Urologic trauma guidelines: a 21st century update

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Abstract | Trauma is the leading cause of death between the ages of 1 and 44 years in the USA. While stabilization of life-threatening injuries is the primary goal in the evaluation of all trauma patients, subsequent diagnosis and treatment of secondary injuries are requirements for good trauma care. The genitourinary system is involved in 10% of trauma cases, and these injuries can be associated with considerable morbidity and mortality. Accordingly, physicians involved in the initial evaluation and subsequent management of trauma patients should be aware of the diagnosis and treatment of injuries that can occur in the genitourinary system. In 2009, the European Association of Urology provided specific recommendations for the evaluation, diagnosis and management of genitourinary trauma. Here, we review and discuss these recommendations in order to provide a concise summary for clinicians involved in the evaluation and management of trauma patients and their associated genitourinary injuries.

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Learning objectives

Upon completion of this activity, participants should be able to:

1 Describe recommendations in regard to management of kidney injuries on the basis of a review of 2009 guidelines from the European Association of Urology.
2 Describe recommendations in regard to management of ureteral and bladder injuries, on the basis of that review.
3 Describe recommendations in regard to management of urethral and external genital injuries, on the basis of that review.

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Introduction

In the USA, trauma is the number one cause of death in people aged 1–44 years, and accounts for over 120,000 total deaths per year.[1] The genitourinary system is involved in approximately 10% of all traumatic injuries, with the kidney the most frequently involved organ.

Competing interests
The authors, the journal Chief Editor S. Farley and the CME questions author L. Barclay declare no competing interests.

Initial evaluation of genitourinary trauma patients requires the separation of life-threatening injuries from those that can be stabilized and treated later.

The cause of injury will often influence the management strategy. Most genitourinary trauma can be categorized as either blunt or penetrating (although iatrogenic injuries also occur). In penetrating gunshot injuries, for example, the caliber of the bullet should be noted. Low-velocity bullets cause a small "permanent cavity" type injury, and the energy transmitted to the tissue along the projectile path is much less than with high-velocity bullets, which may induce extensive damage to the surrounding tissue.[2]

Urologists are often included in the evaluation of genitourinary injuries. However, all physicians involved in the initial evaluation and subsequent management of trauma patients should be aware of the diagnosis and treatment of injuries that can occur in the genitourinary system. In 2009, the European Association of Urology provided specific recommendations for the evaluation, diagnosis and management of genitourinary trauma.[3] In the following sections, we review and discuss these recommendations in order to provide a concise summary for clinicians involved in the management of trauma patients and their associated genitourinary injuries.

Renal trauma

The kidney is the most commonly injured genitourinary organ, and is involved in about 1–5% of all trauma patients.[4,5] While renal injury can lead to considerable morbidity and mortality, advances in imaging and treatment strategies have led to increased renal salvage and a decreased need for surgery in the majority of renal trauma cases.[6–8]

Diagnosis

Patient history and examination

In blunt force injuries, an important part of history taking is the extent of deceleration involved. Rapid deceleration can result in renal artery thrombosis, renal vein disruption or renal pedicle avulsion. A seatbelt, steering wheel or airbag may compress the renal artery between the abdominal wall and spine, resulting in thrombosis.

Patients with pre-existing renal abnormalities may be at an increased risk for injury, and a history of ureteropelvic junction obstruction, renal tumor, cyst or calculi or solitary kidney may complicate a minor injury.[9,10] While nephrectomy may be a life-saving maneuver in a trauma patient, a solitary kidney should always be recognized prior to its removal.

Hemodynamic stability should be noted and used to guide future management. Patients with shock (systolic blood pressure <90 mmHg) are followed closely. Abdominal distension, palpable mass, flank abrasions and flank ecchymoses should be noted. Bullet entry and exit wounds should be identified and the trajectory of the bullet considered. Stab injuries can appear small, but may penetrate deep into the abdominal cavity.

Hematuria is a hallmark of renal trauma, but does not always correlate with the degree of injury;[11] indeed, more-serious injuries, such as renal pedicle injuries, arterial thrombosis or disruption of the ureteropelvic junction, can occur without any hematuria.[12] A urine dipstick is a rapid and reliable test to screen for microscopic hematuria; however, false-negative findings do occur in approximately 3–10% of cases.[13]

Serial hemoglobin level and hematocrit are important markers of blood loss and guide management strategies. A low hematocrit, especially in the presence of shock, implies the need for rapid resuscitation. Response to initial resuscitation and need for transfusion should be recorded. An initially elevated creatinine level usually suggests pre-existing renal pathology.

Imaging

CT with intravenous contrast is the gold standard for radiographic diagnosis of stable patients with suspected renal injuries. CT can define the location of the injury, identify renal contusions and devitalized segments, and allow visualization of the entire retroperitoneum and abdominal organs. A pedicle injury is diagnosed by a lack of contrast enhancement of the kidney (Figure 1) or a central parahilar hematoma. A large medial hematoma displacing the renal vasculature suggests a venous injury. CT angiography provides assessment of the renal vasculature. Images taken at a 10–15 min delay will allow visualization of the renal collecting system and diagnosis of renal pelvis and ureteral injuries. Renal pelvis injuries may be indicated by contrast extravasation just medial to the renal hilum (Figure 2).

Not all patients with suspected renal injury need to undergo CT. This is particularly important in light of recent concerns that CT may cause secondary cancers, especially in children.[14] In one of the few prospective studies performed in the field of genitourinary trauma,

Key points

- The genitourinary system is involved in 10% of all trauma cases
- The kidney is the most commonly injured abdominal organ in cases of trauma, but most injuries are managed nonoperatively
- Ureteral injuries are often iatrogenic; diagnosis requires high clinical suspicion and site-specific repair
- Bladder injuries are associated with pelvic fractures, which may be life threatening; extraperitoneal injuries can be managed with catheter drainage, while intraperitoneal injuries require open repair
- Catheter realignment can be successful in patients with urethral injuries; posterior distraction defects require delayed primary urethroplasty, while open anterior injuries require immediate exploration and primary repair
- External genital injuries can be diagnosed by history and physical examination; emergent exploration and repair is indicated in cases with marked hematoma, penile fracture or testicular disruption

Figure 1 | Abdominal CT with intravenous contrast. Lack of contrast enhancement of the right kidney when compared to the left suggests a right renal pedicle injury.

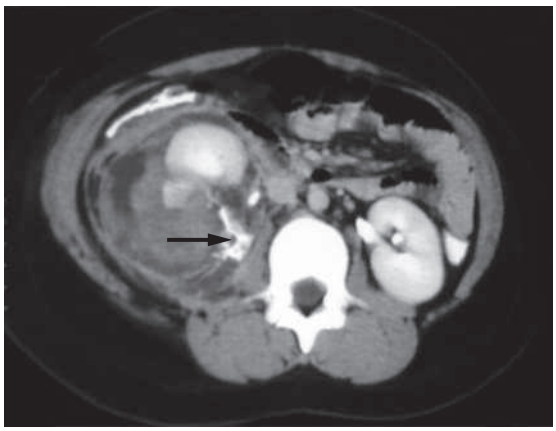

Figure 2 | Abdominal CT with intravenous contrast. Medial extravasation (arrow) of contrast medium signifies a right renal pelvis injury.

Mee *et al.*[15] showed that in patients with blunt, non-deceleration trauma, microscopic hematuria and no shock, the incidence of renal injury is low and imaging can be withheld. If microscopic hematuria—or any degree of gross hematuria—and shock are present, renal imaging should be performed. In patients with rapid deceleration injuries, imaging should be performed in order to rule

out ureteral avulsion or renal pedicle injury.[16] In cases of penetrating trauma with a relevant wound site, imaging should be performed regardless of hematuria status.[17] Hematuria in children can be managed like hematuria in adults;[18] however, hypotension may not occur even in those with life-threatening blood loss, so vigilance in the evaluation of the injured child is essential.

Ultrasonography is seldom used as the primary imaging technique in the USA. This modality may be useful in determining which patients need further imaging with CT, and may eliminate unnecessary scans. Currently, it is best used for serial evaluation of stable injuries, or after urinoma or retroperitoneal hematoma.[19]

Intravenous pyelography (IVP) is no longer the preferred modality in renal trauma patients, but may be the only study available in some areas. IVP can establish the presence or absence of the kidneys, define the parenchyma and outline the collecting system. Nonvisualization, contour deformity or extravasation of contrast medium should lead to further evaluation with CT, if available. Nonvisualization or nonfunction of a kidney usually indicates severe trauma to the kidney, such as pedicle injury or shattered kidney. Extravasation implies trauma involving the capsule, parenchyma or collecting system.

In unstable patients who have to go immediately to the operating room, a one-shot intraoperative IVP on the table can be performed. A single plain film is taken 10 min after injection of 2 ml/kg contrast medium. This can provide useful information on a suspected injury, as well as determining the functional status of the contralateral kidney.[20] We find one-shot IVP particularly helpful in identifying easy-to-miss ureteral injuries.

MRI and angiography are lesser used modalities in the initial evaluation of renal trauma patients. MRI is used in patients with an iodine allergy, if CT is not available, or in rare cases when CT findings are equivocal.[21] The most common indication for angiography is nonvisualization of the kidney on IVP when CT is not available. It is also the test of choice for the evaluation of renal venous injuries.

As in all genitourinary systems, the American Association for the Surgery of Trauma (AAST) has developed a grading system for renal trauma, which should be used both in clinical and research settings.[22]

Management

The two absolute indications for surgery in renal trauma patients are life-threatening renal hemorrhage with hemodynamic instability, or an expanding or pulsatile perirenal hematoma identified intraoperatively.[23,24] The latter signifies a grade V vascular injury. Relative indications include persistent bleeding and suspected renal pelvis or ureteral injury.

For major injuries causing urinary extravasation or devitalized renal fragments, an initial conservative approach may be taken.[25] Most injuries will heal with nonoperative treatment, but there can be an increased rate of complications and late surgery.[26,27] In cases of persistent extravasation or urinoma, management is usually successful with ureteral stenting or nephrostomy tube placement.

Surgical management

Operative exploration, with the aim of hemorrhage control and renal salvage, is required in a minority of renal trauma patients.[24] Surgery should be performed using a transperitoneal approach with vascular control achieved prior to opening the Gerota's fascia.[28–30] The renal vasculature is accessed through the posterior parietal peritoneum, incising over the aorta and medial to the inferior mesenteric vein.

Renorrhaphy is the preferred technique for renal reconstruction. If a polar injury occurs or if nonviable tissue is present, a partial nephrectomy may be necessary. Watertight closure of the collecting system is recommended, but simple closure of the parenchyma over the collecting system can be successful as well. An omental pedicle flap or perirenal fat bolster can be used in the case of renal capsule injury.[31] We recommend placement of a retroperitoneal drain.

Nephrectomy is required in about 13% of renal trauma patients, although we believe that a strict nonoperative approach, as discussed below, can decrease this percentage dramatically. Those patients who need to undergo nephrectomy generally have a penetrating injury, an increased need for transfusion, hemodynamic compromise, high injury severity scores and associated intra-abdominal injuries.[32,33] Mortality is higher in patients who require nephrectomy, but deaths are usually the result of the associated injuries rather than the renal trauma alone.[34] Grade V renovascular injuries are generally treated with nephrectomy, though repair may be attempted in cases of solitary kidney or bilateral injury.[35] Arteriography with selective embolization can be considered in these cases; however, the results can be poor in patients with grade V injuries.[36] Segmental arterial injury can be managed nonoperatively with good results.[37]

Nonsurgical management

Conservative management is the treatment of choice for the majority of patients with renal injuries. It has a low failure rate (1%) and may ultimately save kidneys and reduce the number of renal units that might otherwise be lost iatrogenically during attempted repair.[6] We use a nonoperative management approach in all patients who are not exsanguinating from the kidney, which results in a lower nephrectomy rate without increasing morbidity or mortality. Even patients with urinary extravasation and solitary injuries can be managed expectantly, with a resolution rate of more than 90%.[38]

"Ultraconservative" treatment of renal trauma has not been well defined in the literature. We define it as a combination of imaging parameters limited to those described in Mee and colleagues' seminal 1989 prospective study,[15] and limiting renal surgery only to those patients who are exsanguinating from the kidney or who have renal pelvis or ureteral injuries.[39] First, imaging is reserved only for patients with gross hematuria, microscopic hematuria with concomitant shock

or significant deceleration injury. Second, nonoperative management is always performed if the patient is hemodynamically stable, responds favorably to less than two units of blood transfusion, and when imaging does not show any lesion that requires surgery (for example, ureteral injuries and grade V vascular injuries). Finally, exploratory laparotomy for other abdominal injuries in patients with renal injuries that do not require surgery should not necessarily include retroperitoneal or renal exploration.

Even patients with penetrating renal trauma (Figure 3) can be managed conservatively. Surgical exploration should be performed if the injury involves the hilum, or if continued bleeding, ureteral injuries or pelvic lacerations are present.[40] Low-velocity gunshot and stab wounds in stable patients have good outcomes when managed with a nonoperative approach, but tissue damage resulting from high-velocity gunshot injuries may necessitate exploration and nephrectomy.[41] The site of penetration can also help determine management decisions: for example, 88% of stab wounds posterior to the anterior axillary line can be managed nonoperatively.[42]

The necessity of follow-up CT in patients managed conservatively is controversial, but relative indications include fever, increased pain or persistent bleeding. We seldom perform serial CT in patients after injury unless their condition deteriorates.

Complications

Delayed retroperitoneal bleeding can occur within several weeks of the injury, and is managed with selective angiographic embolization.[43] Perinephric abscess formation can be managed with percutaneous drainage, which has a lower rate of renal loss than open reoperation and drainage.[24] Hypertension after renal trauma is estimated to occur in less than 5% of patients,[44,45] and is caused acutely by external compression from a perirenal hematoma (Page kidney) or chronically as a result of compressive scar formation (Goldblatt kidney). Treatment includes pharmacological management, excision of ischemic parenchyma, vascular reconstruction, or nephrectomy.[46]

Urinary extravasation usually resolves over time unless obstruction or infection is present. Persistent extravasation usually responds well to stent placement or nephrostomy drainage.[27] Delayed onset of marked hematuria after penetrating trauma most often indicates the presence of arteriovenous fistula. Percutaneous embolization is often successful in these instances, but surgery may be required to repair large fistulas.[47]

Ureteral trauma

Trauma to the ureter is rare, accounting for only 1% of all urinary tract traumas. Ureteral injuries are most likely to occur iatrogenically: in a review of 452 ureteral injuries, 75% were iatrogenic, whereas blunt and penetrating trauma accounted for 18% and 7% of injuries, respectively. Gynecological procedures accounted for 73% of the iatrogenic injuries, followed by general surgical (14%) and urological (14%) procedures. The lower third of the ureter was much more commonly injured (74%) compared to the upper and middle thirds (13% each).[48]

Figure 3 | Abdominal CT of a patient with a penetrating injury of the right kidney. Laceration extends through the parenchyma but does not seem to involve the renal pelvis or vasculature. Conservative management may be attempted in a hemodynamically stable patient, even in cases of penetrating trauma with considerable parenchymal injury.

Diagnosis

As there are no classic symptoms and signs associated with ureteral trauma, the diagnosis is usually based on clinical suspicion.[49] Hematuria is a poor indicator of ureteral injury, being present in only half of all cases.[50] Physicians should suspect ureteral injury in patients with upper urinary tract obstruction, urinary fistula formation, or sepsis after surgery or traumatic injury.[51] During surgery, direct observation of the injury, one-shot intraoperative IVP or extravasation of intravenous dye (such as methylene blue or indigo carmine) may identify the site of injury.

CT is the most frequently used diagnostic modality in this setting, owing to its prevalent general use in trauma patients. Extravasation of radiological contrast medium or unilateral nonvisualization of the ureter confirms the diagnosis.[49,52] If CT is nondiagnostic and the suspicion is high for ureteral injury, a kidneys, ureters and bladder (KUB) radiograph taken 30 min after contrast injection can reveal extravasation. If still inconclusive, retrograde pyelography can definitively diagnose or rule out ureteral injury (Figure 4).

Management

Ureteral injuries are classified based on their severity. Grade I–II injuries can be managed with placement of ureteral stents or nephrostomy tubes. Stenting allows secure drainage of the kidney and provides canalization and stabilization of the injury, and is also believed to reduce the risk of subsequent stricture, although data supporting this are currently lacking.

Grade III–IV injuries should be repaired directly, using the following principles: judicious debridement of ureteral ends to healthy tissue; spatulation of ureteral ends; placement of internal stent; watertight ureteral closure

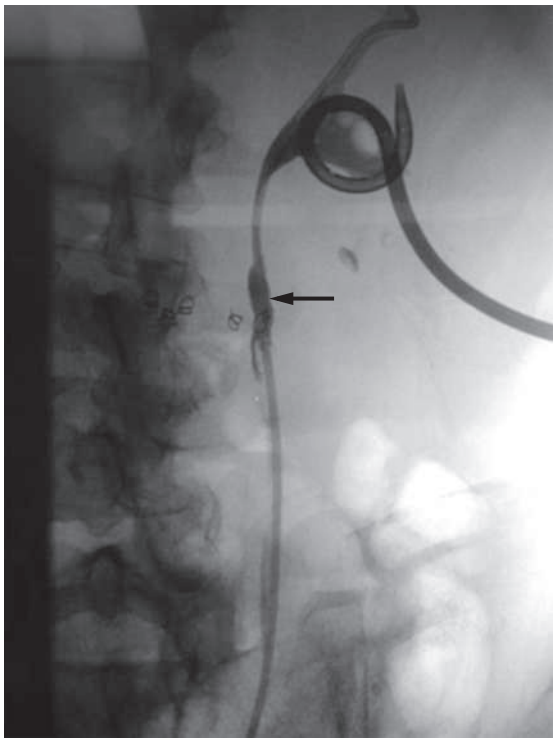

Figure 4 | Retrograde pyelography of a patient with suspected left ureteral injury. A ureteral catheter and nephrostomy tube are in place. An irregularity (arrow) at the level of the ureteropelvic junction is noted in the area of surgical clips, but there is no extravasation of contrast medium.

with absorbable interrupted suture; placement of external drain; and isolation of injury with peritoneum or omentum. The type of repair performed depends on the location of injury (Table 1).

Postoperative care typically includes removing the bladder catheter after 2 days and the wound drain 2 days later if drainage is low. The stent can be removed after 6 weeks, with follow-up IVP or renography performed after 3 months to assess the patency of the repair. Stricture formation should be recognized and treated with endourological or open surgical techniques.

Bladder trauma

Blunt trauma is responsible for the majority (67–86%) of bladder injuries, with penetrating trauma accounting for 14–33%.[53–55] Motor vehicle accidents are the cause in 90% of cases.[56,57] Bladder injuries are associated with pelvic fracture in up to 97% of cases, and more than 50% of the associated fractures involve the pubic ramus.[55,58–60] Up to 30% of patients with pelvic fractures will have some degree of bladder injury.[61] High-risk pelvic fractures include those with pubic arch involvement, gross hematuria and/or hemodynamic instability.[62] 25% of intraperitoneal bladder ruptures occur in patients without a pelvic fracture.[57] A bladder that is empty is rarely injured unless by direct penetrating or crushing injuries, but a fully distended bladder may rupture with only a relatively light blow.

Bladder injury is classified as either extraperitoneal or intraperitoneal. Combined rupture may occur in 2–20% of cases.[57,63–65] Extraperitoneal injury is associated with leakage of urine within the perivesical space, whereas intraperitoneal injury involves disruption of the peritoneal surface with urinary extravasation.

Most iatrogenic bladder injuries occur during obstetric and gynecological procedures (52–61%), followed by urological (12–39%) and general surgical (9–26%) procedures.[66,67] Injuries are frequently identified using cystoscopy; when not performed, an underestimation of injury occurs.[68]

Diagnosis

The most common symptoms of major bladder injury are gross hematuria (82%) and abdominal tenderness (62%).[55] Suprapubic bruising, abdominal distension and voiding problems occur less frequently.[56] Urinary extravasation may cause delayed swelling of the perineum, scrotum, thighs or anterior abdominal wall.

The combination of pelvic fracture and gross hematuria strongly predicts bladder rupture, and is an absolute indication for immediate cystography in patients with blunt trauma.[55,57,61,69] Clear urine and no pelvic fracture almost eliminates the possibility of bladder rupture; however, 2–10% of ruptures may result in only microscopic hematuria or no hematuria.[56,70]

Retrograde cystography provides an accurate diagnosis in 85–100% of bladder rupture cases.[56,57,61,71] A plain film, bladder-filled film, and post-drainage films are required, and half-filled and oblique films may also be useful. Filling with a minimum of 350 ml of contrast medium is needed to obtain the highest diagnostic accuracy. The post-emptying film will be the diagnostic image in about 10% of cases.[57]

CT cystography can be used instead of conventional cystography for diagnosing bladder injury with 95% sensitivity and 100% specificity.[72] Again, the procedure must be performed using retrograde filling of at least 350 ml of dilute contrast medium[57,73] for adequate diagnosis.

Management

Catheter drainage of an extraperitoneal rupture will provide safe management in most patients, even if there is extensive retroperitoneal or scrotal extravasation.[74] A 90% success rate was reported with this approach, with virtually all patients healed by 3 weeks.[56,75] Bladder neck involvement, bone fragments in the bladder wall or entrapment of the bladder may necessitate surgical intervention.[65] Intraperitoneal ruptures after blunt injury require surgical exploration and repair (Figure 5). Penetrating bladder injuries should also be managed with emergency exploration and repair in most cases.[74]

Suture repair is generally sufficient for iatrogenic injuries, and extravesical dissection is usually not indicated. If the injury is sustained during gynecological operations, repair can be performed transvaginally or abdominally. Bladder perforation during transurethral resection of the prostate or bladder tumors is usually managed sufficiently

with catheter drainage, especially when the injury is extraperitoneal, although direct repair of intraperitoneal injuries may be required in some cases.[76,77]

Blunt urethral trauma

Urethral injuries are usually not life threatening, but associated pelvic fractures and multiorgan injuries can be deadly. Blunt trauma is the cause of 90% of all urethral injuries.[78]

Diagnosis

Blood at the meatus is the most specific sign, and is present in 37–93% of patients with posterior urethral injury and 75% of patients with anterior urethral trauma.[79,80] In females, blood at the vaginal introitus is present in more than 80% of patients with pelvic fractures and coexisting urethral injuries.[81] Inability to void can also be a nonspecific sign of urethral disruption, whereas a high-riding prostate is an unreliable finding.

The gold standard for evaluation of urethral injury is retrograde urethrography (RUG). The Foley catheter balloon is inflated with 1–2 ml of saline in the fossa navicularis. 20–30 ml of contrast medium is injected through the catheter while films are taken in a 30° oblique position (Figure 6). Urethroscopy is seldom performed during the initial evaluation of patients with suspected urethral trauma.

The nomenclature for urethral injuries is confusing and often inaccurate. In many reports, pelvic-fracture-associated defects of the urethra are called "posterior urethral injuries", even though 80% of them are in fact anterior (that is, located distal to the sphincter).[82] The term "PUDD" (posterior urethral distraction injuries) is also commonly used, and is likewise mostly inaccurate.

Management

If urethral injury is suspected, we make a single attempt at placement of a Foley catheter. If successful, peri-catheter RUG should be performed when the patient is stable to determine the presence and extent of urethral injury. If initial catheterization fails, primary realignment techniques, such as bedside flexible cystoscopy or rigid cystoscopy in the operating room, or the use of biplanar fluoroscopy, interlocking sounds or magnetic catheters, should be performed according to surgeon preference.[83–86] Immediate realignment is associated with a re-stricture rate of approximately 60%, while a suprapubic tube alone results in a nearly 100% rate of stricture formation.[84] We leave a catheter in for 6 weeks and perform cystoscopy (under anesthesia) and RUG at the time of catheter removal. If a suprapubic tube is also present, this is left in place in anticipation of a 60% rate of urethral stricture formation. If stricture formation occurs, it must be treated with subsequent delayed primary anastomotic urethroplasty. The timing of this procedure is a subject of debate, but we wait at least 3 months to allow the tissue to heal and the scar to stabilize before attempting urethroplasty.

If endoscopic realignment fails, a suprapubic catheter should be placed. A bedside suprapubic tube is usually placed, but formal operative exploration and placement of an open urinary drainage tube can also be performed. Often, we try again later to get a catheter across the defect, usually in the operating room using direct rigid cystoscopy: alternatively, a combination of rigid urethroscopy from below and flexible cystoscopy from above using the suprapubic tube tract can be successful. Traction on the catheter is never used, as this may harm continence due to pressure necrosis of the sphincter mechanism at the bladder neck.

Table 1 | Surgical repair of ureteral injuries by location

Location of injury	Best repair options	Secondary repair options
Upper third	Uretero-ureterostomy	Transuretero-ureterostomy Ureterocalycostomy
Middle third	Uretero-ureterostomy	Transuretero-ureterostomy Boari flap
Lower third	Direct reimplantation	Psoas hitch
Complete ureteral loss	Ileal interposition Autotransplantation	Nephrectomy (last resort only)

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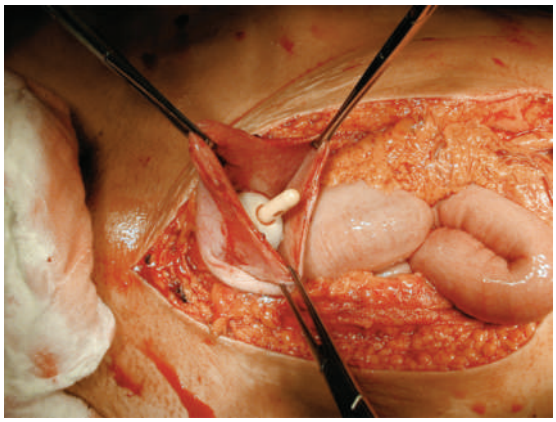

Figure 5 | Surgical repair of an intraperitoneal bladder injury. This type of injury always requires operative repair. The bladder is "bi-valved", revealing the Foley catheter. The ureteral orifices should be visualized, and any other injuries to the bladder noted and repaired. Repair is achieved with a two-layer suture closure.

Figure 6 | Retrograde urethrography in a patient with urethral injury. Extravasation of contrast medium suggests posterior urethral injury. Suprapubic catheterization and delayed urethroplasty is indicated for this type of injury.

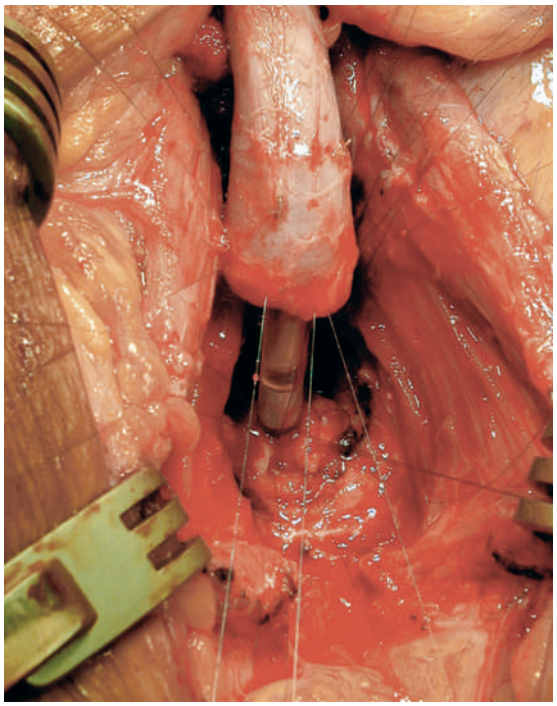

Figure 7 | Posterior urethral distraction injury repaired with delayed urethroplasty. A perineal approach is shown, with the bulbous urethra divided. Sutures are placed and a tension free anastomosis will be performed over the Foley catheter.

The gold standard for posterior urethral distraction defects is delayed urethroplasty. Most injuries are repaired with a primary anastomosis via a perineal approach (Figure 7). At the distal point of obliteration, the bulbar urethra is divided and mobilized to the base of the penis. This provides 4–5 cm of elastic lengthening to facilitate a tension-free spatulated overlapping anastomosis.[87] If additional urethral length is needed, a "progressive perineal approach" can bridge up to 8 cm of separation.[88] Midline separation of the proximal corporal bodies, inferior pubectomy, or supracorporal urethral rerouting can also provide the additional length necessary for the repair. The re-stricture rate after delayed anastomotic urethroplasty is less than 10% and the risk of impotence is approximately 5% .[89–95]

Open anterior female urethral injuries should be repaired immediately, usually through the transvaginal approach in the operating room.

Open anterior male urethral injuries

Stab wounds, gunshot wounds, dog bites and other open wounds involving the urethra often require immediate exploration due to penis and testicle involvement, and may be repaired primarily. Urethral strictures form in fewer than 15% of cases.[96] Patients with gunshot wounds can undergo retrograde urethrography if microscopic or macroscopic hematuria is present on urinalysis. Alternatively, if open repair is planned, urethral injuries can be searched for directly and repaired if present.

When exploring these injuries, the penis is degloved with a circumferential subcoronal incision. In complete disruptions, the corpus spongiosum is mobilized at the level of the injury and the urethral ends are dissected distally and proximally. The ends are then spatulated, and an end-to-end anastomosis is performed over a 16 F Foley catheter. Small lacerations are closed with fine absorbable material. Careful closure of the corpus spongiosum and the skin prevents the formation of a fistula. After 10–14 days, retrograde urethrography is performed. If there is no leakage at the anastomotic site, the catheter can be removed. If there is leakage, leave the catheter and repeat the study 1 week later.

If the damage is extensive (defects longer than 1.0–1.5 cm) and primary repair is not possible, the urethra should be marsupialized and placement of a suprapubic catheter considered. Acute placement of a graft or flap has no role. A delayed elective procedure can be performed at a minimum of 3 months after injury.

Genital trauma

One-third to two-thirds of genitourinary injuries involve the external genitalia.[97] Genital injury results from blunt trauma in 80% of cases and penetrating trauma in the remainder. Approximately 35% of genitourinary gunshot injuries involve the genitals.[98,99]

Penile fracture

A direct blow or sharp bending force to an erect penis may lead to a penile fracture. A sudden cracking or popping sound and immediate detumescence during sexual intercourse are indicative of such an injury. Rupture of the tunica albuginea and an enlarging hematoma creates the classic "eggplant deformity". Injury to the corpus spongiosum or urethral trauma occurs in 10–22% of cases.[100] Repair is achieved by surgical correction and suturing of the ruptured tunica using absorbable sutures. Long-term outcomes and protection of potency are most favorable after immediate exploration and repair.

Blunt scrotal trauma

Blunt scrotal trauma can lead to testicular rupture in as many as 50% of patients.[101] A force of approximately 50 kg is needed to cause testicular rupture.[102] Scrotal ultrasonography is the recommended diagnostic test, and will help differentiate between intratesticular and/or extratesticular hematoma and testicular contusion or rupture.[103–105] Exploration, rather than pursuing further diagnostic tests, is better in patients with equivocal findings on ultrasonography. Repair consists of surgical exploration with excision of necrotic testicular tubules and closure of the tunica albuginea with running absorbable suture. Early intervention results in >90% preservation of the testis, while delayed surgery ultimately leads to orchiectomy in 45–55%.[101]

Blunt scrotal trauma may also cause subcutaneous hematoma, hematocele or, in rare cases, testicular dislocation. Large hematoceles should be treated surgically, even in the absence of testicular rupture. Testicular

dislocation can be unilateral or bilateral, and may be subcutaneous with epifascial displacement, or internally dislocated with movement of the testicle to the external ring, inguinal canal or abdominal cavity. Manual replacement or orchidopexy is the preferred treatment in these instances.

Vulvar trauma

Blunt trauma to the vulva is rare, but is associated with vaginal, pelvic or abdominal injuries. It may also cause voiding difficulties, and catheterization is often required. CT of the pelvis should be performed to identify associated injuries. Vulvar hematoma or blood at the introitus is associated with vaginal injuries, and further examination under sedation or anesthesia is indicated. Most vulvar injuries do not require surgery, but open injuries can be associated with significant blood loss and may require blood transfusion. In hemodynamically stable women, NSAIDs and ice packs are sufficient.[106] If the hematoma is massive, surgery with lavage and drainage may be necessary. In cases of vulvar laceration, suture after debridement is recommended, as is primary repair of associated vaginal injuries. If the bladder, rectum or bowel is involved, laparotomy and even colostomy may be necessary.

Penetrating penile trauma

Animal and human bites are rare causes of penetrating genital trauma, and are associated with a high risk of wound infection. Antibiotic coverage should be directed according to the most common associated pathogen. *Pasteurella multocida* accounts for 50% of dog-bite infections, while *Escherichia coli*, *Streptococcus viridans* and *Staphylococcus aureus* are less commonly involved.[107,108] Antibiotic choices include penicillin–amoxiclavulanic acid, doxycycline, cephalosporin or erythromycin for 10–14 days.[109,110] Local wound care is indicated, and rabies vaccination should be considered, especially if the patient's immunization status is unknown.

Surgical exploration with the goal of conservative debridement of necrotic tissue is recommended in patients with penetrating penile trauma. Primary alignment of disrupted tissue usually heals well, owing to the excellent penile blood supply, even in cases of extensive injury.[111] Nonoperative management is recommended for small, superficial injuries in which the Buck fascia is intact.[99] Split-thickness grafts can be used in cases of extensive loss of penile shaft skin, with an additional 0.015 in thick graft to reduce the risk of contraction.[111] Grafts can be placed acutely if there is no infection, or after several days of wet-to-dry dressing changes or a vacuum-assisted closure device if active infection is present.

Penetrating injuries to the scrotum also require surgical exploration with debridement of nonviable tissue and, if necessary, primary reconstruction of the testis and scrotum. If complete disruption of the spermatic cord is present, realignment without vaso-vasostomy can be performed.[112] If there is extensive destruction of the tunica albuginea of the testis, mobilization of a free tunica vaginalis flap can allow closure of the testicle. Severe lacerations of the scrotal skin should be sutured, and in most cases can be closed primarily. Adequate washout and debridement prior to closure is important to ensure optimal healing.

Conclusions

An understanding of genitourinary trauma is important in the initial evaluation and subsequent management of trauma patients. For renal trauma, the mechanism of injury is an important factor. Hematuria is the hallmark diagnostic sign in patients with renal trauma, but the degree of hematuria may not correlate with the severity of injury. Hemodynamic status should be closely observed. Most renal trauma can be managed nonoperatively: if not, then renal salvage should be the goal.

Most ureteral injuries are iatrogenic, but may also result from traumatic injuries. Clinical suspicion and extravasation of radiological contrast medium provides the diagnosis. Precise and site-specific techniques are used for the repair of these injuries. Watertight repair is the goal, and an internal stent and external drain should be placed.

Bladder injuries are often associated with pelvic fractures, which may be life threatening. Cystography with 350 ml of contrast medium is the diagnostic study of choice. Iatrogenic injuries during pelvic surgery can also occur, and cystoscopy is an important adjunct to aid in diagnosis. Extraperitoneal bladder injuries can be managed with Foley catheter drainage, but intraperitoneal injuries require surgical repair.

A single, nontraumatic attempt at urethral catheterization can be performed in patients with suspected urethral injuries. Retrograde pyelography will provide the definitive diagnosis. For posterior distraction defects, delayed primary urethroplasty is the gold standard treatment strategy. By contrast, open anterior injuries in males require immediate exploration, and can be repaired primarily.

The external genitalia are involved in one-third to two-thirds of all genitourinary injuries. Penile fracture is diagnosed based on history and physical examination, and requires immediate surgical exploration and repair. Marked hematoma or testicular injury can result from both blunt and penetrating scrotal trauma. In females, vulvar and vaginal injuries should be suspected when there is blood at the vaginal introitus.

Review criteria

We searched for original articles focusing on genitourinary trauma in MEDLINE and PubMed published between 1965 and 2010. The search terms we used were "renal trauma", "ureteral injuries", "trauma", "bladder trauma", "genitourinary injuries", "urethral injuries" and "external genitalia injuries". All papers identified were English-language, full-text papers. We also searched the reference lists of identified articles for further papers.

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Author contributions

Both authors contributed equally to researching data for the article, discussing content and writing the manuscript. R. A. Santucci performed review/editing of the manuscript before submission.