The World Health Organization (WHO) predicts a dramatic worldwide rise in the burden of disease caused by road traffic accidents and war. This rise will directly influence the incidence of urogenital trauma, in that motor vehicle crashes (MVCs) and firearm injuries are responsible for the overwhelming majority of major renal and pelvic injuries. In one population-based study, the percentage of trauma patients in the United States who had renal injuries was 1.2% (incidence, 4.9 per 100,000 population). Thus, in 1 year, some 14,000 patients with renal injuries are hospitalized nationwide. Approximately 45,000 pelvic fractures occur each year in the United States, 15% to 25% of which are associated with urologic injury. Urogenital injuries, though rarely fatal, can cause profound long-term morbidity and permanently impair quality of life.

Blood in the urine is the hallmark of injury to the urogenital system; however, as an isolated indicator, it is not specific for injury location or severity. In penetrating abdominal trauma, hematuria is a signal that the kidneys, the ureters, and the bladder must be evaluated. Urethral and genital injuries are suspected only in the setting of wounds to the pelvis, the perineum, or the buttocks. When hematuria occurs in association with blunt trauma, the entire urogenital system must be evaluated: the forces associated with high-speed MVCs and falls can cause injuries to both the upper and the lower regions of the urogenital tract.

In what follows, each of the major urogenital organs is treated separately. New imaging modalities and a growing emphasis on nonoperative management of upper and lower urinary tract injuries have dramatically changed the field of urologic trauma. Concomitant injury to both the upper and the lower urinary tract is rare, but extra vigilance must be maintained to detect such injury when it does occur. Evaluation and management of trauma to the female reproductive organs requires special expertise, particularly when the patient is the victim of a sexual assault.

Injuries to the Kidneys

INITIAL EVALUATION

The most reliable sign of injury to the kidney is hematuria (see Figure 1), except in patients with renal artery thrombosis or pedicle avulsion, who may have no blood in their urine. However, the degree of hematuria correlates poorly with the severity of renal injury, and as a result, criteria for imaging in these patients must take into account both the mechanism of injury and the probability of severe kidney injury. Accordingly, a Consensus Statement from a Renal Trauma Subcommittee convened by the WHO proposed guidelines for imaging renal injuries [see Table 1]. As with all guidelines, exceptions exist. A high degree of suspicion for renal trauma is required for patients who do not meet the hematuria criteria for imaging but who have experienced a fall from a height, have sustained a direct blow to the flank, or have other indicators (e.g., persistent flank pain or severe associated injuries).

Computed tomography is the first-line imaging modality for all cases of suspected renal trauma in hemodynamically normal and stable patients. A standard examination includes helical (spiral) CT with a portal venous phase (from the diaphragm to the ischial tuberosities) to visualize active arterial bleeding [see Figure 2a], followed after 10 minutes by delayed images (from the kidneys to the ischial tuberosities) to identify urinary contrast extravasation [see Figure 2b]. CT should not be used as the primary evaluation method in hemodynamically unstable patients: other diagnostic tests, such as diagnostic peritoneal lavage (DPL) or ultrasonography, should be performed before renal imaging with CT.

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 [see Figure 3 and Table 2].

MANAGEMENT

Differences in the management of blunt and penetrating renal trauma are a result of the greater instability of the patient after penetrating trauma and the higher likelihood of severe renal injuries after firearm and stab wounds.

Nonoperative

Increasing numbers of renal injuries are being managed nonoperatively. The accuracy and rapidity of helical CT, combined with the improvements achieved in resuscitation methods, have reduced the number of renal explorations performed. Currently, one half of all penetrating renal injuries and fewer than 5% of blunt injuries necessitate operative management. All grade I and II renal injuries, regardless of the mechanism of injury, can be managed with observation alone because the risk of delayed bleeding is extremely low. Most grade III and IV injuries, including those with devitalized parenchymal fragments and urinary extravasation, can be managed nonoperatively with close monitoring, serial hematocrit measurement, and repeat imaging in selected cases. Active arterial bleeding, in the absence of other associated injuries, can be treated with emergency arteriography and angioembolization.

Thrombosis of the renal artery or its branches is treated expectantly unless the contralateral kidney is absent or injured, in which case emergency revascularization is indicated. Treatment with modalities such as endoluminal stenting and thrombolytic therapy is a promising but still experimental approach.

Operative

The only absolute indications for renal exploration are pedicle avulsion, pulsatile or expanding hematoma, and hemodynamic instability resulting from renal injury. Shattered kidneys (grade V) and renal vascular injuries (grades IV and V) call for immediate renal exploration and, usually, nephrectomy [see Figure 4]. In patients who require laparotomy for associated injuries, renal exploration and reconstruction of grade III and IV injuries may reduce the likelihood of delayed complications. Thus, exploration of suspected kidney injuries (as determined by previous imaging or on-table evaluation) in patients undergoing laparotomy for major
Injuries to the Urogenital Tract — 2

Spleenic or bowel injury should be attempted by surgeons experienced in repairing an injured kidney. In reality, the success of nonoperative management for most grade III and IV injuries means that operative intervention in cases of blunt trauma is typically limited to patients with the most severe renal injuries, in whom conservative management fails either because of bleeding or because of ongoing urinary extravasation despite ureteral stenting.14

A significant number of patients with a penetrating injury and a minority of those with blunt trauma require immediate laparotomy before radiographic evaluation.15 Hematuria should alert the surgeon to the possibility of renal injury, and the presence of a perinephric hematoma visible through the mesocolon should prompt further evaluation. If a major renal injury is suspected on the basis of the size of the hematoma or an abnormal intraoperative intravenous pyelogram (IVP), exploration is indicated.

Intraoperative IVP (so-called one-shot IVP) is indicated when exploration of a kidney is planned and no preoperative imaging is available. The main purpose of a one-shot IVP in this setting is to confirm the presence of a contralateral functioning kidney; a potential benefit is the ability to rule out major injury. The plain abdominal film is obtained 10 minutes after injection of a 150 ml bolus of iodinated contrast material. If the injured kidney is adequately imaged and found to be normal, exploration may be omitted16; otherwise, the kidney should be explored. In critically ill patients with multiple associated injuries, renal exploration is indicated only if a pulsatile or expanding hematoma is present, in which case expeditious nephrectomy is necessary. If exploration is not done, staging with CT should be completed once the patient is stable; angioembolization and percutaneous drainage can be used to manage bleeding and urinary extravasation, respectively.17-19

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**Figure 1** Algorithm outlines management of renal injuries.
The priorities of operative management for grade III, IV, and V injuries are hemorrhage control and definitive repair of the collecting system. A midline transabdominal incision permits exploration of the kidneys and provides optimal access to the renal hilum. After intraperitoneal sources of bleeding have been controlled, preliminary isolation of the renal artery and vein should be achieved before Gerota’s fascia is opened. There is some controversy regarding the value of early vascular control, with one randomized controlled trial showing no benefit from early isolation of the vessels in cases of renal gunshot wounds; however, the weight of the remaining evidence suggests that this technique is still valuable if renal reconstruction is the goal of exploration.

Isolation of the renal vessels is accomplished by opening the posterior peritoneum medial to the inferior mesenteric vein or by reflecting the ipsilateral colon (provided that the perinephric hematoma is left undisturbed). Once vessel loops have been placed around the renal artery and vein, Gerota’s fascia is opened. If massive bleeding occurs when the hematoma is entered, Rumel tourniquets or vascular clamps are applied to occlude the renal artery. If this maneuver does not stop the bleeding, one should suspect a venous injury and occlude the renal vein as well. Surface cooling of the kidney is not advocated, because of time constraints and concerns about possibly exacerbating hypothermia. Total exposure of the kidney by means of sharp and blunt dissection facilitates identification of injury to the parenchyma, the renal pedicle, or the collecting system. The renal capsule should not be pulled off the parenchyma: doing so would complicate subsequent repair.

Renal reconstruction includes sharp debridement of all devitalized tissue, achievement of hemostasis, closure of the collecting system, coverage of the defect, and drainage. Renal salvage should be possible in nearly 90% of grade III and IV injuries. Nephrectomy is reserved for destroyed kidneys that cannot be reconstructed or for cases of serious renal injury associated with other life-threatening injuries (e.g., vascular or hepatic trauma) in which taking the time required for attempted renal repair would jeopardize the life of the patient.

A number of sophisticated products are available for enhancing surgical hemostasis and reducing the need for tedious ligation of individual small arterioles on the parenchymal surface. Such products include a hemostatic bandage applied directly to the cut surface of the kidney, polyethylene glycol–based hydrogels, fibrin glue, and a gelatin matrix–thrombin tissue sealant (FloSeal; Baxter International, Inc., Deerfield, Illinois). To date, none of these products have been evaluated in the setting of blunt renal injuries, but results in elective partial nephrectomy models are encouraging.

Once hemostasis is satisfactory, the collecting system is scrutinized for evidence of injury. If the extent of the injury is unclear, 2 to 3 ml of methylene blue is directly injected into the renal pelvis while the ureter is occluded with a vessel loop to identify any openings in the collecting system. Open calyces or infundibula are closed with 4-0 absorbable sutures. Often, the renal capsule can be used to cover exposed renal parenchyma and provide additional hemostasis. The defect in the parenchyma can be filled with folded absorbable gelatin sponges as the capsule is closed over the bolsters. If the capsule has been destroyed, coverage may be obtained with an omental or perinephric fat flap tacked down over the defect, a patch constructed from polyglycolic acid or peritoneum, or an entire sac of polyglycolic acid wrapped around the kidney, with the parenchymal edges kept well apposed.

At the end of the procedure, the kidney is returned to its location within Gerota’s fascia, which is not reaproximated. Closed-suction drainage of the renal fossa is recommended only after repair of the collecting system; internalized stents are reserved for complex injuries (e.g., large lacerations of the renal pelvis or the ureteropelvic junction [UPJ]).
Postintervention Care

Management of patients after operative or nonoperative intervention for renal trauma depends on the presence and severity of associated injuries. The most significant urologic complications are urinary leakage, urinoma formation, and delayed bleeding.

**After nonoperative management** Bed rest is prescribed until the urine becomes grossly clear. Drainage of the bladder with a Foley catheter is necessary only until other injuries are stable and the patient can void spontaneously. For grade IV injuries with large amounts of urinary extravasation, follow-up imaging 48 to 72 hours after the initial scan is recommended to evaluate the degree of ongoing extravasation. CT is recommended, though in children, protocols that reduce the radiation exposure should be used. If at 72 hours the amount of extravasation has not decreased from that seen on the initial scan, stenting is indicated. Cystoscopy and internal double J stenting allow successful treatment of the small percentage of cases in which the injury does not close spontaneously.30 When a double J stent is used to manage persistent extravasation, the urinary bladder should be decompressed with a Foley catheter. Parenchymal fragmentation and arterial thrombosis cause ischemia and often delay resolution of urinary leakage.31 Nevertheless, internal stenting almost invariably suffices, though resolution of extravasation can take weeks to months. Ultrasonography is useful for following such collections and for reducing the patient’s radiation exposure. For small uninfected collections adjacent to the kidney, no intervention is needed. If a perinephric fluid collection is large enough to compress the ureter or becomes infected, additional percutaneous drainage is indicated [see Figure 6]. The drain fluid is tested for creatinine, and if the findings are consistent with a urine leak, the drain is left in place until the collection resolves and leakage can no longer be demonstrated on contrast imaging.

Delayed bleeding is a rare but serious complication of nonoperative management of major lacerations.32 Pseudoaneurysm formation is the most common cause of delayed bleeding [see Figure 7].33 Gross hematuria usually, but not invariably, accompanies the bleeding. If it is seen in conjunction with hypotension or a decreasing hematocrit, urgent angiography is the best initial approach; selective embolization is an effective treatment that renders exploration unnecessary in most instances.

**After operative management** Retroperitoneal drains are removed within 48 hours after renal exploration unless the creatinine concentration in the drained fluid is higher than that in the serum. Persistent urinary leakage is best evaluated by means of repeat CT with delayed cuts. As with nonoperative management,
internal stenting and percutaneous drainage are the mainstays of treatment for leaks and urinomas, respectively. Postoperative hemorrhage is rare if the injured parenchyma has been adequately debrided and repaired. Angiographic evaluation with embolization is the best approach for postoperative renal bleeding.

Functional imaging Postoperative nuclear imaging is recommended in patients with grade IV and V injuries involving significant parenchymal loss or vascular injury. The goal is to identify patients with significant loss of functioning renal tissue who are at potential risk for chronic renal insufficiency. Patients whose level of residual function in the injured kidney, as determined by radionuclide scintigraphy, is less than 25% should be considered as having a solitary kidney. This information is useful in counseling patients who participate in high-risk sports activities (e.g., skydiving, motocross, and hang gliding). The optimal timing of postoperative nuclear imaging has not been determined, but by 3 months, the hematoma and inflammation related to the injury usually have resolved. Hypertension is a rare late complication of renal reconstruction, usually renin-mediated and deriving from an ischemic segment of renal parenchyma. Occasionally, angiography delineates the ischemic segment of the kidney, and excision of the nonperfused segment or complete nephrectomy may be required.

Injuries to the Ureters

Initial Evaluation

Ureteral trauma [see Table 2] is rare, accounting for fewer than 1% of genitourinary injuries. Furthermore, the absence of physical signs of injury makes diagnosis difficult, and a delayed presen-
tation is not uncommon. Gross or microscopic hematuria may be absent in 25% to 70% of patients with ureteral injuries, and as many as one half of all ureteral injuries resulting from blunt trauma are not recognized immediately. A high index of suspicion and a high degree of vigilance are necessary if the diagnosis is to be made early enough to prevent late consequences such as urinoma, sepsis, and nephrectomy.35-37

The mechanism of injury has a particular bearing on the diagnosis and management of ureteral injury. Overall, penetrating wounds are the predominant cause of these injuries. CT with delayed cuts should be performed when ureteral injury is suspected and the patient is stable. Imaging is of variable usefulness in the detection of ureteral injuries, but extravasation of the contrast agent is diagnostic.38 Only 10% to 20% of ureteral injuries are caused by blunt trauma, and within this category, MVCs predominate.39 In children, ureteral injury at the UPJ often occurs after severe deceleration.39 Children’s ureters are particularly prone to injury at this location because the hyperextensibility of their spines can result in ureteral avulsion at the UPJ.37,38,40

**Management**

All injuries to the ureter should be repaired surgically [see Figure 8] unless a delay in diagnosis has resulted in an abscess or a urinoma [see Figure 9]. If an abscess or a urinoma is present, drainage by means of percutaneous nephrostomy, coupled with ureteral stenting, allows infection and inflammation to resolve before definitive management; in this setting, an operative approach is likely to result in nephrectomy.

**Ureteral Exploration**

In stable patients, blunt ureteral injuries are typically identified by preoperative radiographic studies, which allow directed exploration and repair (see below). With penetrating trauma, ureteral injury may not be suspected until the time of laparotomy, when a hematoma is found near the kidney or ureter. Direct inspection of the entire trajectory of the offending agent requires particular vigilance for direct injury to or contusions of the ureter. Injection of indigo carmine into the collecting system identifies extravasation. Direct injection saves time and ensures that injuries are not missed as a result of low urine output from shock or renal injury. One study found that all penetrating ureteral injuries were detected at laparotomy without previous imaging.36

**Reconstruction and Repair**

Ureteral injuries should undergo surgical reconstruction as soon as they are recognized unless associated injuries prevent such a strategy. For example, gunshot injuries to the iliac vessels or the ureters may necessitate heroic vascular reconstruction. Ligation of the ureter with subsequent nephrostomy tube drainage or exteriorization of a ureteral stent allows elective reconstruction months later. Percutaneous and endoscopic approaches can also be used to establish urinary drainage if ureteral exploration is not feasible.

Reconstructive steps in ureter repair include debridement of devitalized tissue, creation of a spatulated tension-free anastomosis, watertight mucosal approximation, stenting, coverage of the repair with vascularized tissue when feasible, and appropriate drainage.44 Stab wounds generally cause less tissue damage than gunshot wounds and are more easily repaired; partial transections may be closed primarily.

**Upper ureter** Disruption or transection of the upper ureter or the UPJ is repaired by means of debridement and primary anastomosis of the renal pelvis and the ureter. Mobilization of the ureter is limited to ensure that the blood supply is not compromised. Interrupted 5-0 or 6-0 absorbable sutures are preferred, and a double J ureteral stent or a nephrostomy tube is inserted before completion of the anastomosis.

**Medial ureter** Injuries to the abdominal ureter between the UPJ and the pelvic brim are repaired by means of ureteroureterostomy [see Figure 10]. After debridement, the ends are spatulated on opposite sides, and an interrupted approximation is completed over a double J stent. In cases of overlying colonic, duodenal, or pancreatic injury, the anastomosis should be covered with omentum or retroperitoneal fat. Large defects in the abdominal ureter may necessitate transureteroureterostomy, in which the injured ureter is passed behind the mesocolon to the contralateral side. Anastomosis of the injured ureter to a 1 to 2 cm opening in the medial side of the normal ureter can be achieved without tension. With transureteroureterostomy, a stent (usually a 5 French pediatric feeding tube) should cross the anastomosis and be brought out through the normal lower ureter or bladder.

**Distal ureter** Ureteral injuries in the pelvis should be managed with reimplantation into the bladder. The distal stump is ligated, and after the anterior bladder wall is opened, the proximal end of the ureter is brought through a new hiatus on the back wall of the bladder. The ureter is then spatulated and approximated to the bladder mucosa with interrupted chromic sutures. One 3-0 anchoring stitch brings the distal apex of the ureter to the muscle and mucosa; the rest of the sutures approximate the mucosa. A refluxing reimplantation is acceptable in adults. Larger defects can be bridged by performing a vesicopsoas hitch, in which the bladder is sewn to the central tendon of the psoas muscle. The dome is mobilized by dividing the obliterated umbilical arteries bilaterally and, if necessary, the contralateral superior vesical artery. Three interrupted nonabsorbable sutures that enter the detrusor muscle
but not the bladder lumen) anchor the dome above the iliac vessels. Complex bladder or vascular injuries in the pelvis make transureteroureterostomy a more attractive option for avoiding further dissection in the injured area. A ureteral stent should be used in all ureteral reimplantations. The bladder is closed in two layers with a continuous 2-0 absorbable suture. Closed-suction retroperitoneal drainage and Foley catheter decompression of the bladder are essential.

Postintervention Care

Postoperative care of ureteral trauma relates mainly to the manipulation of drains and the management of complications. Retroperitoneal drains may have significant output for several days but are removed after 2 to 3 days unless output is consistent with a urine leak as determined by creatinine measurement (see above). Bladder catheterization is necessary for 7 days after ureteral reimplantation. In combined bladder and ureteral reconstructions, contrast cystography is indicated before catheter removal. Cystoscopic removal of the double J stent is usually performed with local anesthesia 4 to 6 weeks after operation. CT, IVP, or renal scintigraphy 3 months after removal of the stent rules out the possibility of asymptomatic obstruction.

Fistula formation, usually the result of distal obstruction or necrosis of the ureter, should be managed by means of antegrade or retrograde drainage of the collecting system with percutaneous or endoscopic techniques. Drainage of periureteral fluid collections may also be necessary. If recognition of an injury or a complication is delayed, reconstruction should be deferred for at least 3 to 6 months until all inflammation has subsided.

Injuries to the Bladder

INITIAL EVALUATION

Bladder injury [see Table 2] is most often caused by blunt injuries, with penetrating trauma accounting for 14% to 33% of civilian cases. About 9% of patients with a pelvic fracture have an infected urinoma in a patient with left grade IV injury who presented 7 days after injury with fever and sepsis and subsequently underwent ureteral stenting. The urinoma was drained percutaneously.
associated injury to the bladder, though there is only a weak association between the type of fracture sustained and the likelihood of bladder injury. Because the fracture type has poor predictive value for the type of associated genitourinary trauma, all patients with pelvic fractures and any degree of hematuria should be suspected of having a bladder injury. Approximately two thirds of bladder injuries are extraperitoneal and one third intraperitoneal, a distinction that has important management ramifications.

The signs and symptoms of bladder injury are generally non-specific [see Figure 11], though 95% of patients with bladder rupture present with gross hematuria. Patients may complain of suprapubic pain, dysuria, or an inability to void. Physical examination may reveal tenderness in the suprapubic region, ileus, or an acute abdomen. The percentage of patients without any hematuria ranges from 0% to 3%. Laboratory studies are usually inconclusive unless significant reabsorption of urine causes elevated serum creatinine levels, hyperkalemia, or hyponatremia.

Bladder rupture can be accurately diagnosed with either retrograde CT cystography or plain-film retrograde cystography. The indications for cystography include blunt trauma with gross hematuria, pelvic fractures requiring internal fixation, the presence of bony fragments in the bladder, bladder neck injury, which may compromise continence; rectal injury; and female genital lacerations associated with pelvic fracture. After 10 days, plain-film or CT cystography is performed to document healing. Once the extravasation has resolved, catheter removal can be based on the patient’s overall status and mobility. If extravasation persists, cystography is repeated at appropriate intervals until healing occurs.

Operative
All penetrating injuries and all intraperitoneal ruptures of the bladder are managed by means of bladder exploration and repair.

**Nonoperative**
Extraperitoneal bladder injuries caused by blunt trauma are generally managed nonoperatively with 10 days of catheter drainage. Contraindications to nonoperative management include urinary infection; pelvic fractures requiring internal fixation; the presence of bony fragments in the bladder; bladder neck injury, which may compromise continence; rectal injury; and female genital lacerations associated with pelvic fracture. After 10 days, plain-film or CT cystography is performed to document healing. Once the extravasation has resolved, catheter removal can be based on the patient’s overall status and mobility. If extravasation persists, cystography is repeated at appropriate intervals until healing occurs.

**Operative**
All penetrating injuries and all intraperitoneal ruptures of the bladder are managed by means of bladder exploration and repair.

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**Figure 7** Shown is a pseudoaneurysm of the left kidney after blunt injury.
If the patient requires laparotomy for associated injuries and can tolerate the extra operating time, repair of extraperitoneal bladder injuries is also recommended. 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. By enlarging this opening, one can inspect the interior of the bladder to exclude concomitant extraperitoneal injuries, which occur in 8% of cases. 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 occurrence. 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 injuries discovered at laparotomy without previous CT cystography call for systematic evaluation. By opening the bladder vertically at the dome or along the anterior surface, one can identify sites of injury intravesically 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 two layers of continuous 2-0 slowly absorbable sutures.

Postintervention Care

Adequate urinary drainage is essential to successful healing of the repaired bladder. There is no evidence that suprapubic catheters are superior to urethral catheters in this context. However, the catheters placed during trauma resuscitation are 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 overlying the suture line) is recommended. Cases of severe hematuria resulting from extensive injuries or coagulopathy warrant additional drainage with a suprapubic cystostomy tube to allow irrigation of clots and proper decompression of the bladder.

The perivesical drain can be removed after 48 hours unless the creatinine level in the drained fluid indicates ongoing urinary leakage. In the majority of patients with a bladder repair, 7 days of catheter drainage is sufficient to allow healing. Because bladder repair is reliable, any complications of bladder injury are usually related to a delay in diagnosis rather than to postoperative morbidity. Azotemia, ascites, and sepsis can result from an unrecognized intraperitoneal injury. Bladder neck injury, if overlooked, leads to scarring and incompetence of the proximal sphincter mechanism, with resultant incontinence, especially in females.

Injuries to the Urethra

INITIAL EVALUATION

Almost all injuries to the male urethra [see Table 2] are caused by blunt trauma. Prostatomembranous urethral distraction...
injuries in males occur in 5% of pelvic fractures, which are the most common cause of posterior urethral injury. Anterior urethral (penile and bulbular urethral) injuries are commonly caused by straddle injury but may be the result of penile fracture or penetrating injuries to the genitalia. The female urethra is rarely injured, but when such injury occurs, it is usually associated with bladder injury and pelvic fracture.\(^\text{51}\)

Blood at the urethral meatus—the classic sign of injury to the male urethra—is an indication for immediate urethrography. Attempts at catheter placement risk converting an incomplete injury to a complete disruption and are to be discouraged if urethral injury is suspected.

Because signs of urethral injury are variable, retrograde urethrography is the essential diagnostic test used for documenting the location, nature, and extent of injury. Extravasation of the contrast agent is evidence of urethral injury [see Figure 13]. In the absence of extravasation, a Foley catheter should be passed. If a catheter has been placed but its position is unclear, contrast injection will confirm its placement in the bladder. In such cases, the catheter should be left in place until a pericatheter contrast study can fully evaluate the urethra. In cases of pelvic fracture and complete posterior urethral injury, bladder injury must be excluded by open bladder exploration or via cystography through a percutaneously placed suprapubic tube.

**Anterior Urethra**

Immediate surgical reconstruction is preferred for penetrating injuries of the bulbar and penile urethra and for urethral injuries associated with penile fracture. For these grade III and IV injuries, primary repair is associated with a lower stricture rate than simple realignment.\(^\text{55,56}\) Wounds accompanied by major tissue loss and defects larger than 2 cm (e.g., grade V injuries) or major associated injuries are best treated with suprapubic tube urinary diversion (see below) and subsequent reconstruction at a tertiary referral center.

**Suprapubic Cystostomy**

Many centers continue to use suprapubic cystostomy as the primary management of prostatomembranous urethral disruption and straddle injuries to the bulbar urethra. Suprapubic cystostomy, with the tube percutaneously placed under fluoroscopic guidance, allows temporary urinary diversion for initial stabilization and evaluation of the patient. Cystography can then be performed via the suprapubic tube to rule out associated bladder injury. Straddle injuries must be treated with suprapubic diversion unless the urethral disruption is only partial and allows passage of a guide wire or catheter under fluoroscopic guidance. Finally, suprapubic cystostomy is also recommended for penetrating injuries to the anterior urethra if the injuries were caused by high-velocity weapons and are characterized by extensive tissue loss; if serious associated injuries are present; or if bony fractures prevent proper placement of the patient in the lithotomy position.

**Posterior Urethra**

Posterior urethral (prostatic and membranous urethral) injuries can be managed with suprapubic cystostomy or early primary urethral realignment. Realignment without sutured repair renders definitive reconstruction unnecessary in a significant percentage of patients.\(^\text{52}\) Bladder neck injury and wide separation of the bladder from the urethra warrant immediate surgical intervention.\(^\text{53}\) Simultaneous rectal injury often occurs in this setting and necessitates evacuation of the pelvic hematoma, irrigation, placement of drains, and primary realignment of the urethra. Primary realignment is also preferred in cases of open reduction and internal fixation of pelvic fractures because the risk of hardware contamination is considered to be lower with a urethral catheter than with suprapubic cystostomy.\(^\text{54}\)

Primary realignment is usually performed through a lower midline abdominal incision, which allows antegrade passage of instruments through the bladder at the same time as retrograde passage of instruments from the urethral meatus. Flexible cystoscopes or magnetic-tipped catheters advanced under fluoroscopic guidance are used to place a wire into the bladder beyond the injury, and a Council-tip Foley catheter is then advanced over the wire. Neither mucosal approximation nor direct anastomosis is the goal. Suprapubic catheter drainage is not required, but a perivesical drain should be left in place for 48 hours.

**Patient presents with trauma suggestive of bladder injury**

Perform retrograde plain-film cystography or CT cystography with adequate bladder filling.
Perform retrograde urethrography if there are signs of urethral injury.

**Patient has intraperitoneal rupture or penetrating injury**

Assess for contraindications to conservative management: urinary tract infection, bony fragments in the bladder, bladder neck injury, female genital lacerations from pelvic fracture, and requirement for laparotomy for associated injuries.

**Patient has extraperitoneal rupture from blunt trauma**

Explore bladder via intraperitoneal or extraperitoneal approach.
Repair injuries from inside bladder.
Close bladder in two layers.
Provide adequate urinary drainage.

**Conservative management is contraindicated**

Remove perivesical drain when output is low.
Obtain follow-up cystogram at 7–10 days.
Remove catheters when there is no extravasation.

**No contraindications to conservative management are present**

Manage with large-bore catheter drainage for 10 days.

**Figure 11** Algorithm outlines the management of bladder injury.
Injuries to the Urogenital Tract — 11

Postintervention Care

Catheter care is of great importance after urethral reconstruction or suprapubic cystostomy. Urethral catheters should be secured to the abdominal wall in the early postoperative period. After immediate reconstruction of the anterior urethra, the Foley catheter should remain in place for 3 weeks, at which time a contrast voiding cystourethrogram should be obtained. If extravasation is present, the catheter should be replaced for 1 week and the study repeated. After primary realignment of urethral injuries, the urethral catheter is left in place for 6 weeks, at which time a percutaneous retrograde urethrogram is obtained, with the expectation that any extravasation will have resolved.

If the patients initially underwent diversion with a suprapubic tube alone, the tube should be changed after a tract has formed (usually about 4 weeks after the procedure) and then monthly until reconstruction can be performed. Stricture formation or complete obliteration of the urethra may be the final result of this nonoperative approach. Subsequent radiographic studies will indicate whether secondary endoscopic or open procedures are needed.

Injuries to the Vagina, Uterus, and Ovaries

Injuries to the female genitalia [see Table 4 and Figure 15] must be regarded as especially morbid because of their association with sexual assault and interpersonal violence, as well as because of the potential medical complications (infection and bleeding). Genital trauma is reported in 20% to 53% of sexual assault victims.57,58 Blunt unintentional trauma, including pelvic fracture and straddle injuries, often results in perineal and vaginal injuries and, less commonly, cervical and uterine trauma.59-61 Enlargement of a reproductive organ predisposes that organ to injury.62 Penetrating
injuries account for almost all injuries to the fallopian tubes, the ovaries, and the nongravid uterus.\textsuperscript{63}

**INITIAL EVALUATION**

A history of sexual trauma must be sought; if such a history is elicited, appropriate police and support services must be notified.\textsuperscript{64} In addition, if sexual assault has occurred, informed consent for the rest of the patient assessment must be obtained. This assessment includes a history, physical examination, collection of evidence and laboratory specimens, and treatment, as outlined by the American College of Obstetricians and Gynecologists.\textsuperscript{65} The percentage of assault victims with identifiable spermatozoa in the vaginal specimens is lower than 50%.\textsuperscript{66}

All female patients with evidence of lower urinary tract and urethral injury should undergo examination of the external genitalia, as well as speculum examination of internal organs. The finding of blood implies vaginal laceration. In the presence of pelvic fracture or impalement injury, vaginal laceration warrants complete evaluation (with cystourethrography, proctoscopy, and laparotomy, as indicated) to rule out associated urinary tract and GI tract injuries. Failure to identify vaginal injury associated with pelvic fracture may lead to abscess formation, sepsis, and death.

**MANAGEMENT**

Perineal lacerations in the absence of associated urinary tract and rectal injury can be managed in the emergency department. Only large hematomas must be incised and drained, with ligation of vessels. Lacerations of the vulva may be closed primarily after irrigation and debridement. Interrupted absorbable sutures allow any accumulated fluid to drain and eliminate the need for suture removal. Drains are used if there is a large cavity; if hemostasis is suboptimal, the wound may be packed.\textsuperscript{67}

Vaginal and cervical lacerations from either blunt or penetrating injury will bleed extensively if the pudendal vessels are injured.\textsuperscript{68} If bleeding is not severe, examination and repair with local anesthesia is possible in the ED. If large lacerations are associated with bleeding and hematoma, speculum examination under anesthesia permits more complete assessment and repair of injuries. Vaginal lacerations should be closed with continuous or interrupted absorbable sutures that include mucosal and muscular layers. Antibiotic-soaked vaginal packing should be left in place for 24 hours. Perioperative administration of broad-spectrum antibiotics is sufficient, unless injuries are more complex.

Complex vaginal and perineal lacerations associated with pelvic fracture must be managed much more aggressively to prevent the morbidity and mortality characteristic of open fractures.\textsuperscript{69} Evaluation of vaginal injuries with the patient under anesthesia, cystography, and rigid proctoscopy are mandatory. The vaginal laceration should be closed with absorbable sutures. Even in the absence of injury to the bladder or the rectum, diversion of the urinary and fecal streams should be considered to facilitate care of the perineal wound;\textsuperscript{67} however, I rarely divert the fecal stream unless the perineal injury extensively involves the rectum or the sphincter.\textsuperscript{68} Extraperitoneal bladder rupture associated with vaginal lacerations must be repaired operatively to prevent infection of a pelvic hematoma or formation of a vesicovaginal fistula. Urologic, gynecologic, and orthopedic consultations are necessary for care of associated injuries.

Injury to the pelvic genital organs is rare in a nongravid patient. Penetrating trauma is the most common cause, and the majority of patients have associated injuries necessitating laparotomy.\textsuperscript{62} Blunt injury of the nongravid uterus and the pelvic organs occurs in the face of preexisting abnormalities; DPL demonstrates hemoperitoneum in these instances.\textsuperscript{63} The uterus, the organ most commonly injured, is repaired with figure-eight sutures or a two-layer closure using slowly absorbable sutures.\textsuperscript{62} Avulsion of the uterine artery or extensive blast destruction of the uterus may necessitate hysterectomy.\textsuperscript{61} When hysterectomy is necessary for trauma, the vaginal cuff should be left open to allow drainage of the operative bed.\textsuperscript{69} Lacerations to the ovary or the fallopian tube are managed by primary closure or salpingo-oophorectomy if contralateral structures are normal.

After hysterectomy or repair of vaginal lacerations, a vaginal pack should remain in place for 24 hours. Hemorrhage caused by uterine injury has been treated with oxytocin, which increases uterine tone and controls bleeding. Fertility after injury to the female reproductive organs is not well documented, but patients must be counseled about the possible adverse consequences of uterine and adnexal trauma.

**Table 3**  Management of Urethral Trauma

<table>
<thead>
<tr>
<th>Location of Injury</th>
<th>Mechanism of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior (prostatic and membranous urethra)</td>
<td>Realignment or suprapubic cystostomy</td>
</tr>
<tr>
<td>Anterior (bulbar and penile urethra)</td>
<td>Suprapubic cystostomy</td>
</tr>
</tbody>
</table>
Injuries to the Penis

Injury to the flaccid penis is rare, occurring mainly as a result of penetrating trauma and machinery accidents.\textsuperscript{56,70,71} The increased use of protective armor on the torso has caused a shift in battlefield urologic injuries from renal structures to pelvic and genital organs.\textsuperscript{72} Penile fracture is an uncommon injury of the tunica albuginea that occurs only with full penile rigidity.\textsuperscript{73-75} Prompt operative treatment allows recovery of erectile function after most penile injuries \textbf{[see Table 5]}. Remarkably, in many cases, penile replantation successfully restores erectile capability.

**INITIAL EVALUATION**

Missed intromission, acute bending of the penis, and a snapping or popping sound followed by acute pain and immediate detumescence are characteristic of penile fracture. Delayed presentation, attributable to embarrassment, is common. Penetrating injuries to the penis may result from deliberate attempts at mutilation, as well as from accidental firearm injury (typically occurring when a

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**Table 4  AAST Organ Injury Scales for Female Reproductive Tract**

<table>
<thead>
<tr>
<th>Injured Structure</th>
<th>AAST Grade</th>
<th>Characteristics of Injury</th>
<th>AIS-90 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vagina*</td>
<td>I</td>
<td>Contusion or hematoma</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Superficial laceration (mucosa only)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Deep laceration (into fat or muscle)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Complex laceration (into cervix or peritoneum)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Injury to adjacent organs (anus, rectum, urethra, bladder)</td>
<td>3</td>
</tr>
<tr>
<td>Vulva*</td>
<td>I</td>
<td>Contusion or hematoma</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Superficial laceration (skin only)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Deep laceration (into fat or muscle)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Avulsion (skin, fat, or muscle)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Injury to adjacent organs (anus, rectum, urethra, bladder)</td>
<td>3</td>
</tr>
<tr>
<td>Nongravid uterus*</td>
<td>I</td>
<td>Contusion or hematoma</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Superficial laceration (&lt; 1 cm)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Deep laceration (≥ 1 cm)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Laceration involving uterine artery</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Avulsion or devascularization</td>
<td>3</td>
</tr>
<tr>
<td>Fallopian tube†</td>
<td>I</td>
<td>Hematoma or contusion</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Laceration &lt; 50% of circumference</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Laceration ≥ 50% of circumference</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Transection</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Vascular injury or devascularized segment</td>
<td>2</td>
</tr>
<tr>
<td>Ovary†</td>
<td>I</td>
<td>Contusion or hematoma</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Superficial laceration (depth &lt; 0.5 cm)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Deep laceration (depth ≥ 0.5 cm)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Partial disruption of blood supply</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Avulsion or complete parenchymal destruction</td>
<td>3</td>
</tr>
<tr>
<td>Gravid uterus*</td>
<td>I</td>
<td>Contusion or hematoma (without placental abruption)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Superficial laceration (&lt; 1 cm) or partial placental abruption (&lt; 25%)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Deep laceration (≥ 1 cm) in second trimester or placental abruption &gt; 25% but &lt; 50%; deep laceration in third trimester</td>
<td>3; 4</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Laceration involving uterine artery; deep laceration (≥ 1 cm) with &gt; 50% placental abruption</td>
<td>4; 4</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Uterine rupture in second trimester; uterine rupture in third trimester; complete placental abruption</td>
<td>4; 5; 4-5</td>
</tr>
</tbody>
</table>

\textsuperscript{*Advance one grade for multiple injuries, up to grade III.  
\textsuperscript{†}Advance one grade for bilateral injuries, up to grade III.
thral, scrotal, bladder, and rectal injuries must be excluded. Amputation is a catastrophic event. Proper preservation of the amputated organ is critical for successful restoration of function. The amputated part should be placed on saline-soaked gauze inside a clean bag, which should then be sealed and placed inside a second bag containing ice slush. Cold ischemia times longer than 24 hours are acceptable and allow transport of the patient to tertiary centers, where replantation can be performed. Even at normal temperatures, replantation 16 hours after injury has been successful. Microsurgical repair techniques have certain advantages, including better preservation of the penile shaft skin and the possibility of a sensate glans and normal orgasmic function. However, astonishing results have also been reported with the conventional technique of corporal reattachment without microvascular reanastomosis of the dorsal neurovascular structures.

**MANAGEMENT**

A circumferential subcoronal incision provides exposure after penile fracture and most penetrating injuries of the shaft and permits corporal and urethral repair. The superficial layers and skin are bluntly degloved back to the base of the penis. For deeper injuries, proximal to the suspensory ligament or in the crura, a penoscrotal or perineal incision is required to provide access to the corpus cavernosum. Rupture of the corpus cavernosum as a result of a fracture, a stab wound, or a bullet wound is signaled by the presence of active bleeding and a defect in the fibrous tunica albuginea. Careful exploration and inspection of the corpus spongiosum are mandatory, even if urethrography shows no extravasation. Tunical ruptures caused by fracture are transversely oriented and sometimes extend behind the spongiosum; this structure may have to be mobilized and retracted for adequate visualization of the injury.

The tunica albuginea is closed with interrupted 3-0 slowly absorbable sutures. Debridement and curettage have occasionally been used in this setting but generally are reserved for late presentations. Skin closure is possible with most penetrating injuries to the penis. The extensive vascular supply to the skin is rarely compromised. Interrupted chromic sutures provide a cosmetic closure and allow drainage of residual blood between the sutures. A lightly compressive dressing is sufficient; tight wraps are to be avoided because they may lead to necrosis of swollen shaft skin. Catheter drainage is mandatory if urethral injury is present. Sexual intercourse is contraindicated for 1 month after penile injury.

**Penile Amputation**

Microsurgical replantation differs from simple corporal reattachment in that the neurovascular structures are reanastomosed in addition to the urethra and the tunica albuginea. With corporal reattachment, a spatulated end-to-end urethral anastomosis is performed with interrupted absorbable sutures over a urethral catheter. The adventitia of the corpus spongiosum is reapproximated in a second layer, and the tunica albuginea and its septum are then connected. The restored cavernosal 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 microsurgical techniques are available, the dorsal nerves, the dorsal arteries, and the deep dorsal vein are each reanastomosed in a second layer, and the tunica albuginea and its septum are then connected. Temporary ectopic replantation of the penis has been described in cases where the perineum is heavily contaminated or too extensively damaged for immediate replantation. Postoperative care includes urinary diversion, bed rest, anticoagulation (in selected cases where the perineum is heavily contaminated or too extensively damaged for immediate replantation).
cases), hydration, and monitoring of arterial flow in the distal penis.

**Table 5  AAST Organ Injury Scales for Male Genitalia**

<table>
<thead>
<tr>
<th>Injured Structure</th>
<th>AAST Grade</th>
<th>Characteristics of Injury</th>
<th>AIS-90 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrotum</td>
<td>I</td>
<td>Contusion</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Laceration &lt; 25% of scrotal diameter</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Laceration ≥ 25% of scrotal diameter</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Avulsion &lt; 50%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Avulsion ≥ 50%</td>
<td>2</td>
</tr>
<tr>
<td>Testis*</td>
<td>I</td>
<td>Contusion or hematoma</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Subclinical laceration of tunica albuginea</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Laceration of tunica albuginea with &lt; 50% parenchymal loss</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Major laceration of tunica albuginea with ≥ 50% parenchymal loss</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Total testicular destruction or avulsion</td>
<td>2</td>
</tr>
<tr>
<td>Penis†</td>
<td>I</td>
<td>Cutaneous laceration or contusion</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Laceration of Buck’s fascia (cavernosum) without tissue loss</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Cutaneous avulsion, laceration through glans or meatus, or cavernosal or urethral defect &lt; 2 cm</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Partial penectomy or cavernosal or urethral defect ≥ 2 cm</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>Total penectomy</td>
<td>3</td>
</tr>
</tbody>
</table>

*Advance one grade for bilateral injuries, up to grade III.
†Advance one grade for multiple injuries, up to grade III.

**Injuries to the Scrotum and Testes**

**INITIAL EVALUATION**

Scrotal trauma may result in testicular injury or genital skin loss [see Table 5]. Because blunt injuries to the testicle are difficult to recognize, high-resolution ultrasonography has become a key element in the evaluation of scrotal trauma [see Figure 17]. When a straddle injury or penetrating mechanism suggests the possibility of urethral injury, retrograde urethrography is indicated.

Penetrating scrotal injuries commonly involve not only the testis but also the corpora cavernosa, the urethra, and the spermatic cord. Ultrasonography is useful to ascertain the integrity of the arterial inflow to the testis.80 The excellent blood supply of the scrotal skin allows most penetrating injuries to be debrided and closed. Even simple bite injuries can be irrigated and closed with appropriate antibiotic coverage. Exceptions to this general rule include complex contaminated human and animal bites, which are left open and are treated with intravenous antibiotics and local wound care (or debridement in cases of severe soft tissue infection).81

Rupture of the testicle is often immediately painful, with rapid onset of swelling. Falls, straddle injuries, and direct blows are common mechanisms of injury.82 However, seemingly minor degrees of trauma may be associated with delayed onset of pain; in this scenario, testicular torsion must be included in the differential diagnosis. Physical signs of rupture include scrotal swelling, tenderness, and ecchymosis. Injury to the scrotal wall or the tunica vaginalis may cause significant swelling without rupture of the tunica albuginea of the testis; pelvic hematoma caused by fracture can result in massive scrotal swelling. For these reasons, blunt injury to the scrotum should be evaluated by ultrasonography unless the findings from the physical examination are normal.

The ultrasonographic characteristics of testicular rupture [see Figure 18] include loss of normal homogeneity of the testicular

*Figure 16  Shown is a case of penile fracture. A linear tear in the tunica albuginea can be seen (arrow).
Trauma and thermal injury

Injuries to the urogenital tract — 16

Patient presents with injury to scrotum

Obtain retrograde urethrogram to rule out urethral injury if indicated.

Injury is penetrating

Perform scrotal ultrasonography.

Evidence of rupture is seen

Explore scrotum through vertical incision. Extend any penetrating lacerations. Debride devitalized scrotal skin.

No evidence of rupture is seen

Manage conservatively with ice, analgesia, and elevation.

Patient has testicular injury

Patient has spermatic cord injury

Testis is viable


Testis is not viable

If vas is injured, debride both ends and ligate with nonabsorbable suture. Ligate bleeding vessels. Extend incision cephalad as needed.

Testis is viable

If vas is injured, debride both ends and ligate with nonabsorbable suture. Ligate bleeding vessels. Extend incision cephalad as needed.

Testis is not viable

Perform orchiectomy. Ligate vas and vessels separately.

Figure 17  Algorithm outlines management of injury to the scrotum or testes.

Figure 18  (a) Ultrasonogram of ruptured testes shows intraparenchymal hematoma and heterogeneous echotexture. (b) Ultrasonogram of ruptured testes shows indistinct testicular contour and abnormal echotexture.
the mechanism, as when clothing and skin are caught in a power takeoff, this approach is not recommended. The intrinsic microvasculature of the skin is probably damaged. Scrotal skin loss caused by burns or electrical or mechanical injury usually spares the testis, which has a separate blood supply. Conservative debridement is possible if there is no infection, but the demarcation between viable and nonviable tissue should be identified before extensive debridement. Management depends on the amount of skin remaining. Options include primary closure, immediate coverage with meshed split-thickness skin grafts, and placement of the testes in subcutaneous pouches in the thigh.

References

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84. Wessells H: Genital skin loss: unified reconstructive approach to a heterogeneous entity. World J Urol 17:107, 1999

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