Urological Injuries during Colorectal Surgery

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Abstract

The proximity of the colon and rectum to the organs of the urologic system virtually ensures that iatrogenic urologic injuries become a distinct possibility during complex colorectal surgical procedures. An intimate knowledge of urogenital anatomy as well as strategies for identification and repair of potential injuries is of paramount importance. Attention is mandated when operating within the narrow confines of the pelvis, as this is where these structures are most at risk. The ureters are at highest risk of injury, followed by the bladder and urethra. The nature of these injuries encompasses both functional and mechanical morbidities. Patient factors, including prior pelvic surgery, radiation, inflammatory bowel disease, infectious processes, and urogenital abnormalities all increase the risk of injury. As colorectal surgeons encounter an increasing number of patients with the above risk factors, it is important to be familiar with the various urologic injury patterns, their diagnosis, and appropriate management.

Keywords
- iatrogenic injury
- ureter
- bladder
- urethra
- colorectal surgery

Due to the proximity of the colon and rectum to the organs of the urologic system, iatrogenic urologic injuries unfortunately become a distinct possibility during complex colorectal surgical procedures. This article will review the anatomy of the urogenital anatomy as well as strategies for identification and repair of potential injuries. The ureters are at highest risk of injury during colorectal surgery, followed by the bladder and urethra[1]; this review will focus primarily on these injuries. Certain patient factors, including prior pelvic surgery, radiation, inflammatory bowel disease, infectious processes, and congenital urogenital abnormalities may all further increase the risk of injury.[2,3] As colorectal surgeons encounter an increasing number of patients with these above risk factors, it is important to be familiar with the various urologic injury patterns, their diagnosis, and most appropriate means of management.

Ureteral Injuries

Risk Factors

Although rare, ureteral injury is one of the most common forms of iatrogenic urologic injury. More commonly encountered during gynecologic surgery, 5 to 15% of ureteral injuries result from colorectal surgery.[1] The left ureter, intimately associated with the mesentery of the descending colon, is at the highest risk of injury. As one would expect, the greatest rates of ureteral injuries are seen with operations involving this anatomic region, including low anterior resection (LAR), abdominoperineal resection (APR), and sigmoid colectomy.[4–6] The right ureter, as it courses in the retroperitoneum posterolateral to the cecum, is also at risk during lateral mobilization of the right colon.

A recent retrospective population-based study of patients in the United States undergoing colorectal surgery found the overall incidence of ureteral injury to be 0.28%. The incidence was found to be significantly higher in patients with stage 3 or 4 cancer, malnutrition, steroid use, and in operations done at teaching hospitals. Rectal cancer cases were found to have the highest rates of ureteral injuries (7.1/1,000), followed by Crohn's disease and diverticular disease (2.9/1,000 each). In this review, laparoscopic surgery was associated with a lower incidence of ureteral injuries when compared with open (1.1 vs. 2.8/1,000, $p < 0.001$). Of the specific operations reviewed, APR was found to have the highest rate of ureteral injury at 7.1/1,000 cases.[7]

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Another recent population-based retrospective study from Denmark showed an overall ureteral injury rate of 0.44%. In contrast, laparoscopic surgery was associated with a higher risk of ureteral injury when compared with open (0.59 vs. 0.37%, $p = 0.03$). This was largely accounted for by operations specific for rectal cancer, in which the ureteral injury rate was significantly higher in laparoscopic versus open surgery (1.0 vs. 0.42%, $p = 0.007$).[8] A recent study reviewing data from the National Surgical Quality Improvement Program (NSQIP) database found an overall incidence of ureteral injury of 0.6%, with no significant difference between open and laparoscopic techniques.[9] Another recent study analyzed the National Inpatient Sample database and found an overall ureter injury rate of 0.06% in gastrointestinal surgery, with the highest incidence in rectal surgery (0.11–0.25%). The authors found significantly higher injury rates in open versus laparoscopic surgeries (0.34 vs. 0.06%, $p < 0.0001$). They also found metastatic disease to be significantly associated with elevated risk of ureteral injury.[10] Yet another retrospective review of a single institution's experience with colorectal surgery found an increased incidence of ureteral injury with laparoscopic versus open surgery (0.66 vs. 0.15%, $p = 0.007$).[11]

As can be seen from these studies, the relationship of surgical modality and ureteral injury is not clear. As with most large database reviews, the reported findings are subject to several limitations, including potential bias, as surgical decision making in many cases is influenced by several patient and disease factors that are difficult to control for and may predispose one to higher risks of ureteral injury. One of the potential advantages of an open technique is the ability to utilize not only visual cues but also haptic feedback to aid with determination of ureteral location. The advent of robotic surgery has led to an increasing number of colorectal procedures being performed utilizing this platform. To date, there is no clear indication as to whether or not robotic colorectal surgery, which is limited by the lack of haptic feedback, influences the risk of ureteral injury positively or negatively when compared with a traditional laparoscopic or open approach.

Locations/Scenarios

An intimate knowledge of the natural course of the ureters and the areas at which they are most at risk of injury is essential. In general, the ureter is divided into three anatomic segments: (1) the upper third from ureteropelvic junction (UPJ) to the upper sacroiliac (SI) joint, (2) the middle third as it courses over the sacrum, and (3) the lower third from the inferior SI joint to the ureterovesical junction (UVJ) in the bladder. The ureter originates at the UPJ and courses inferiorly along the anterior border of the psoas muscle, before crossing under the gonadal vessels and passing over the iliac vessels, typically at the point of bifurcation of the common iliacs. The ureters then course into the bladder wall at an oblique angle at the UVJ. The left ureter is in proximity to the left colic artery and inferior mesenteric artery (IMA), and is adjacent to the descending and sigmoid colon. The right ureter is adjacent to the cecum, appendix, and terminal ileum. Ureteral injuries tend to occur at either the origin of the IMA from the abdominal aorta, laterally at the pelvic brim, and between the lateral rectal ligaments.[1]

Because of its proximity to the IMA, it is essential to identify and protect the left ureter prior to IMA ligation. The ureter can be visualized through the parietal peritoneum and is often identified by its serpiginous surface blood vessels and the elicitation of vermiculation with gentle handling of the ureter itself. An essential component to avoiding injury of the ureters is the maintenance of appropriate embryonic planes during dissection of the mesentery off the retroperitoneum. This can be achieved by dividing along the mesenteric aspect of the white line of Toldt. One should be cognizant of the course of the ureter in an obese patient, as increased retroperitoneal fat will often displace its course in a more medial fashion than is anticipated.

Identifying Injury Intraoperatively

In the event of ureteral injury, identification intraoperatively can allow for immediate repair and avoidance of reoperation and long-term morbidity. The use of preoperatively placed ureteral catheters has been shown to aid with intraoperative identification of ureteral injuries. Alternatively, intraoperative consultation can be made in selected cases for ureteral catheter placement to aid with detection of a suspected injury or if the anatomic course of the ureter is not clear. The intravenous (IV) administration of methylene blue or indigo carmine can also aid with diagnosis of a ureteral injury, as the leakage of blue dye into the peritoneal cavity is indicative of injury. The caveat to this is that it will not aid in the diagnosis of potential pending leaks, such as those caused by inadvertent thermal injuries. Therefore, it is still prudent to visualize the entirety of the exposed ureter for any evidence of injury or compromise. Performance of an on-table IV pyelogram is yet another option for intraoperative diagnosis in operating rooms (ORs) where this technology is available.

Preventative Measures

Although several potential preventive measures have been described, none can replace an intimate knowledge of ureteral anatomy, along with appropriate and deliberate surgical dissection. As mentioned earlier, clear identification of the ureter prior to vessel ligation helps prevent unintended damage or ligation of the ureters. In some instances, particularly in reoperative surgery or in the setting of locally invasive neoplasm or diverticular disease, clear identification can be difficult. At times, it may be prudent to proceed with lateral dissection of the colon and mesentery, identifying the ureter proximal or distal to the area of uncertainty to minimize the risk of injury.

It is also of utmost importance to meticulously review any preoperative imaging prior to embarking upon surgical exploration, as this may reveal abnormalities in urogenital anatomy that may significantly influence surgical strategizing. For instance, it would be prudent to confirm the presence of renal agenesis prior to searching for the ureters, as this may cause significant delay and confusion on the part of

the surgeon. Duplicated ureters are also a rare finding on preoperative imaging. Hydronephrosis/hydroureter seen on preoperative imaging should alert the surgeon as to a potential obstructive process; in the setting of malignancy, an en bloc resection of the involved ureteral segment may be required, and preparation for possible ureteral reconstruction should be made preoperatively.

An area that has garnered much attention and controversy has been the use of ureteral catheters to aid with identification and avoidance of ureteral injury. Despite this, there are no clear indications for their use, and the decision to do so in most cases relies solely on surgeon preference and comfort. To date, no randomized controlled trials have been undertaken to evaluate the efficacy of catheter placement. A recent NSQIP study showed that catheters were placed more often for diverticular disease, pelvic surgeries (LAR and APR), and when there is a history of radiation. This study also showed increased usage of catheters in recent years. Overall, the placement of catheters was found to be benign, with only a mild increase in operative time and length of stay.[12] Despite the perceived improvement in intraoperative detection of the ureters, catheter placement does not ensure a reduced rate of ureteral injury. However, ureteral catheters do aid in improving detection of injury during surgery, allowing prudent consultation and management.[13] Although overall safe, significant morbidity has been reported with ureteral catheter placement, and judicious usage is advised.[14,15] A recently published survey of the NSQIP database found that prophylactic catheters were placed in 4.9% of colectomies, most commonly for diverticulitis. On multivariate analysis, it was found that ureteral catheter placement did significantly decrease ureteral injury rate, while diverticular disease, T4 malignancy, and an open approach all increased risk.[16] Another area of interest in minimally invasive surgery is the use of lighted ureteral catheters. In a recent review of more than 150 patients with complex pelvic disease who had lighted ureteral catheters placed preoperatively, none sustained ureteral injuries.[17] Although more investigation is warranted, this is a potentially useful tool.

Intra- and Postoperative Management

Although the identification of an iatrogenic ureteral injury intraoperatively can be a devastating realization for the surgeon, the immediate recognition allows for repair within the same operation, potentially saving the patient from further morbidity. Upon recognition of injury, it is wise to seek urologic consultation to aid with evaluation and repair. The nature of injury, ranging from complete transection to devascularization to thermal injury, greatly influences the management of ureteral injuries. Contusions can be generally managed with the placement of an indwelling ureteral stent ("double-J stent") to prevent edema and stricture that could potentially lead to hydronephrosis.[1] In general, stents are left in place for 4 to 6 weeks. Importantly, imaging should be done prior to removal to rule out ureteral stricture or continued leakage.[18,19] More severe contusions or devascularization of the ureter may require removal of the afflicted portion of ureter with immediate reconstruction. Thermal injuries can cause localized devascularization and, when identified intraoperatively, can be managed with placement of a stent, with imaging to confirm the absence of complications prior to removal. These patients should typically be followed up for up to 3 months after stent removal to monitor for development of ureteral stricture.[1] Laceration or transection of the ureter is managed based on the location of injury, as is described in ►**Table 1**.[20]

Table 1 Grading of ureteral injuries per the American Association for the Surgery of Trauma guidelines[20]

Grade 1	Contusion or hematoma without devascularization
Grade 2	Transection <50%
Grade 3	Transection ≥50%
Grade 4	Complete transection with <2 cm of devascularized tissue
Geade 5	Complete transection with ≥2 cm of devascularized tissue

The general principles for repair of ureteral injury involve creating a tension-free anastomosis, repair over a stent to avoid stricture, and wide drainage of the repair. Drain placement can aid with early diagnosis of a postoperative leak, as the drain fluid can be sent for creatinine levels. While the nuances of ureteral injury repair are many and are well described in the urologic and trauma literature, here we will discuss the general concepts and strategies commonly employed for repair of ureteral injuries, depending on the location of injury.

Proximal Ureter

The proximal third of the ureter extends from the UPJ to the upper portion of the SI joint. Injuries in this region account for ~2% of all iatrogenic ureteral injuries.[4] These injuries are generally managed via an ureteroureterostomy (UU) over a double-J stent. This method of repair is highly successful and generally well tolerated by patients. Crucial steps for performing this repair include the debridement of the ureteral edges to healthy tissue, spatulation of the edges to avoid stricture, creation of a tension-free anastomosis, and the use of absorbable sutures to prevent future stone development (►**Fig. 1**). Performance of a nephropexy, in which the kidney is mobilized and fixed to the psoas tendon, can add up to 4 cm of length to allow ureteral reanastomosis over greater lengths of distance. Due to the length of the right renal vein, greater lengths can be gained on the right side in comparison to the left.

Some cases preclude the ability to perform a primary anastomosis. Alternatives include interposition grafts utilizing either ileum or the appendix. It is not advised to utilize bowel as an interposition graft if the patient has documented Crohn's disease, radiation enteritis, or a baseline serum creatinine above 2.0 mg/dL.[1,21] In the most extreme cases, often when injury has occurred to the renal parenchyma or pelvis itself, nephrectomy may be indicated. As mentioned earlier, knowledge of preoperative imaging and confirmation of a contralateral kidney must be performed prior to removal. If the contralateral kidney

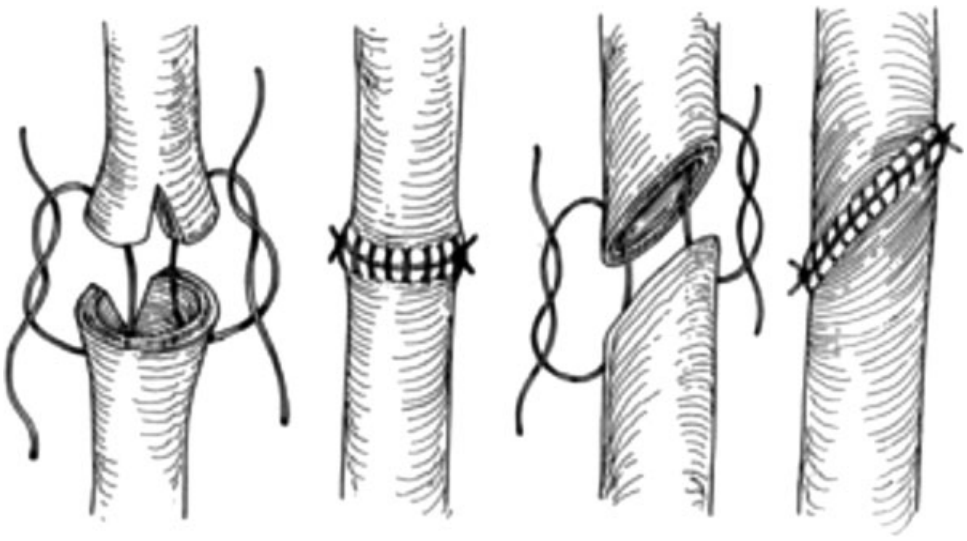

Fig. 1 Ureteral anastomosis.

is indeed absent or nonfunctioning, then autotransplantation of the kidney with vascular anastomosis to the iliac vessels and ureteral reimplantation directly into the bladder can be performed. This is a complex procedure, and it is advised to only attempt this at centers with experience with such operations and their postoperative management.[22]

Middle Ureter

The middle ureter runs from the upper portion of the SI joint, over the bony sacrum, to the inferior border of the SI joint. This anatomic zone accounts for 7% of all ureteral injuries.[4] When possible, debridement and tension-free primary UU over a stent are the preferred approach to repair. In instances where a tension-free anastomosis is not possible, then bladder mobilization with performance of a psoas hitch or Boari flap creation may be considered. The psoas hitch entails mobilization of the contralateral side of the bladder via ligation of the superior vesical pedicle. Identification of the contralateral ureter is of utmost importance to avoid injury while performing mobilization. The mobilized bladder is then sutured to the ipsilateral psoas tendon, taking care not to entrap the genitofemoral nerve. A transverse anterior cystotomy is performed, and the proximal end of the injured ureter is then spatulated and an anastomosis is fashioned, approximating mucosa to mucosa with absorbable sutures. A ureteral stent is then placed, the anterior cystotomy is then closed in a vertical fashion, and a Foley catheter is generally left in place for 7 to 14 days (►**Fig. 2**). A cystogram to confirm the absence of bladder leakage is advised prior to Foley removal.[1]

A Boari flap can be used for injuries involving a longer segment of the ureter. This again entails mobilization of the bladder with fixation to the psoas on the ipsilateral side to the injury. A rectangular flap of the anterior bladder wall is raised and then tubularized. This is fashioned as a bridge to the proximal aspect of the ureter, which is again spatulated and anastomosed to the flap (►**Figs. 3** and **4**). Like the psoas hitch repair, anastomosis should be performed with absorbable sutures and should be done over a stent, which typically stays in place for 6 to 8 weeks. A Foley catheter should be left postoperatively and removed at 7 to 14 days after absence of leak confirmed on imaging.

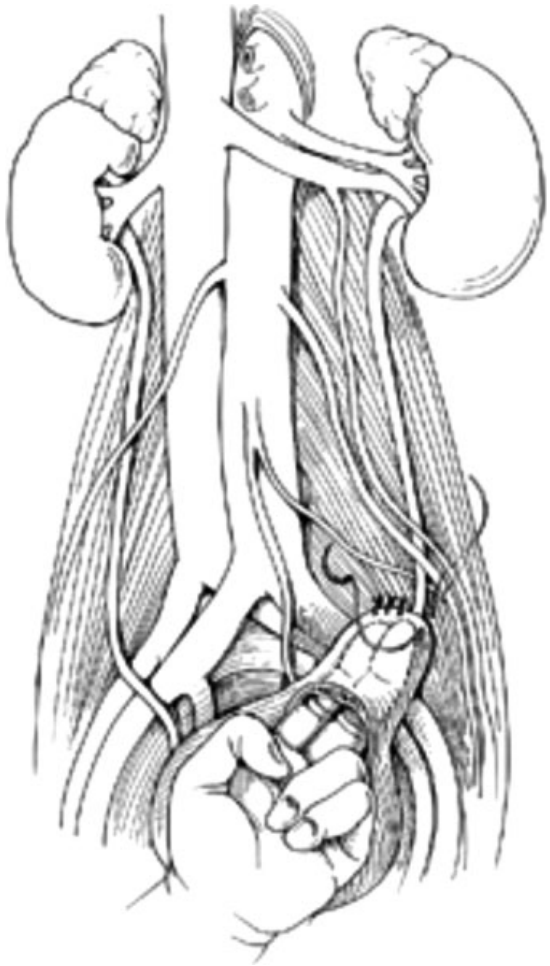

Fig. 2 Psoas hitch.

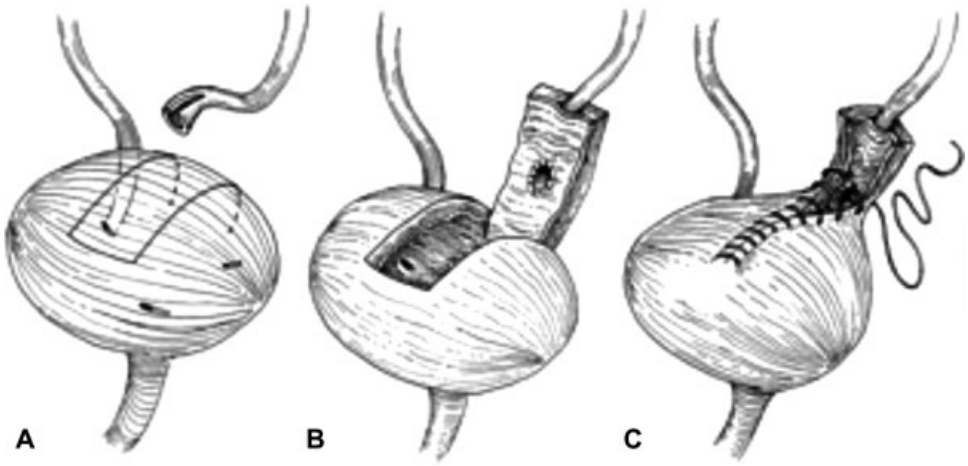

Fig. 3 Boari flap.

Fig. 4 Boari flap on cystogram.

Another option for repair of the injured mid-ureter is a transureteroureterostomy. This is performed by tunneling the injured ureter across to the contralateral ureter via the posterior peritoneum just anterior to the aortic bifurcation. Creation of an end-to-side anastomosis between the two ureters is then performed. Although necessitated at times due to patient anatomy and injury pattern, this approach is not favored due to the need to manipulate and alter the contralateral, previously uninjured ureter.

Distal Ureter

The distal ureter traverses from the inferior portion of the SI joint to the UVJ. Injuries in this location account for the vast majority (up to 91%) of all iatrogenic ureteral injuries.[4] The treatment of choice for these injuries is direct reimplantation of the ureter into the bladder. Although there are many described techniques of reimplantation, it is generally advised to tunnel the ureter in the anterior bladder wall toward the bladder neck. Due to the proximity of these injuries to the bladder, it is rare that any mobilization needs to be done to perform a tension-free anastomosis. If needed, then mobilization as described earlier can be performed to facilitate reanastomosis. Again, debridement to healthy tissue, spatulation of the proximal end, and anastomosis with absorbable sutures over a stent are highly advised.

Missed Injuries

Missed injuries of the ureter generally present in a delayed fashion, and are associated with generic symptoms, such as abdominal pain, fever, and intra-abdominal fluid collections. Serum creatinine levels can be elevated due to rapid reabsorption of creatinine by the peritoneum. Percutaneous drainage of intra-abdominal fluid can be performed and, if creatinine levels are significantly elevated, can be diagnostic of a missed injury of the urinary tract. Imaging in the form of an IV contrast-enhanced abdominal and pelvic computed tomography (CT) with delayed imaging can be of use to aid with diagnosis.[23] Potential treatment depends on time of diagnosis from index operation and includes guided placement of a ureteral stent, proximal diversion with percutaneous nephrostomy tubes, or direct repair as previously described, if technically feasible.[2] Attempts at repair beyond 2 weeks postoperatively can be significantly more difficult, and erring toward temporary proximal diversion with delayed repair may be wise.

Bladder Injuries

Risk Factors

Inadvertent injury to the bladder is a rare occurrence during colorectal surgery, with an incidence of $<1\%$.[5] Most data regarding bladder injuries come from patients undergoing gynecologic procedures. However, factors which can increase the risk of bladder injury during colorectal surgery include adjacent inflammatory or infectious processes, previous pelvic

surgery, invasive neoplastic processes, and a history of radiation. Ensuring that the bladder is adequately drained, whether by Foley catheter insertion or having the patient void prior to arriving to the OR, will help avoid potential trocar injuries during laparoscopic or robotic surgery.

Location/Scenarios

The bladder, being a pelvic organ, is at risk of injury during any pelvic operation. Reoperative surgery in the face of surgical adhesions or other factors that can obscure anatomic planes, such as inflammatory and malignant processes, can make clear identification of the bladder more difficult and lead to higher rates of injury. The presence of a colovesical fistula, attributed to diverticular disease in up to 90% of cases, can mandate additional manipulation of the bladder and potential for injury.[24] In this case, dissection of the colon off the bladder is often difficult and can lead to bladder injury. The incidence of colovesical fistulas is higher in men, likely due to the protective effects of the uterus being interposed between the colon and bladder in the female pelvis. Another scenario encountered by the colorectal surgeon is that of locally invasive sigmoid or rectal cancer with bladder involvement.

Identifying Injury

In most cases, direct inspection and maintaining a high level of clinical suspicion are the best means to identify bladder injuries intraoperatively. If the patient is undergoing minimally invasive surgery and a bladder catheter is present, the catheter can be inspected for signs of gas within the bag. Direct visualization of the Foley catheter within the operative field is perhaps the most obvious way to diagnose a bladder injury. If clinical suspicion is high but gross inspection of the bladder surface does not reveal any obvious injury, instillation of saline dyed with methylene blue retrograde into the bladder via the Foley catheter can aid in diagnosis.[25] When available, urologic consultation should be sought once a bladder injury has been diagnosed. Intraoperative cystoscopy can also be utilized to aid with diagnosis. It is important to also assess the trigone and the ureteral orifices to assure their location with respect to the site of injury, so as to maintain their integrity during repair of the injury.

Although most bladder injuries are identified intraoperatively, undiagnosed injuries to the bladder can result in significant morbidity for the patient, resulting in the need for sometimes complex reoperation. Occult injuries often become apparent after Foley removal and can manifest in myriad ways, from oliguria to frank drainage of urine from surgical incisions. Although intraoperative management of bladder injury often requires simple layered repair, management of injuries diagnosed postoperatively depends largely on whether the intra- or extraperitoneal bladder is involved. Suspicion of a bladder injury should prompt confirmatory studies. This includes cystography, which can be done either fluoroscopically or under CT.[18] Of note, CT cystograms should be performed with active retrograde filling of the bladder, as passive filling can miss small injuries. Percutaneous drainage for sampling of intra-abdominal fluid can also be undertaken to confirm the presence of urine.

Table 2 Grading of bladder injuries per the American Association for the Surgery of Trauma guidelines[26]

Grade 1	Contusion, intramural hematoma, partial laceration
Grade 2	Extraperitoneal bladder wall laceration <2 cm
Grade 3	Extraperitoneal (≥ 2 cm) or intraperitoneal (<2 cm) bladder wall laceration
Grade 4	Intraperitoneal bladder wall laceration ≥ 2 cm
Grade 5	Intraperitoneal or extraperitoneal bladder wall laceration extending into the bladder neck or trigone

Intra- and Postoperative Management

Treatment of bladder injuries depends largely on the extent and location of the injury. The American Association for the Surgery of Trauma guidelines, as seen in ►**Table 2**, are generally followed when considering approaches for repair of bladder injuries.[26]

In general, extraperitoneal injuries that are not extensive can be managed expectantly with Foley catheter drainage for 1 to 2 weeks. Confirmatory cystogram to confirm healing should be performed prior to catheter removal. The vast majority of iatrogenic bladder injuries encountered intraoperatively are intraperitoneal. The first step in management should be clear visualization of the extent of the injury. Once the injury has been delineated, any grossly devitalized tissue should be debrided, and the bladder should be reapproximated with a two-layer repair of the mucosa and seromuscular layers. Like ureteral repair, it is important to use absorbable sutures to prevent future issues with stone formation. Bladder instillation with methylene blue and saline via the Foley catheter can be performed after repair to ensure complete closure of the defect. The Foley catheter should be left in place for 1 to 2 weeks, with confirmatory cystogram prior to removal.

Injuries that involve the posterior bladder or that encroach upon the trigone are more complex and need additional attention. Due to the risk of ureteral ligation with simple repair, the preferred approach is to mobilize the bladder and perform a controlled anterior cystotomy to directly visualize the posterior injury and the ureteral orifices. It is generally advised to place retrograde ureteral catheters prior to repair to prevent inadvertent closure or stenosis of the ureters. At times, identification of the ureteral orifices can be challenging. This can be simplified by IV administration of methylene blue or indigo carmine along with Lasix. Repair is again performed in two layers with absorbable sutures. If the ureters are compromised at their insertion into the bladder, it is occasionally necessary to perform reimplantation into the bladder.[1] Again, the Foley catheter is left indwelling for 1 to 2 weeks and cystogram is performed prior to removal. If Foley catheter insertion is unsuccessful or contraindicated, then suprapubic catheter drainage should be performed.

Urethral Injuries

Risk Factors

Although extremely rare, intraoperative urethral injuries can have devastating consequences for the patient if undiagnosed. While the most common scenario for urethral injury is from traumatic Foley catheter placement, the urethra is also at risk of injury during pelvic surgery, particularly in patients with locally advanced neoplasms, a history of radiation, or in the presence of other inflammatory or infectious processes.[1] Additionally, the urethra is also at risk for injury during the anterior aspect of perineal dissection, such as during an APR. These injuries most commonly involve the membranous portion of the urethra as it courses through the prostate gland.[1] With the advent of minimally invasive transanal surgery, an increase in the incidence of urethral injury during anterior dissection has been reported, and attention to visual cues and adherence to appropriate surgical planes are paramount to avoiding these injuries.[27,28] The use of lighted urethral stents has been described to help early identification and avoidance of injury to the urethra during transanal surgery.[29]

Identification of Injury

Significant injuries to the urethra can often be diagnosed by the presence of the Foley catheter visible within the operative field. If there is suspicion of injury without direct visualization of the catheter, then the use of methylene blue, either intravenously or via direct injection into the urethral meatus, can aid with identification of occult injury. Unfortunately, not all urethral injuries are identified intraoperatively, where they can be directly managed and repaired. This is particularly true for injuries caused by thermal spread, which can present days to weeks after surgery. These injuries can lead to morbid conditions such as rectourethral or urethrocutaneous fistulas. Suspicion for these conditions should be raised in the presence of symptoms such as fecaluria, pneumaturia, the leakage of urine into the perineum, and recurrent urinary tract infections. Common methods for postoperative diagnosis of urethral injuries include physical examination, often requiring examination under anesthesia, retrograde urethrogram, and cystoscopy for direct visualization of potential defects.

Intra- and Postoperative Management

When diagnosed intraoperatively, urethral injuries can often be managed by primary, tension-free repair utilizing absorbable sutures. Additional length and mobility can be achieved during repair by dissection and mobilization of periurethral tissues. It is essential to perform repairs over a catheter to prevent stenosis. Failure to do so can lead to urethral stricture and possibly bladder outlet obstruction. The presence of a urethral stricture can be confirmed by retrograde urethrogram. The catheter should be left in place for up to 4 weeks to allow proper healing and prevent stenosis. In many cases, patients with urethral injuries have a history of preoperative radiation therapy or have the presence of local inflammation. Due to these factors, it is advisable to buttress any repair with remote healthy tissue, such as omentum, a muscle flap, or bioprosthetic material, to decrease the risk of subsequent fistula formation or repair breakdown. Urinary fistulas can have devastating consequences and are technically challenging to manage. They are classified into five distinct stages based on the size and location of the fistula (►**Table 3**).

Table 3 Classification of urinary fistulas based on size and location[26]

Stage 1	Low (less than 4 cm from the anal verge and nonirradiated)
Stage 2	High (more than 4 cm for the anal verge and nonirradiated)
Stage 3	Small (less than 2 cm irradiated fistula)
Stage 4	Large (more than 2 cm irradiated fistula)
Stage 5	Large (ischial decubitus fistula)

Treatment of urinary fistula can be complex and often requires input from a surgeon with experience in reconstructive urologic work. An initial trial of urinary diversion via either a Foley or suprapubic catheter should be attempted for 4 to 6 weeks in low-grade fistulas. Approach to the repair depends on the location of the fistula and in many cases, can be aided with the mobilization of muscle flaps.[30,31] In severe cases of urinary fistulas, particularly those involving radiated tissues, fecal diversion via colostomy or ileostomy can aid with healing. Addition of a suprapubic catheter in addition to Foley catheter can further aid with bladder decompression and facilitate healing.[32] Prior to removal of the catheter, a retrograde urethrogram can be performed around the catheter to evaluate for persistent fistula.

Conclusion

Iatrogenic injury of the urinary tract is unfortunately an inevitability for the colon and rectal surgeon whose practices encompasses complex reoperative surgery, treatment of locally advanced cancers, inflammatory bowel disease, and severe diverticulitis. While the advancement of technology has supplied an ever-expanding supply of tools to be taken advantage of by the surgeon, none will replace in depth knowledge of anatomy and meticulous surgical technique. Prompt identification of injuries is critical, and a general knowledge of repair strategies is essential. Perhaps most importantly, acknowledging one's own limitations and knowing when to consult with urologic colleagues is often the key to supplying the patient with the best chance for recovery from injury with the best functional results.

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Conflict of Interest
None declared.

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