has not been consistent with globally low levels of ureteral injuries and no significant association with surgical approach.[13, 14]

Anatomy. The ureter begins posterior to the renal artery at the ureteropelvic junction and courses along the anterior edge of the psoas muscle. The gonadal vessels cross ventral to the upper third ureter from medial to lateral. The ureter then passes over the iliac vessels normally at the location of the bifurcation of the common iliacs.[15] **In females the ureter crosses**

ABBREVIATIONS: CT (computerized tomography), SAS (simple absorbable sutures)

dorsal to the ovary and underneath the broad ligament within 2 cm of the uterine vessels. At this location is where a majority of iatrogenic injuries occur during gynecologic surgery. In the male the vas deferens crosses ventral to the ureter (immediately proximal to the ureter entering the detrusor) as it courses from the midline prostate to join the gonadal vessels laterally near the internal inguinal ring. The ureter courses through the bladder wall (detrusor muscle) at an oblique angle. Although significant variability exists, the blood supply to the ureter originates through multiple small unnamed arterial branches of the renal, aorta, gonadal, internal iliac and middle rectal vessels. The vessels approach the ureter from the medial aspect above the iliacs and from the lateral aspect inferior to the iliacs. This anatomic relationship is clinically important when mobilizing the ureter.

During surgery of the colon and rectum iatrogenic ureteral injuries usually occur at the 3 distinct locations of 1) the takeoff of the inferior mesenteric artery, 2) where the infundibulopelvic ligament/uterine vessels cross the pelvic brim and 3) between the lateral rectal ligaments (fig. 1).[16]

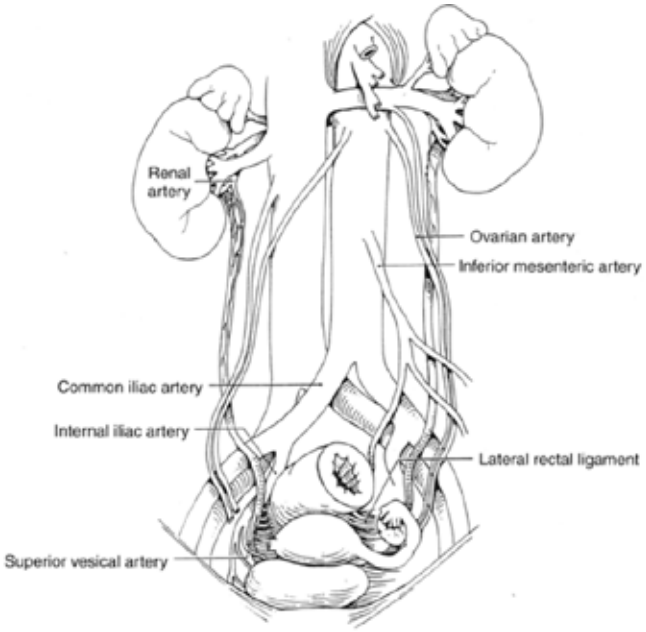

Figure 1. Anatomy of ureter.

Prevention/early identification. Ureteral catheterization can be performed to aid in identification of the ureters and ureteral injuries but it does not prevent ureteral injury. Nam and Wexner assessed the clinical value of prophylactic ureteral catheter placement before 162 laparoscopic segmental left and right colectomies, and no ureteral complications or injuries occurred.[4] Operative time was increased by 11.3 minutes. In another small randomized trial sequential versus simultaneous ureteral catheterization was compared and there was no increase in operative times when catheterization was performed simultaneously in patients undergoing complex or reoperative colorectal procedures.[17]

Lighted ureteral stents are also commercially available and were placed in 66 patients prior to abdominopelvic surgery.[6] The most common complication was self-limiting hematuria in 98.4% of patients with an average duration of 2.5 days for unilateral stenting and 3.3 days for bilateral stenting. In summary, the use of stents prophylactically seems to add a slight amount of time to the surgical procedure with minimal complications and, although the overall low incidence of ureteral injury may not be lowered significantly by stent placement,[18] early detection appears to be an advantage if injury does occur. With greater surgeon experience, iatrogenic injury rates decrease.[5] **The choice for prophylactic ureteral stenting is a surgeon preference based on multiple variables including complexity of case, anatomy and experience.**

Diagnosis of a suspected injury can also be confirmed in multiple ways. On rare occasions an on-table intravenous pyelogram can be performed but this is a challenging option due to timing and inadequate imaging in many cases. Other options are generally feasible and more definitive. In most cases cystoscopy may be performed to confirm patency of the ureteral orifices by visualizing efflux of indigo carmine or fluorescein. Ureteral catheters may be passed to evaluate ureteral patency as well or for retrograde injection of methylene blue or radiographic contrast to confirm the site of injury. Alternatively, if cystoscopy is not possible an anterior cystotomy allows complete inspection of the bladder, identification of the ureteral orifices and access for ureteral catheter passage as needed. These approaches should facilitate diagnosis and localization of ureteral injury in nearly all operative situations. For complex cases at higher risk for urinary tract injury placement of ureteral catheters may facilitate more prompt identification of iatrogenic injury, thereby reducing morbidity through immediate intraoperative rather than delayed repair.

Mechanisms of injury. Iatrogenic ureteral injuries can be classified based on the mechanism of injury, including laceration, ligation, devascularization and energy related. Prompt identification and repair (if necessary) are optimal to avoid postoperative morbidity.

Laceration: Transection or partial laceration of a ureter is repaired depending on the location of the injury. Crucial technical keys include spatulation of the ureter prior to repair, a tension-free anastomosis and using only short to moderate-term absorbable sutures.

Ligation: **For a ligation injury recognized intraoperatively, the clamp or tie should be removed and a ureteral stent placed for 4 to 6 weeks if tissue viability and integrity are restored after confirmation of ureteral patency.** Imaging with renal ultrasound or contrast radiograph (CT or intravenous pyelogram) should be performed to detect a subsequent ureteral stricture. These injuries and resultant ureteral stricture can manifest without symptoms with silent renal atrophy and thus, follow-up is prudent to confirm ureteral patency.

Devascularization: A devascularization injury is usually not apparent at the time of surgery. These injuries are more common after radiation therapy and vascular surgery. The normal healthy ureter is resistant to this type of injury due to the extensive collateral blood supply. **If suspected at the time of surgery, ureteral excision of devascularized tissue and repair are indicated.** Stents should also be considered to aid in healing. These injuries can present months after the initial surgery usually as obstruction due to a ureteral stricture.

Energy: Various energy sources are used for dissection and hemostasis during surgery. They can be a source of injury to

the urinary tract, and are emerging as a more frequent cause of ureteral injury. These injuries can present in the early postoperative period as either a fistula (urinoma) or stricture formation. Thermal devices, particularly monopolar cautery, can induce tissue damage depending on the proximity, duration and energy setting used.[19] Such injuries result from local devascularization and urothelial damage. If recognized intraoperatively, conservative treatment with a ureteral stent can be used to decrease postoperative ureteral edema. Similar to a crush injury, these cases should be followed with imaging at least 3 months after stent removal to detect the development of a ureteral stricture.

Location of specific ureteral repair. **General principles for ureteral repair include use of absorbable suture to prevent stone formation, a tension-free spatulated anastomosis over an indwelling ureteral stent and placement of a closed suction drain in the area of repair. These surgical principles must be adhered to regardless of the surgical approach.**

Elevated drainage after repair can be differentiated from peritoneal fluid by sending the drain contents for creatinine levels and comparing them to serum levels. If fluid creatinine levels are equal to serum levels, the drainage is not urine. For a delayed repair, delineation of the length and location of injury is necessary for surgical planning and patient counseling. Individualized treatment is based on location, stricture disease, integrity of the abdomen and surgeon experience. Other than enteric interposition (ileal ureter) and autotransplantation, each of the described procedures in all segments of the ureter can be performed in the appropriate patient with minimally invasive surgical techniques (robotic or laparoscopic repair).[20-22]

Proximal Third: Injuries to the proximal third ureter account for 2% of ureteral injuries.[11] **Repairs to injuries of the proximal ureter depend on the length of the damaged segment. Simple spatulated ureteroureterostomy with ureteral stent placement is the preferred method of repair** (fig. 2). Success rates for ureteroureterostomy are greater than 90% in most series. Mobilization of the kidney with fixation sutures to the psoas tendon (nephropexy) can allow for lengths of up to 4 cm to be repaired in a tension-free fashion with ureteroureterostomy. Right nephropexy provides more length than left due to the shorter left renal vein. In cases of long segments of damaged ureters a bowel interposition (ileum or appendiceal) can be used.[23-25] Crohn's disease, radiation enteritis and a serum creatinine greater than 2.0 mg/dl are contraindications to constructing an ileal ureter. Depending on the capacity/size of the bladder, a psoas hitch (fig. 3) or Boari flap (fig. 4) can sometimes be used to reach the upper ureter.[26, 27] However, these procedures are more commonly used for injuries of the middle and distal third ureter. An individualized approach must be taken for long proximal ureteral strictures.

Middle Third: Injuries to the middle third ureter account for 7% of ureteral injuries.[11] **If the injury is at the level of the iliac vessels or proximal, the preferred method of repair is ureteroureterostomy for short segments. For larger segments in which a tension-free anastomosis is not possible, a ureteroneocystotomy is performed with the aid of a psoas hitch or Boari flap.**

For a psoas hitch, the bladder is mobilized by ligating the superior vesical pedicle on the side contralateral to the injury (fig. 3). Localization of the contralateral ureter is prudent prior to this maneuver. **The bladder can then be opened through a transverse anterior cystotomy and secured to the psoas tendon using several 2-zero simple absorbable sutures through the psoas tendon. Care must be taken not to include the genitofemoral nerve positioned on the anterior surface of the muscle lateral to the common iliacs. The suture should be placed linear to the tendon to avoid entrapment of the femoral nerve running in the belly of the psoas muscle.[28]**

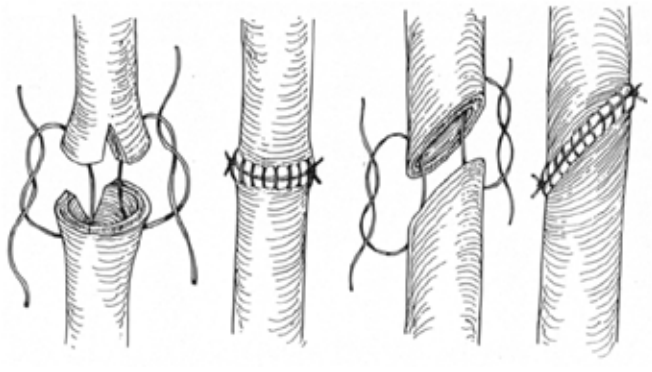

Figure 2. Ureteroureterostomy with spatulated anastomosis of running absorbable suture.

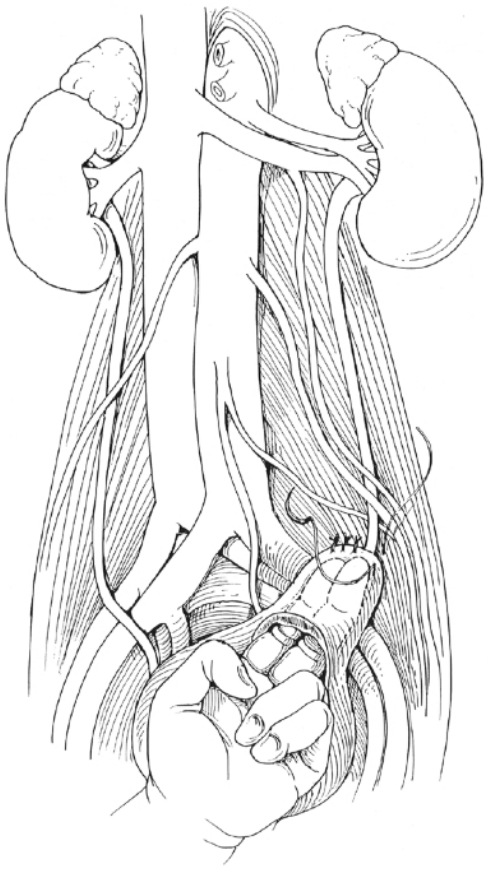

Figure 3. Psoas hitch after transverse cystotomy and interrupted anchoring sutures placed through psoas tendon.

The ureter can be tunneled by passing a clamp from the bladder lumen (near the hitched area) through the muscle fibers and grasping a stay stitch placed on the distal ureter. The ureter can then be passed through the wall of the detrusor and a widely spatulated anastomosis can be completed using interrupted 3 to 4-zero SAS placed from mucosa to mucosa. Tunneling the ureter at an oblique angle through the wall of the detrusor can prevent urinary reflux but may have a slightly higher stenosis/stricture rate. A ureteral stent can then be placed and the anterior cystotomy closed in a vertical fashion. A Foley catheter should be kept indwelling for 7 to 14 days with stent removal 4 to 6 weeks after surgery.

For injuries spanning longer more proximal distances, a Boari flap technique can be used (fig. 4), which is another effective yet more complex method for replacement of an extensively damaged mid ureter. A flap of the anterior bladder wall is raised in a rectangular fashion and affixed to the psoas tendon as previously described. The vascular supply of this flap is based on the ipsilateral superior vesical artery. The ureter is tunneled through the most proximal portion of the flap and a neo-orifice is created using the aforementioned technique. A ureteral stent is placed. The bladder flap is then tubularized and closed in a 2-layer fashion using running 3-zero SAS for mucosal approximation followed by running 2-zero SAS for seromuscular approximation. Again, a Foley catheter should be kept in place for 7 to 14 days with stent removal at 4 to 6 weeks after surgery. This procedure should not be performed in a patient with a small bladder capacity as functional capacity can be significantly reduced with resultant postoperative voiding dysfunction. In patients who received prior pelvic irradiation extensive bladder mobilization with Boari flap formation to the upper ureter can be fraught with complications. A well-vascularized bladder flap with a tension-free anastomosis is key to preventing complications such as recurrent stricture and urine leak.

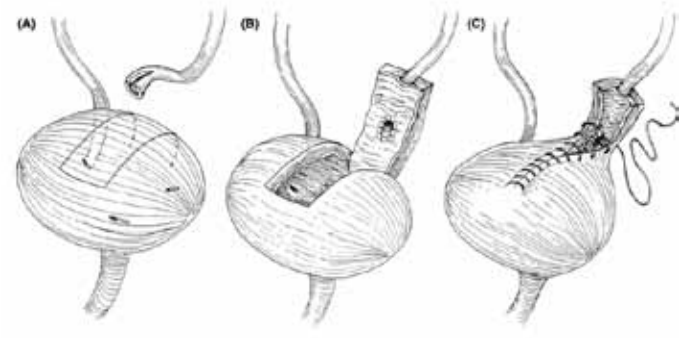

Figure 4. Boari flap. *A*, incision site for posterior pedicle based bladder flap. *B*, ureteral reimplantation with transverse submucosal tunnel. *C*, tubularization of bladder flap.

Lastly, transureteroureterostomy can be performed by tunneling the injured ureter under the posterior peritoneum anterior to the bifurcation of the great vessels. The ureter can then be anastomosed end-to-side to the contralateral uninjured ureter with minimal mobilization to the recipient ureter. **Absolute contraindications to transureteroureterostomy are insufficient ureteral length and a diseased contralateral ureter. Relative contraindications include a history of urothelial carcinoma, nephrolithiasis, irradiation, chronic infection and retroperitoneal fibrosis.** Due to the inherent risks of operating on both ureters, this procedure is not popular with reconstructive surgeons but still has a rare place in the armamentarium of reconstructive urology.

Distal Third: Injuries to the distal third ureter account for 91% of ureteral injuries.[12] **The repair of choice for distal ureteral injuries is a ureteroneocystotomy,** which can be performed via primary anastomosis to the bladder for injuries to the distal 2 to 3 cm. Open surgical techniques of passing the ureter through the bladder wall and anastomosis are applied regardless of the surgical approach. Principles of reconstruction mandate a tension-free anastomosis, which may be performed via an intravesical approach by opening the bladder and "tunneling" under an intact bladder mucosa, or via an extravesical approach by incising the detrusor muscle without opening the bladder. Following the ureteral anastomosis, the detrusor muscle is reapproximated over the ureter, creating the intramural tunnel. These techniques are usually accomplished without the need for bladder mobilization but tension can be decreased via limited bladder mobilization through transection of the contralateral superior vesical pedicle with or without a psoas hitch.

Extensive ureteral injury or loss. Occasionally, significant ureteral injuries or the condition of the patient is not amenable to repair in the consultative session. Situations involving extensive ureteral loss, infection or patient instability pose extraordinary challenges and will likely involve extensive reconstruction such as ileal interposition and/or autotransplantation. In these extenuating circumstances the surgeon may elect to perform a ureteral ligation in the most distal aspect of the viable ureter followed by percutaneous nephrostomy drainage. This approach, although not optimal, will facilitate reducing operating time considerably in an unstable patient and allow for more extensive preoperative preparation in advance of the future reconstruction.[29]

BLADDER INJURIES

Injuries to the bladder can result from any surgical procedure in the pelvis or as a result of trochar insertion during laparoscopy. If recognized at the time of injury, an isolated bladder injury is usually repaired without difficulty. Patients with prior radiation and inflammatory bowel disease are at increased risk for enterovesical or colovesical fistula formation after an injury. With the use of multilayer reconstruction and tissue flap interpositions (omental), risks can be minimized in higher risk patients. Short or moderate absorbable sutures are always used (never permanent or long duration absorbable sutures).

Anatomy. The cephalad and posterior portions of the bladder are covered with peritoneum while the ventral and lateral surfaces of the bladder are within the extraperitoneal space of Retzius. Posteriorly, the peritoneum meets the anterior rectal peritoneum forming the rectovesical space approximately 2 cm cephalad to the tips of the seminal vesicles. Upon filling, the bladder distends to a position outside of the true pelvis. Thus, umbilical trochar insertion without drainage of the bladder is ill advised. The vascular supply to the bladder is based on the internal iliac artery (hypogastric artery), and the venous drainage occurs through the internal iliac vein. **Surgically, the**

vascular pedicles to bladder are divided based on the relation to the ureters into the lateral pedicle (also known as the superior vesical pedicle, lateral to the ureters) and posterior pedicle (posteromedial to the ureters).

Diagnosis and staging of injury. Risk factors for bladder injury include previous operations, radiation, malignant infiltration, chronic infection and inflammation. Intraoperative identification allows for immediate repair. Injuries to the bladder are usually detected by visualization of the Foley balloon after transection, a rush of fluid into the operative field during pelvic dissection or of the bladder mucosa site. Often gynecologists perform cystoscopy at the end of the procedure to rule out lower tract injury, and bladder injuries may be detected at that time. Lastly, in an operative setting in which there is suspicion of a bladder injury retrograde filling of the bladder catheter with dye colored saline or sterile water may confirm injury via extravasation into the operative field.

Repair of injuries. **All bladder injuries recognized intraoperatively should be repaired.** Closed suction drains should be left in place after repairs. Suprapubic tube placement is not necessary in most cases.

For injuries to the ventral bladder, dome or posterior bladder away from the ureteral orifices, the mucosa is closed in a running fashion using 3-zero SAS followed by a seromuscular running suture of 2-zero SAS accomplishing a 2-layer closure (fig. 5). **Prior to closure however, the surgeon must inspect the entire bladder via cystoscopy or directly inspection through the cystotomy to rule out any possible concomitant injury and confirm the presence of effluxing urine from each ureteral orifice.** After closure, the bladder should be irrigated to ensure a watertight closure. A third layer in a Lembert fashion can be used in cases at high risk for fistula formation or when a leak is identified. In the laparoscopic setting a 1-layer closure is often performed using 2-zero SAS to close all layers of the bladder. I

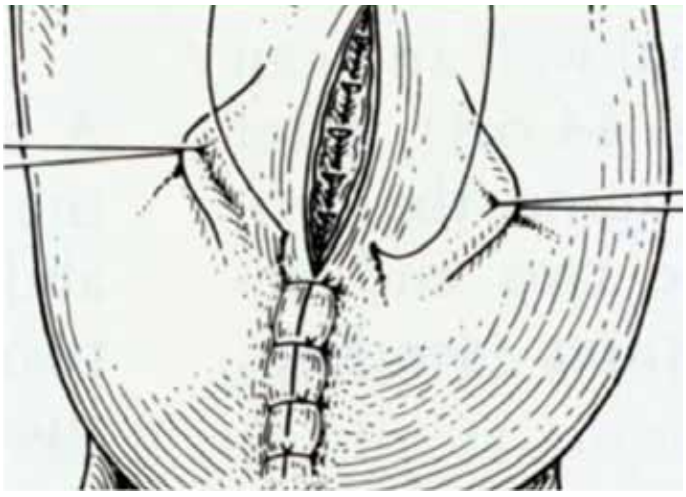

Figure 5. Bladder injury 2-layer closure repair.

prefer an additional layer of 2-zero SAS in a Lembert fashion, particularly for more extensive injuries.

For injuries more posterior involving the trigone of the bladder or near the ureteral orifices, a thorough inspection for possible ureteral injuries is mandated and can be accomplished by mobilization of the bladder anteriorly within the space of Retzius. An anterior cystotomy is then performed in the sagittal plane extending caudal to the pubic symphysis which allows maximal exposure to the interior of the bladder and full inspection of the trigone. A self-retaining retractor is then placed with the retraction blades within the bladder lumen. Indigo carmine can be adminstered through an intravenous access and can aid in identification of the ureteral orifices. Bilateral ureteral catheters or stents can be placed for injuries approaching the ureteral orifices. Closure of the posterior bladder injury is then performed from this anterior luminal exposure. The deep muscular layer is initially closed using 2-zero SAS followed by closure of the mucosal layer using 3-zero SAS. In patients who have received neoadjuvant radiotherapy a more extensive dissection with interposition of omentum or perivesical fascia can minimize the risk of fistula formation.

Unrecognized bladder injuries (delayed presentations). An unrecognized bladder injury will usually present clinically in the early postoperative period in a delayed fashion. Increased drainage from the surgical incisions, vagina or surgical drains is a common sign of bladder injury. The bladder may also become distended with ileus, particularly with intraperitoneal leakage of urine. Lastly, extravasation may be seen on postoperative imaging as diagnosis can be made radiographically by a CT cystogram or fluoroscopic cystogram.[30, 31] **Passive filling of the bladder with opacification from filtered contrast from the kidneys is not sufficient to diagnose a bladder injury and is not a true CT cystogram. A CT cystogram is performed with retrograde contrast instillation (through a Foley catheter) of 200 to 300 cc water soluble contrast prior to the exam,** and the catheter is clamped during the scan. Extraperitoneal injuries are identified by contrast extravasation being confined to the lateral pelvic side walls or within the space of Retzius. For small extraperitoneal injuries discovered after surgery without complicating factors, treatment consists of a Foley catheter for 7 to 14 days. Intraperitoneal or bladder neck injuries require intraoperative repair.

URETHRAL INJURIES

Difficult Foley catheter placement. One of the most frequent calls to the urologist is the inability to pass a catheter in patients undergoing non-urological interventions. Often urological history is limited or non-existent, and the urologist is being asked to pass a catheter without endoscopic guidance. A brief chart review can be useful because a history of prostate cancer and prostate surgery may be helpful in catheter selection. A review of the medication list may indicate medical therapy for benign prostatic hyperplasia. These factors may offer some suggestion as to the source of catheterization difficulties.

When assessing the situation, it is often helpful to inquire as to the nature of the problem. First, what type of catheter was used and second, where did the obstruction appear to be? When the catheter is halfway or not close to being in, one may infer that the likelihood is a stricture or benign prostatic hyperplasia causing catheter resistance near the bladder. **In most situations of unknown history passage of an 18Fr coude catheter seems prudent due to the likelihood of an enlarged prostate. If unable to pass 18Fr, passage of a 12Fr catheter may be useful in the likelihood of a structure or bladder neck contracture.[32]**

Before attempting any catheter insertion it is best to ensure adequate lubrication of the urethra by injecting lubricating jelly directly into the urethra and manipulating it along the length of the urethra. This maneuver is followed by adequate straighten-

ing of the penis to remove angulation. If these measures fail, flexible cystoscopy can be used to place a guide wire, which is passed through the area of narrowing. Dilation over the wire ensues to facilitate passage of a Councill tip catheter over the guide wire. Using these techniques, catheterization should be successful in the majority of cases. **If not, placement of a suprapubic tube is a decision based on many factors such as acuity of surgery needed and the route of surgery being chosen, multiple abdominal surgeries, presence of a distended bladder and available instrumentation. This decision should be made carefully and in consultation with the operating surgeon.**

Direct injuries to the urethra are fortunately rare but can occur during extirpative surgery for anorectal malignancies or vaginal surgeries. Most of these injuries consist of urethral mucosal laceration and/or false passages, and **warrant Foley catheter placement for a period of time to successfully facilitate healing in the majority of cases.**

Diagnosis of injury. During surgery, urine leakage may not be evident within the surgical field due to bladder decompression with the Foley catheter. In areas of concern for injury retrograde injection of methylene blue tinted saline can aid in diagnosis. A l4 gauge angiocatheter is placed in the urethral meatus next to the Foley (do not remove the Foley) and 10 to 20 ml saline are injected. An egress of fluid is indicative of injury and identifies the area needing further exploration. Also, visualization of the Foley catheter or leakage of fluid from the periurethral tissues indicates probable urethral laceration.

Repair of injuries. If recognized at the time of surgery and the surgical approach is amenable to repair, then repair of small and uncomplicated iatrogenic urethral injuries seems reasonable. The urethra and periurethral tissue should be mobilized to obtain a tension-free repair. Initially, careful dissection of the periurethral tissues is needed to fully expose the extent of urethral wall laceration. Use of cautery should be minimal during this dissection, and bipolar cautery should be considered if needed. For small defects or urethral lacerations after adequate localization and exposure, the goal is a water-tight repair with 3-zero or 4-zero SAS in multiple layers over a Foley catheter. In women undergoing vaginal surgery the urethral repair may be reinforced with the periurethral fascia and/or a Martius flap.[33]

If the patient has received neoadjuvant radiation therapy, or tissue compliance is poor or urethral injury is extensive, placement of tissue interposition flaps will likely be needed to reduce the risk of fistula formation. Urethral mobilization and advancement may be needed. For severe injuries or those requiring significant adjacent tissue mobilization, primary repair is likely not the best option. A suprapubic catheter is placed and repair can be performed after several months. Re-staging will be required. A multitude of complex reconstructive techniques are available with variable success rates and morbidity.[34]

CONCLUSIONS

Iatrogenic injuries to the urinary tract are an inevitable byproduct of extensive pelvic operations in patients with complex pathological conditions. Early identification and repair are key in minimizing morbidity. In cases of significant postoperative complications (ie large urethrorectal fistula in radiated field) a multidisciplinary approach to diagnosis, staging and repair should be taken.

DID YOU KNOW?

- When responding to an intraoperative consultation, having a systematic and prospective approach is necessary to facilitate optimal outcomes.
- Careful exploration should be performed to identify the complication and mechanism of injury.
- A tension-free ureteroureterostomy is preferred for ureteral injuries proximal to the level of the iliac vessels when feasible.
- The repair of choice for lower ureteral injuries is ureteroneocystostomy with or without a psoas hitch to facilitate reimplantation.
- All bladder injuries recognized intraoperatively should be repaired in 2 layers, creating a watertight closure.
- Prior to closure of bladder injuries, ureteral patency should be ensured.
- Careful follow-up after intervention is necessary to reduce morbidity of injury.

Appendix 1. Systematic approach to intraoperative consultation

- Initial assessment of patient stability
- Medical and surgical imaging review
- Pertinent imaging review
- Obtain/request equipment and supplies to facilitate intervention
- Determine intended operation/what's left to complete
- Identify complication and mechanism of injury
- Consider current patient position/approach as planning repair

Appendix 2. Equipment and supply preparation before intervention

Items to request for difficult urethral catheterization/urethral injury:

- Foley kit
- Anesthetic lubricant (can place into syringe for retrograde injection into male urethra)
- 16/18Fr coude tip Foley catheters
- 12Fr straight Foley catheter
- Flexible cystoscope
- Hydrophilic guide wire, "regular" or super-stiff guide wires
- 5Fr open ended ureteral catheter
- Flexible cystoscopy
- Urethral dilators (preferably passed over wire)
- Council tip Foley catheter
- Suprapubic catheter tray

Items to request for suspected bladder injury:

- Access to Foley catheter if present or placement of Foley catheter
- Fluid to perform leak testing
- Methylene blue or equivalent to aid in leak detection
- Cystoscopy (flexible or rigid, depending on patient position)

Continued

Appendix 2, *continued*

- Larger catheters (20Fr) in case bladder repair is needed.
- Items to request for suspected ureteral injury:
- Guide wires (hydrophilic and regular)
- Flexible or rigid cystoscopy
- Intravenous methylene blue, indigo carmine or fluorescein (note: methylene blue takes a long time and may not excrete, thus indigo carmine or fluouroscein preferred)
- Open ended ureteral catheters
- Double-J® stents in case of need to leave an indwelling stent

REFERENCES

1. St Lezin MA and Stoller ML: Surgical ureteral injuries. Urology 1991; **38:** 497.
2. Frober R: Surgical anatomy of the ureter. BJU Int 2007; **100:** 949.
3. Taylor J: Consults & Emergencies: Intraoperative. In: AUA University Core Curriculum Series. Edited by TG Smith III. Linthicum, Maryland: American Urological Association Education and Research, Inc. September 3, 2019. Available at https://university.auanet.org/modules/webapps/core/index.cfm#/corecontent/199.
4. Nam Y and Wexner S: Clinical value of prophylactic ureteral stent indwelling during laparoscopic colorectal surgery. J Korean Med Sci 2002; **17:** 633.
5. Larach SW, Patankar SK, Ferrara A et al: Complications of laparoscopic colorectal surgery. Analysis and comparison of early vs. latter experience. Dis Colon Rectum 1997; **40:** 592.
6. Chahin F, Dwivedi A, Paramesh A et al: The implications of lighted ureteral stenting in laparoscopic colectomy. JSLS 2002; **6:** 49.
7. Scala A, Huang A, Dowson HMP et al: Laparoscopic colorectal surgery—results from 200 patients. Colorectal Dis 2007; **9:** 701.
8. Fry DE, Milholen L and Harbrecht PJ: Iatrogenic ureteral injury. Options in management. Arch Surg 1983; **118:** 454.
9. Goodno JA Jr, Powers TW and Harris VD: Ureteral injury in gynecologic surgery: a ten-year review in a community hospital. Am J Obstet Gynecol 1995; **172:** 1817.
10. Assimos DG, Patterson LC and Taylor CL: Changing incidence and etiology of iatrogenic ureteral injuries. J Urol 1994; **152:** 2240.
11. Selzman AA and Spirnak JP: Iatrogenic ureteral injuries: a 20-year experience in treating 165 injuries. J Urol 1996; **155:** 878.
12. Al-Awadi K, Kehinde E, Al-Hunayan A et al: Iatrogenic ureteric injuries: incidence, etiological factors and the effect of early management on subsequent outcome. Int Urol Nephrol 2005; **37:** 235.
13. Zafar S, Ahaghotu C, Libuit L et al: Ureteral injury after laparoscopic versus open colectomy. JSLS 2014; **18:** e2014.00158.
14. Ferrara M and Kann BR: Urologic injuries during colorectal surgery. Clin Colon Rectal Surg 2019; **32:** 196.
15. Anderson JK, Kabalin JN and Cadeddu JA: Surgical Anatomy of the Retroperitoneum, Adrenals, Kidneys, and Ureters. In: Campbell-Walsh Urology, 9th ed. Edited by AJ Wein, LR Kavoussi, AC Novick et al. Philadelphia: Elsevier Saunders 2007; chapt 1, p 34.
16. Delacroix SE Jr and Winters JC: Urologic Complications of Colorectal Surgery. In: Improved Outcomes in Colon and Rectal Surgery. Edited by C Whitlow, D Beck, D Margolin et al. New York: Informa 2009; chapt 1, p 9.
17. Pokala N, Delaney CP, Kiran RP et al: A randomized controlled trial comparing simultaneous intra-operative vs sequential prophylactic ureteric catheter insertion in re-operative and complicated colorectal surgery. Int J Colorectal Dis 2007; **22:** 683.
18. Coakley K, Kasten K, Sims S et al: Prophylactic ureteral catheters for colectomy: a National Surgical Quality Improvement Program-based analysis. Dis Colon Rectum 2018; **61:** 84.
19. Emam T and Cuschieri A: How safe is high-power ultrasonic dissection? Ann Surg 2003; **237:** 186.
20. Patil NN, Mottrie A, Sundaram B et al: Robotic-assisted laparoscopic ureteral reimplantation with psoas hitch: a multi-institutional, multinational evaluation. Urology 2008; **72:** 47.
21. Lee DI, Schwab CW and Harris A: Robot-assisted ureteroureterostomy in the adult: initial clinical series. Urology 2010; **75:** 570.
22. Schimpf MO and Wagner JR: Robot-assisted laparoscopic distal ureteral surgery. JSLS 2009; **13:** 44.
23. Boxer RJ, Fritzsche P, Skinner DG et al: Replacement of the ureter by small intestine: clinical application and results of the ileal ureter in 89 patients. Trans Am Assoc Genitourin Surg 1978; **70:** 99.
24. Goldwasser B, Leibovitch I and Avigad I: Ureteral substitution using the isolated interposed vermiform appendix in a patient with a single kidney and transitional cell carcinoma of the ureter. Urology 1994; **44:** 437.
25. Verduyckt FJ, Heesakkers JP and Debruyne FM: Long-term results of ileum interposition for ureteral obstruction. Eur Urol 2002; **42:** 181.
26. Riedmiller H, Becht E, Hertle L et al: Psoas-hitch ureteroneocystostomy: experience with 181 cases. Eur Urol 1984; **10:** 145.
27. Warwick RT and Worth PH: The psoas bladder-hitch procedure for the replacement of the lower third of the ureter. Br J Urol 1969; **41:** 701.
28. Müller C, van Houwelingen EE and Huygen F: Femoral neuropathy following a psoas hitch vesicopexy. BMJ Case Rep 2018; doi: 10.1136/bcr-2018-225158.
29. Watterson J, Mahoney J, Futter N et al: Iatrogenic ureteral injuries: approaches to etiology and management. Can J Surg 1998, **41:** 379.
30. Deck AJ, Shaves S, Talner L et al: Computerized tomography cystography for the diagnosis of traumatic bladder rupture. J Urol 2000; **164:** 43.
31. Jarrett TW and Vaughan ED: Accuracy of computerized tomography in the diagnosis of colovesical fistula secondary to diverticular disease. J Urol 1995; **153:** 44.
32. Sliwinski A, D'Arcy F, Sultana R et al: Acute urinary retention and the difficult management: current emergency management. Eur J Emer Med 2016; **23:** 80.
33. Malde S, Spilotros M, Wilson A et al: The uses and outcomes of the Martius fat pad in female urology. World J Urol 2017; **35:** 473.
34. Webster GD, Mathes GL and Selli C: Prostatomembranous urethral injuries: a review of the literature and a rational approach to their management. J Urol 1983; **130:** 898.

Study Questions Volume 39 Lesson 11

1. While performing a psoas hitch and ureteroneocystotomy for ureteral reconstruction, the 2 neural structures that may be injured are the
   a. femoral and ilioinguinal nerves
   b. genitofemoral and ilioinguinal nerves
   c. femoral and genitofemoral nerves
   d. femoral and ilioinguinal nerves

2. Following total abdominal hysterectomy, cystoscopy reveals no left ureteral efflux. Your exploration reveals a suspected ligation injury to the left ureter adjacent to the pelvic vessels. After removal of the offending suture, the next step is
   a. assess for bleeding, place a closed suction drain alongside the area of injury and close
   b. repeat cystoscopy to reassess efflux and place a ureteral stent
   c. perform ureteroureterostomy over a ureteral stent
   d. perform ureteral reimplantation with a psoas hitch

3. A 74-year-old man with no urological history is about to undergo a knee replacement. He is anesthetized and you are called by the orthopedic team as they are unable to place a 16Fr Foley catheter. The next step is
   a. attempt passage of an 18Fr coude tip catheter
   b. attempt passage of a 12Fr straight Foley catheter
   c. use filiforms and followers to perform a urethral dilation
   d. perform flexible cystoscopy

4. A 62-year-old man with colon cancer is undergoing a sigmoid colectomy following preoperative pelvic radiation. Intraoperatively, the colorectal surgeon suspects a ureteral injury near the insertion of the ureter into the bladder. Following administration of intravenous indigo carmine, blue is seen pooling in the deep pelvis. Cystoscopy confirms the presence of efflux from the contralateral ureteral orifice. The most appropriate management is
   a. placement of a ureteral stent
   b. exploration and ureteral repair
   c. ureteroureterostomy
   d. ureteroneocystostomy

5. During total abdominal hysterectomy for uterine fibroids urine is observed pooling in the pelvis. Exploration confirms the Foley balloon visible through a 2 cm laceration of the posterior bladder wall. The next step is
   a. cystoscopy
   b. anterior cystotomy
   c. 2-layer closure
   d. 2-layer closure with omental interposition

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