Surgical Management of Urologic Trauma and Iatrogenic Injuries

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KEYWORDS
• Trauma • Kidney • Bladder • Urethra • Ureter • Genitalia

KEY POINTS
• Trauma patients requiring urologic-specific evaluation must be identified.
• The most efficient means of diagnosing urologic trauma should be determined based on the mechanism of injury.
• The optimal management strategy is based on the location and degree of urologic injury and patient stability.

INTRODUCTION

Genitourinary injuries may be seen as a sequel to both blunt and penetrating trauma occurring in approximately 10% of all patients admitted to an emergency department. Trauma is the number one cause of death in patients aged 1 to 44 and accounts for more than 120,000 deaths per year in the United States, 10% of which have a concomitant component of genitourinary origin with the kidney as the most frequently involved organ.1,2 These injuries may be quite elusive, concealed anatomically in the relatively nonresponsive retroperitoneal and pelvic locations where even intravenous (IV) contrast computed tomography (CT) might not identify them clearly. Urogenital trauma is rarely fatal, but may ultimately become the basis for significant short- and long-term morbidity, if not recognized early during its course. The major causes of genitourinary trauma are motor vehicles accidents, deceleration injuries, and penetrating firearm assault violence, all of which are on the increase.3

Blood in the urine signifies a urogenital injury. However, this is neither specific for location of injury nor a prognosticator for the severity of injury.4,5 Blunt trauma with associated hematuria requires evaluation of both the upper and the lower genitourinary system, as forces associated with high-speed motor vehicle collisions can...
produce significant injury to the entire genitourinary system. Hematuria in patients suffering penetrating abdominal trauma indicates possible urologic injury to the kidneys, ureters, or bladder.

Genitourinary trauma usually occurs in the setting of multisystem trauma. Timely evaluation and management of the trauma patient have the potential to minimize urologic morbidity and mortality. In what follows, each of the major urogenital organs is treated separately. New imaging modalities and a growing emphasis on nonoperative expectant management of both upper and lower urinary tract injuries have changed the field of urologic trauma. Concomitant injury to both the upper and the lower urinary tract is rare, but careful evaluation is critical to identify these devastating injuries.

**RENAL INJURY**

*Initial Evaluation*

Blunt renal trauma constitutes the most common genitourinary organ injury and is the result of motor vehicle collision, falls from heights, a sustained direct blow to the flank, lower rib fractures, or a complication of elective renal surgery from percutaneous stone surgery or partial nephrectomy. In a large population study, the incidence of trauma patients in the United States who had renal injuries was 1.2% with 14,000 patients hospitalized in the United States with renal trauma alone.\(^2\) In addition, 24% of all solid abdominal organ injuries involve the kidneys.\(^6\)

The presenting signs and symptoms of blunt trauma may include flank or abdominal pain and bruising, hematuria, hemodynamic instability, flank hematoma (expanding and pulsatile), and sepsis or ileus from urinary extravasation, which may not be recognized initially and may require delayed recognition and intervention.

Penetrating abdominal injuries as a result of gunshot or stab wounds should always alert the physician to possible renal injury. A thorough physical examination of the abdomen, chest, and back must be performed because gunshot wounds may be misleading because of the small entrance defects and may not initially reveal the extent of tissue damage. To identify the location and extent of the penetration with imaging, a paper-clip marker may be placed at the entrance and exit sites to help define the damage during all imaging techniques, because most penetrating injuries will require surgical exploration.\(^7\)

Contrast CT with delayed imaging of the ureters is the gold-standard imaging modality to evaluate the entire urinary tract as well as the anatomy and function of the kidney. The American Association for the Surgery of Trauma (AAST) Organ Injury Scale is used to classify blunt and penetrating renal injuries and corresponds closely to the appearance of the kidney on CT (Table 1).\(^8\) Renal injuries may be classified as renal contusions, renal lacerations with or without collecting system injury, renal pedicle avulsion, and vascular disruption, renal artery thrombosis, injury to the renal pelvis or ureteropelvic junction disruption.

CT should be performed in all cases of suspected renal trauma in hemodynamically stable patients. The standard protocol includes helical (spiral) CT with a portal venous phase (from the diaphragm to the ischial tuberosities) to survey lower genitourinary structures or the presence of active arterial bleeding, followed after 10 minutes by delayed images to identify the presence of urinary contrast extravasation. CT should not be used as the primary evaluation tool in hemodynamically unstable patients, because these patients should be managed operatively, and other diagnostic tests, such as diagnostic peritoneal lavage or ultrasound, should initiate the evaluation because the critical need of immediate surgical control of bleeding is crucial.

Most blunt renal injuries are minor with contusions that account for 64% to 81% of cases. Wessels\(^9\) in a multicenter study of 6892 patients with renal trauma found
Contusion or hematomas in 64.2%, grade II or III lacerations in 24.8%, grade IV injury in 7.7%, and grade V injury in 3.3% of cases.\textsuperscript{10}

Contemporary CT imaging with support of the grading system has provided a platform for the management of renal trauma and helps dictate the options of nonoperative and angiographic approaches and has been pivotal in decreasing surgical intervention and nephrectomy.\textsuperscript{11}

Angiography is rarely performed, but can be a valuable tool to both diagnose and treat renal injury via transcatheter embolization for active arterial bleeding, a pseudoaneurysm, or an arteriovenous fistula. Because the most common form of surgical management of renal injury is nephrectomy, angioembolization, when feasible, has been shown to decrease the rate of nephrectomy and increase renal salvage.\textsuperscript{9,12–14}

A rare but serious complication of renal arterial thrombosis and embolization with ischemic parenchyma is the development of renovascular hypertension. Development of renovascular hypertension has been documented in 0.2% of cases and is mediated by the renin-angiotensin system and can be managed by a delayed laparoscopic nephrectomy. Long-term follow-up is critical to identify this systemic event, which may develop in a delayed fashion.

Management

The goal of renal trauma management is to preserve the maximal number of renal units in as safe a manner as feasible. Thus, the management of blunt and penetrating renal injury varies greatly.

Nonoperative

There is an established and sustained shift in the renal injury therapeutic paradigm with an increasing nonoperative approach that involves close monitoring, bed rest, serial hemoglobin/hematocrit measurement with transfusions if necessary, and selective repeat CT imaging. Virtually all grade I–IV renal injuries and a select group of grade V injuries are now initially managed conservatively.\textsuperscript{13,15} The accuracy and rapidity of helical CT, combined with improvement in renal reconstruction, have decreased the number of renal explorations and nephrectomies performed over past 2 decades.\textsuperscript{12}

Fewer than 5% of blunt injuries and 36% of all penetrating renal injuries are

<table>
<thead>
<tr>
<th>AAST Grade</th>
<th>Characteristics of Injury</th>
<th>AIS-90 Score</th>
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<tbody>
<tr>
<td>I</td>
<td>Contusion with microscopic or gross hematuria, urologic studies, normal, nonexpanding subcapsular hematoma without parenchymal laceration</td>
<td>2;2</td>
</tr>
<tr>
<td>II</td>
<td>Nonexpanding perirenal hematoma confined to renal retroperitoneum; laceration &lt;1 cm parenchymal depth of renal cortex without urinary extravasation</td>
<td>2;2</td>
</tr>
<tr>
<td>III</td>
<td>Laceration &gt;1 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation</td>
<td>3</td>
</tr>
<tr>
<td>IV</td>
<td>Parenchymal laceration extending through renal cortex, medulla, and collecting system; injury to main renal artery or vein with contained hemorrhage</td>
<td>4;4</td>
</tr>
<tr>
<td>V</td>
<td>Completely shattered kidney; avulsion of renal hilum that devascularizes kidney</td>
<td>5;5</td>
</tr>
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Abbreviation: AIS, abbreviated injury scale.

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Fewer than 5% of blunt injuries and 36% of all penetrating renal injuries are
undergoing operative management.\textsuperscript{9} Ongoing arterial bleeding in hemodynamically
stable patients may be treated with angiography and selective embolization.\textsuperscript{16,17} Thrombosis of the renal artery or its branches is managed expectantly.

Bed rest is maintained until the urine becomes grossly clear. The urethral catheter
can be removed when the patient is stable and can spontaneously void.

All grade IV–V renal injuries that involve urinary extravasation managed nonopera-
tively should initially have a repeat CT scan at 48 to 72 hours to re-evaluate the degree
of urine extravasation. If the degree of extravasation has not diminished, ureteral
stenting is indicated, and the bladder should be decompressed with a urethral cath-
ter.\textsuperscript{17–19} Patients with increasing white blood cell count, fevers, increasing flank
pain, or ongoing blood loss should have a repeat CT scan. Percutaneous drainage
is performed if an infected hematoma or urinoma is detected.

\section*{Operative}

The only absolute indication for surgical exploration in renal trauma is persistent life-
threatening hemorrhage from a severe parenchymal disruption or “shattered kidney,”
renal pedicle transection, or an uncontained expanding hematoma in a patient clinically
in shock and in need of a lifesaving nephrectomy.\textsuperscript{14} Relative indications for renal explo-
lations include patients who have failed conservative management with persistent
bleeding, ongoing urinary extravasation, the critically ill patient with multiple associated
intraperitoneal injuries, or penetrating trauma. Although most kidney explorations
result in nephrectomy, early renal hilum vascular control has been advocated to reduce
the need for nephrectomy. Voelzke and McAninch\textsuperscript{20} reported a series of penetrating
injuries to 206 renal units that were successfully managed expectantly with a salvage
rate of 80%.

The strongest predictor for nephrectomy is the grade of renal injury. A significant
number of patients with penetrating injury and a minority of those with blunt injury
require immediate laparotomy before radiographic evaluation.\textsuperscript{9,21} The use of IV uro-
graphy is currently used as an intraoperative one-shot study with contrast when emer-
gency exploration is needed to assess the presence of a contralateral kidney before
possible nephrectomy. A plain abdominal film is obtained 10 minutes after injection
of a 150-mL bolus of iodinated contrast material.\textsuperscript{22,23} In critically ill patients with mul-
tiple injuries, renal exploration should only be undertaken if a pulsatile or expanding
retroperitoneal hematoma is identified. If exploration is not performed, CT staging of
the renal injury is performed once the patient is stabilized.\textsuperscript{16,24,25}

}\section*{Operative Technique}

A midline transabdominal incision extending from the xiphoid process to the pubic
symphysis allows exploration of the kidneys with optimal access to the renal hilum.
Preliminary isolation of the renal artery and vein may be achieved before Gerota fascia
is opened to minimize blood loss. Early vascular control with isolation of the vessels
has demonstrated potential renal salvage with expected functional restoration of
85%,\textsuperscript{14,20,26} Proximal vascular control is achieved by placing the transverse colon
on the chest and the small intestine in a Lahey bag (BectonDickson, Franklin Lakes,
NJ) and to the right. This placement will expose the root of the mesentery, the ligament
of Treitz, and the underlying great vessels. The retroperitoneal incision is made over
the aorta superior to the inferior mesenteric artery, extending up to the ligament of
Treitz. If a large retroperitoneal hematoma prevents easy feel of the aorta at the level
of the ligament, then the incision should be made medial to the inferior mesenteric
vein. This vein runs a few centimeters to the left of the aorta, where you can dissect
superiorly along the anterior aortic wall until you see the renal vein crossing over the
aorta. Place a vessel loop around the renal vein, which then permits you a guide to the remaining renal vessels, which are then also encircled, but not occluded, unless heavy bleeding is relentless, and then clamping with mannitol should be limited to 30 minutes of warm ischemic time. Most bleeding at this point is managed manually. The kidney is then exposed laterally by mobilizing the colon along the white line of Toldt to shift the colon medially. Open Gerota fascia along the lateral aspect and expose the kidney without incising the capsule. Once hemostasis is achieved, sharp debridement of nonviable parenchyma is performed, and the collecting system is scrutinized for leakage sites. Injection of 2 or 3 mL of diluted methylene blue into the renal pelvis with a 30-gauge needle may help identify openings that are not covered by parenchyma, which will usually seal the tear, if present. The open pelvis defect and open calyces can be closed with 4-0 absorbable sutures. Kidney lacerations are closed by renorrhaphy after suturing identified vessels with 4-0 absorbable suture on the parenchymal surface. FloSeal or Gelfom bolsters can be placed between the lacerated renal surfaces and the renal parenchymal edge followed by closure of the capsule if viable, using 3-0 monofilament absorbable mattress sutures. An omental flap can be sutured to a kidney defect or to wrap the kidney and is guided through a paracolic gutter to reach the reconstructed kidney. In the case of a shattered kidney or multiple lacerations, an envelope of Vicryl mesh may also be placed around the kidney to help maintain the repair. A Jackson-Pratt closed suction drain is placed away from suture lines, and the kidney is placed in a loosely closed Gerota capsule. In the presence of a concurrent injury to the pancreas and left kidney, multiple drains and an interposition of omentum should be placed between the 2 structures.

An injury to the main renal vein will require a repair. Segmental veins can safely be ligated, but the main vein may need repair with a 5-0 Prolene closure of the vein wall laceration. The patient will require bed rest and catheter drainage until gross hematuria clears and is mobile enough to void. Imaging with CT scan and a nuclear functional scan is required at 3 months to evaluate renal function of the injured kidney. Postoperative hemorrhage is rare if the injured parenchyma has been adequately debrided and repaired. If recurrent bleeding occurs, it is best evaluated and managed by angiography.

Complications

The reported complication rate following renal injury ranges between 3% and 20%. Patients with fever, increasing flank pain, and elevated white blood cell count should have a CT scan to evaluate for an infected retroperitoneal hematoma or urinoma. These fluid collections are usually managed by percutaneous drainage ± endoscopic stenting as previously described. Delayed bleeding is a rare and life-threatening complication that is more commonly associated with penetrating injury. Angiography will diagnose and treat possible arteriovenous fistulas or pseudoaneurysm formation.

INJURY TO THE URETER

Initial Evaluation

Ureteral trauma occurs in less than 1% of genitourinary injuries, and thus, the trauma surgeon must maintain a high degree of suspicion when evaluating the trauma patient. Injury to the ureter should be suspected with multisystem trauma involving the bowel, bladder, or vascular injury, deceleration injury, and any penetrating injury near the ureter. Hematuria is present in 25% to 83% of patients. Most injuries result from penetrating trauma, with only 4% to 20% of injuries occurring due to blunt trauma. Children are at an increased risk of ureteropelvic junction disruption, which typically
occurs with severe deceleration injury. In stable patients, a CT scan with delayed images should be performed to evaluate the ureter. Unrecognized injury can result in urinoma, sepsis, and nephrectomy.

**Management**

Ureteral injuries should be repaired surgically unless the diagnosis is made in a delayed fashion. If an abscess or urinoma is present, a percutaneous nephrostomy is placed and periureteral drainage is performed. If an incomplete ureteral injury is identified, retrograde ureteral stenting may be attempted. If unsuccessful, a nephrostomy tube is placed.

**Surgical Exploration**

In stable patients, ureteral injuries should be surgically reconstructed according to the location of the injury. Injuries above the pelvic brim, including ureteropelvic junction disruption, should be debrided, spatulated, and repaired with a primary anastomosis. The ureter must be mobilized sufficiently, but with care to avoid injuring the blood supply. Interrupted absorbable sutures (4-0 or 5-0) are used, and a double-J ureteral stent is placed. If there is a bowel injury adjacent to the repair, omentum can be used to cover the repair. Injuries of the distal ureter (distal to the iliac vessels) can be managed by reimplantation into the bladder. Reimplantation can be performed either in an extravesical approach or by opening the bladder in the midline and bringing the ureter through the bladder wall in a new hiatus on the posterior aspect of the wall. The ureter should be spatulated and anchored to the bladder with 3-0 or 4-0 absorbable sutures. A double-J ureteral stent should be placed. The bladder is then closed in 2 layers with absorbable sutures. A closed suction drain and urethral catheter are placed.

In situations whereby the ureteral defect is too large for primary anastomosis, a psoas hitch or Boari flap may be performed. A psoas hitch involves mobilizing the bladder (dividing the contralateral superior vesical artery may be required) and anchoring it to the psoas tendon. In addition, a Boari flap may be required if the defect is too long for a psoas hitch. Defects in which either a Boari flap or bowel interposition is required should be performed in a delayed fashion.

If the patient is unstable, if the surgeon is unfamiliar with ureteral reconstruction techniques, or if the defect is too long for acute reconstruction, the ureter should be ligated proximal to the injury, a nephrostomy tube placed, and delayed reconstruction performed.

Retroperitoneal drains are removed after 2 to 3 days unless the output is consistent with urine. The urethral catheter can be removed after 7 days. The double-J ureteral stent is removed cystoscopically 4 to 6 weeks after repair, preferably with a retrograde pyelogram to ensure proper healing. A nuclear medicine renal scan, IV pyelogram, or CT scan with delayed images is performed 3 months after stent removal to evaluate for asymptomatic obstruction.

**BLADDER INJURY**

**Initial Evaluation**

Blunt trauma is responsible for most bladder injuries, with penetrating events accounting for 14% to 33% of all injuries. Twenty-nine percent of patients with a pelvic fracture in combination with gross hematuria have a bladder injury, and thus, any type of pelvic fracture and hematuria warrants investigation for a potential bladder injury. A high index of suspicion needs to be present with intoxicated individuals who have a full bladder and sustain even mild trauma and complain of abdominal
pain because they may have ruptured their bladder. Bladder perforations may also be due to iatrogenic instrumentation–related trauma. Approximately two-thirds of patients with a bladder injury are extraperitoneal, and one-third are intraperitoneal, a distinction that typically determines whether the injury is surgically repaired.

The signs and symptoms of bladder injury are generally nonspecific, although 95% of patients present with gross hematuria. The patients may complain of suprapubic pain, dysuria, or inability to void, and on physical examination, may reveal tenderness in the suprapubic region, ileus, or an acute abdomen.38–40

Because of its established accuracy, CT cystography is the test of choice to investigate bladder wall integrity.41,42 Indications for cystography include pelvic fracture with gross hematuria, blunt trauma with gross hematuria, and low-density free abdominal fluid on CT (<25 HU), blunt trauma with a pelvic ring fracture and greater than 30 red blood cells per high power field, penetrating trauma with any degree of hematuria, and an injury to the pelvis. Once patent urethral continuity is determined to be intact, bladder catheterization is performed and the bladder is filled with 300 mL of iodinated contrast. The sensitivity and specificity of CT cystography for bladder rupture are 95% and 100%, respectively.43 Because of the high incidence of concomitant urethral injury seen in bladder rupture (5%–29%), confirmation of urethral integrity is important before catheterization.36,43,44 Confirmation will provide efficient and timely evaluation in the multitrauma patient in whom CT cystography adds to the standard abdominal and pelvic trauma CT imaging. This type of combined imaging has the advantage of rapidly acquired information without transferring the patient while offering the potential to diagnose additional injuries.

Extraperitoneal bladder rupture is nearly always associated with pelvic fractures caused by a burst or shearing mechanism with a subsequent anterolateral wall laceration during traumatic deformation of the bony pelvis. The classic CT finding of extraperitoneal bladder rupture is contrast extravasation around the base of the bladder confined to perivesical and space of Retzius with fluid seen anterior and lateral to the bladder. A CT cystogram may also be able to image and identify bladder neck injury, which needs immediate reconstruction to preserve continence.45

Management

Nonoperative
Accurate classification of bladder injury is vital to enable optimal management. Extraperitoneal ruptures are managed conservatively with placement of a urethral catheter or suprapubic cystotomy if there is a coexisting urethral injury.44,46,47 Contraindications to nonoperative management include urinary infection, pelvic fractures requiring internal fixation, the presence of bony fragments in the bladder, bladder neck injury (that may compromise continence), rectal injuries, and female urethral or vaginal lacerations associated with pelvic fractures. CT or conventional cystography is performed in 10 to 14 days to document healing. Once the extravasation has resolved, catheter removal can be based on the patient’s overall status and mobility. Open repair may be required if ongoing extravasation persists more than 4 weeks.45

Operative
All penetrating and intraperitoneal ruptures of the bladder are managed by means of exploration and repair. If the patient requires laparotomy for associated injuries and can tolerate the extra operating time, surgical repair of extraperitoneal bladder injuries is also prudent. Conversely, in severely unstable patients, catheter drainage can be used as a temporizing measure until the patient is able to undergo exploration.
Bladder exploration can be performed via an intraperitoneal approach or by entering the extraperitoneal space of Retzius in the anterior pelvis. Intraperitoneal injuries present as a stellate rupture of the dome of the bladder, and by enlarging this opening, one can inspect the interior of the bladder to exclude extraperitoneal injuries and evaluate the bladder neck. In cases involving orthopedic reconstruction of the pelvis, the bladder may be approached extraperitoneally through the incision used to expose the pubic symphysis. Although extensive hemorrhage has been described in this scenario, it is a rare event. Most extraperitoneal bladder injuries associated with pelvic fractures are anteriorly located, small in size, and easily closed without a more extensive bladder exploration.

Penetrating injuries and unrecognized blunt bladder injuries discovered at laparotomy without prior CT cystography call for a careful evaluation. By opening the bladder vertically at the dome or along the anterior surface, one can identify sites of injury invasively and inspect the ureteral orifices and the bladder neck. Lacerations are closed with 3-0 absorbable sutures, which approximate detrusor muscle and mucosa in one layer and provide hemostasis. In patients with penetrating injuries, entrance and exit sites must be identified. The cystotomy is then closed with 2 layers of continuous 3-0 slowly absorbable sutures.

Postoperatively, adequate urinary drainage is essential to successful healing of the repaired bladder, and there is no evidence that suprapubic catheters are superior to urethral catheters in this context. The catheter placed during trauma resuscitation is often not of sufficient caliber to allow easy bladder decompression; therefore, a 20-French urethral catheter should be substituted at the end of the operation. A closed suction drain near the bladder closure, but not on the suture line, is a necessity. A suprapubic cystotomy is rarely necessary, but may be an important adjunct if bleeding with clot formation needs irrigation for proper bladder decompression. CT or conventional cystography is performed in 10 to 14 days to document healing. Once the extravasation has resolved, catheter removal can be based on the patient’s overall status and mobility.

URETHRAL INJURIES
Initial Evaluation

Urethral injuries are very uncommon in the genitourinary trauma population, and most are due to blunt trauma. Pelvic fracture urethral injuries (PFUUI) occur with an approximate 1.5% to 5% incidence in patients with pelvic fractures. Although these injuries are rare, they have the potential of incurring substantial long-term morbidity of recurrent stricture disease, incontinence, and erectile dysfunction. For every 1-mm increase of pubic symphysis diastasis, the risk of urethral injury increases 10%. Anterior (penile and bulbar) urethral injuries are most commonly the result of fall-astride, or straddle injuries, but can also occur infrequently as a result of penile fracture or penetrating injury to the genitalia.

Blood at the meatus (37%–93% of patients) is the classic sign of injury to the male urethra and always warrants retrograde urethrogramy (RUG). Patients may also present with inability to void, or a “high-riding” prostate gland on digital rectal examination, which should immediately warrant the need for urethrogramy before any attempt to insert a catheter, which can convert an incomplete injury to a complete transection. Contrast extravasation on RUG demonstrates injury. If a catheter has been placed, cystography can confirm placement. If a PFUI has occurred, a suprapubic tube should be placed and the bladder evaluated with cystography to exclude a concomitant bladder injury.
**Management**

**Pelvic fracture urethral injury**

The recommended treatment of traumatic urethral injuries is based on the location and mechanism of injury. They have been traditionally managed by means of suprapubic cystotomy with delayed reconstruction in 3 to 6 months. Partial disruption is typically cared for nonoperatively with a suprapubic or urethral catheter and is associated with a low risk of stricture formation. In contrast, complete disruption of the prostatomembranous urethra by pelvic fracture is managed surgically with either endoscopic realignment or suprapubic cystostomy placement and delayed urethroplasty. Controversy remains regarding the best initial management strategy of traumatic urethral distraction injuries. A recent study reported 27 patients undergoing primary alignment with 14 patients managed by suprapubic cystotomy and delayed urethral reconstruction at a mean follow-up of 40 months. Realignment was successful in 37% of patients, whereas 11 patients with suprapubic tube went on to urethroplasty in a shorter time with 100% success of functional outcome, concluding that endoscopic realignment offers definitive therapy in approximately one-third of treated patients. Primary realignment is performed through the previously placed suprapubic tube site, which allows antegrade passage of instruments through the bladder at the same time as retrograde instrumentation per urethral meatus. Flexible cystoscopes or magnetic-tipped catheters advanced under fluoroscopy guidance can help place a wire into the bladder beyond the injury, and a Council-tip urethral catheter is then advanced over the wire without any attempt to create a direct anastomosis.

Suprapubic cystotomy still remains the simplest approach, placed percutaneously or at laparotomy with an inevitable urethral obliteration outcome. This procedure allows the patient time to recover and to undergo urethral reconstruction in a specialist center by an experienced reconstructive surgeon. All patients who suffer a PFUI should be followed for at least 1 year for development of a urethral stricture, erectile dysfunction, or urinary incontinence.

**Anterior urethra injury**

Straddle injury to the bulbar urethra is usually managed with a suprapubic cystostomy and delayed repair unless the injury permits passage of a urethral catheter. Surgical repair of the anterior urethra is preferred in cases of penetrating trauma or those associated with penile fracture. Gunshot wounds that result in large defects greater than 2 cm or associated with other major injuries should be treated with a suprapubic cystostomy tube with subsequent reconstruction at a tertiary center.

**PENILE INJURY**

**Initial Evaluation**

Penile trauma is unusual with variable cause, but still comprises 10%–16% of genitourinary injuries reported by several single-institution series. Injury to the flaccid penis is rare, occurring mainly as a result of penetrating or self-mutilation cause. Penetrating and gunshot injuries are uncommon outside of a battlefield setting. Penile fracture is an uncommon injury that results from disruption of the tunica albuginea. It is probably an underreported injury, accounting for 1 in every 175,000 emergency room visits. A large number of the cases reported in the literature are from the Mediterranean region, where there is an increased incidence of “Tagaandan.” Tagaandan is a sexual practice where the erect penis is forcibly pushed down to achieve detumescence. In the United States and Europe, most fractures occur after the penis slips out of the vagina during intercourse and thrusts against the perineum or pubic
symphysis. A retrospective report of 16 patients with penile fracture found that intercourse in stressful situations, such as out of the ordinary locations (6.8%) and extramarital affair (43.8%), appears to have a relationship to the injury.

The clinical picture of a penile fracture includes a missed intromission, acute bending of the penis, and a snapping sound followed by acute pain and immediate detumescence. There is often a delay in presentation attributable to the embarrassment of the social implications.

Penetrating injuries to the penis may result from deliberate attempts at mutilation as well as from accidental firearm injury. Penile swelling is limited to the penis by Buck fascia, but scrotal and perineal ecchymosis will develop, if the deep investing fascia of the penis is disrupted. The inability to void, gross hematuria, and blood at the meatus will strongly point to a urethral injury that warrants further investigation.

Urethral injury is seen in 10% to 22% of penile fracture cases and in 11% to 29% of penetrating penile injuries. RUG and cystoscopy before surgical exploration are means of identifying concomitant urethral injuries sustained during a penile fracture or penetrating penile injury.

**Management**

A circumferential, preputial, subcoronal incision with degloving blunt dissection of the skin and dartos fascia to the base of the penis will provide good exposure for penile fracture and most penetrating injuries. Tunica albuginea fractures are usually transversely oriented and may extend ventrally behind the corpus spongiosum, which presents a deeper injury that will require mobilization and retraction of the urethra to visualize the defect. The tunica albuginea rupture should be closed with interrupted 3-0 polydioxanone absorbable sutures. Even in cases of penetrating injury, most defects can be closed. In circumstances of large tissue loss, the wound may need to be managed in a staged fashion. Once the tunica albuginea has been closed, the dartos and skin are closed with fine suture. A lightly compressive circumferential dressing is placed.

**PENILE AMPUTATION**

Penile amputation is a true emergent catastrophe that is burdened by time-dependent reconstruction by a surgical team with a microvascular and urologic surgeon. Successful restoration of erectile, neurosensory, vascular, and urethral function is dependent on proper preservation of the amputated organ. The amputated part should be placed in saline-soaked gauze and a plastic bag. This bag should then be placed in a second bag containing slushed ice. Cold ischemia times longer than 24 hours are acceptable to allow transport to tertiary centers for replantation. Replantation after 16 hours of warm ischemia has been described.

The creation of an intact microvascular circulation will improve the potential for a viable shaft skin, a sensate glans, and normal orgasmic function and should be performed if possible. Once the urethra is mobilized sufficiently, it is reanastomosed in 2 layers and a catheter placed. The septum of the corpora cavernosa is then connected and the tunica albuginea reanastomosed. The restored cavernosa blood flow preserves the distal corpora, the glans, and the urethra. Ischemic skin loss is expected without reanastomosis of the dorsal artery and vein. When the dorsal arteries, dorsal nerves, and deep dorsal vein are each reanastomosed by an experienced microvascular surgeon and the dartos and skin are closed, preservation of anatomy and function is remarkably high. Postoperative management includes catheter diversion, bed rest, anticoagulation, hydration, and monitoring distal penile arterial flow.
SCROTAL AND TESTICULAR INJURY

Initial Evaluation

Traumatic injuries to the scrotum and testes commonly occur in young men between the ages of 15 and 40 years old, resulting from either blunt or penetrating insults, degloving injuries, and electric burns. Penetrating scrotal injuries commonly involve not only the testes but also the corpora cavernosa, the urethra, and the spermatic cord.65

Clinical presentation of a ruptured testicle can be elusive, but is usually immediately painful, with rapid onset of swelling, tenderness, and ecchymosis. Injury to the scrotal wall or tunica vaginalis may cause significant swelling without rupture of the tunica albuginea of the testis. Testicular torsion should be included in the differential in cases of testicular trauma. A pelvic hematoma caused by pelvic fracture can also result in massive scrotal swelling, so that blunt scrotal injuries need careful scrutiny by ultrasound.

High-frequency ultrasonography with high-resolution images using a 7- to 14-MHz linear array transducer is the optimal imaging technique and a key to accurate evaluation of scrotal trauma, because evaluating the testicles on physical examination after trauma is difficult. As a result, all cases of scrotal blunt trauma should be evaluated with an ultrasound unless the clinical examination is completely normal. It is ideal for noninvasive evaluation of the scrotal contents, including testicular integrity, blood flow, hematoma, fluid collections, and foreign bodies.65

Blunt trauma is the most commonly seen form of trauma and is usually the result of an athletic injury (50%), a motor vehicle collision (9%–17%), or a violent assault.66 Penetrating trauma is usually due to gunshot wounds and stab wounds, animal attacks, and self-mutilation. In a machine injury, degloving or avulsion injury may occur, which may result in the need of a split skin graft replacement.

Management

Scrotal exploration should be performed by making a midline vertical incision along the median raphe. This incision allows for access to both testicles through the same incision. If injury to the spermatic cord is suspected, the incision can be carried toward the groin for better exposure. The objective of exploration is to preserve testicle parenchyma (for endocrine and cosmetic purposes). In addition, large hematomas can be evacuated, thereby shortening the patient’s recovery time.

The tunica vaginalis is opened to allow complete inspection of the tunica albuginea. If a tunica albuginea rupture is present, sharp debridement of any necrotic, nonviable tissue and extruded seminiferous tubules is performed, and the easily identified tunica rents are closed with running 4-0 monocryl sutures. The testis is placed into the scrotum with fixation sutures to the dartos, and a 2-layer closure of the scrotum is carried out with 4-0 absorbable suture. A Penrose drain is placed through a separate incision and removed when drainage stops. Ice, elevation, and anti-inflammatory medication should be started promptly.

Most testicular ruptures can be reconstructed by primary closure of the tunica envelope. Although most testicular ruptures can be closed primarily, a tunica vaginalis graft of the exposed testicular parenchyma may be used if the defect is too large for primary closure.45

Scrotal skin lacerations can usually be closed primarily unless there is prolonged delay before surgical care or there is a grossly contaminated wound associated with a rectal injury. Hemostasis in the scrotum needs much more intense meticulous attention because there is a higher incidence of delayed bleeding in such
hypervascular mobile tissue. The skin and tunica dartos require separate 2-layer closure with a Penrose drain, placed through a dependent stab wound. The scrotum should be elevated and dressed with a firm compression dressing.

In the event of a scrotal avulsion injury from motor vehicle or a high-speed, rotating, machinery mechanism, an extensive debridement, followed by delay with wet to dry dressings, should be applied while awaiting healthy granulation tissue if there is concern about immediate wound management. The defect size and location will dictate the specific tissue transfer mode used, which may include primary closure, meshed split thickness skin grafts, placement of testes in subcutaneous pouches in thigh or abdomen, or the use of Singapore, anteromedial thigh flaps, or an inferior gluteal posterior thigh fasciocutaneous flap.67

REFERENCES


