UCSF
UC San Francisco Previously Published Works

Title
Lower genitourinary tract trauma

Permalink
https://escholarship.org/uc/item/7633s94q

Journal
Trauma (London, England), 18(1)

ISSN
1460-4086

Authors
Bayne, David
Zaid, Uwais
Alwaal, Amjad
et al.

Publication Date
2016

DOI
10.1177/1460408615591624

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

Review Article

Trauma
0(0) 1–9
© The Author(s) 2015
Reprints and permissions:
sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/1460408615591624
tra.sagepub.com

Lower genitourinary tract trauma

David Bayne, Uwais Zaid, Amjad Alwaal, Catherine Harris, Jack McAninch and Benjamin Breyer

Lower genitourinary tract trauma comprises a substantial portion of the trauma burden in the USA. Some key trends and findings are described. Mortality is relatively high in patients with bladder trauma due to associated injuries. Urethral injuries should be suspected in patients presenting with the triad of blood at the urethral meatus, suprapubic fullness indicative of a full bladder, and urinary retention. Urethral injury is common in penetrating penile trauma, and stab wounds to the penis are more likely to involve the urethra than gunshot wounds. Penile fracture is largely a clinical diagnosis and suspicion of fracture requires urgent surgical exploration. Zipper injuries are the most common cause of presentation to the emergency department for penile trauma in adults. Toilet seat injuries are the leading cause of penile pediatric trauma presenting to the emergency department. In the setting of testicular trauma, rates of testicular salvage are excellent when exploration is prompt. Trauma in the form of animal or human bites requires treatment with broad-spectrum antibiotics in addition to repair of the injury. Military trauma has seen an increase in explosive injuries to the lower urinary tracts due to evolution of warfare tactics. Increasing awareness of presentation and context of lower genitourinary tract trauma can reduce delay of diagnosis and morbidity associated with such injuries.

Keywords
Trauma, lower tract, genitourinary, bladder, penis, urethra

Introduction

Trauma accounts for 10% of mortality in the USA and represents a total cost of $406 billion annually in health care costs and productivity losses[1] and is the leading cause of death in individuals between the ages of 1 and 44 years of age.[2] Genitourinary injury is estimated to be present in 10% of trauma cases[1] and its consequences can be both life threatening and have significant impact on quality of life. Appropriate diagnosis and management of these injuries is crucial in limiting mortality and morbidity associated with lower genitourinary tract trauma.

Methods

A literature search to evaluate relevant studies pertaining to lower tract genitourinary trauma was performed. PubMed and Google Scholar were utilized as the search engines using the keywords: bladder trauma, urethral trauma, penile trauma, Fournier's gangrene, pediatric genital trauma, testicular trauma, and military genitourinary trauma. The search was limited to English Language articles published between 1983 and 2014. The findings describe current epidemiolgic, diagnostic, and management practices for lower tract genitourinary trauma.

Lower urinary tract trauma

Bladder trauma

Epidemiology/etiology. In a review of the 8565 documented bladder injures in the National Trauma Data Bank, 75% were men, 57% were under 40 years old and 85% of the bladder injuries were caused by blunt trauma.[3]

Motor vehicle collisions and pedestrian versus automobile accidents are the most common causes of blunt trauma resulting in bladder perforation (80%).[1] The incidence of bladder injury in all cases of blunt

Department of Urology, University of California, San Francisco, CA, USA

Corresponding author:
David Bayne, 400 Parnassus Ave, Suite A610, San Francisco, CA 94123, USA.
Email: bayned@urology.ucsf.edu

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

abdominal trauma has been reported at 1.6%.[4] In a 10-year single institution study, the incidence of bladder trauma was noted to comprise 0.36% of the 15,168 adult blunt trauma cases examined with a mortality from bladder injuries of 11.1%.[5] In general, the high mortality rate in patients with bladder injuries is due to death from concomitant, more severe and life threatening injuries, rather than death caused by the bladder injury itself.[5]

Blunt trauma causing bladder injury rarely results in isolated bladder injury. Overall 80–85% of bladder injuries occur in the setting of pelvic fracture, and conversely only 5.4% of patients with pelvic fracture have a concomitant bladder injury;[5,6] of the bladder injuries that do occur in the setting of pelvic fractures, they are more likely to be extraperitoneal than intraperitoneal. In one case series, all of the extraperitoneal bladder injuries occurred with a concomitant pelvic fracture, whereas 59% of the intraperitoneal bladder injuries occurred with a pelvic fracture. Hollow viscus injury (HVI), on the other hand, was more often associated with intraperitoneal bladder injury (51.9%) compared to only 9.1% of extraperitoneal bladder injuries having HVI.[5] In pediatric patients, the bladder is more vulnerable to intraperitoneal injury due to the more abdominal anatomic position of the pediatric bladder.

Although blunt trauma accounts for the majority of bladder injuries (51–86%), penetrating trauma causes up to 49% of bladder injuries.[1] Gunshot wounds comprise 88% of penetrating bladder injury, but only 3.6% of all abdominal gunshot wounds result in bladder trauma.[1] Iatrogenic injuries in the setting of intra-abdominal surgery can cause bladder injury particularly complex gynecologic procedures, trocar placement for laparoscopic surgery, orthopedic treatment of pelvic fractures with external fixation devices and placement of intrauterine devices.[1] Common urologic procedures such as transurethral resection of bladder tumor, transurethral resection of prostate and incontinence procedures such as laparoscopic bladder neck suspension and vaginal tape can also result in iatrogenic bladder injury.[4] Iatrogenic injury to the intramural ureter is described in full thickness trans urethral resection of the hemitrigone and distal ureter for muscle invasive bladder tumors.[7]

Diagnosis. Bladder injuries rarely occur as isolated injuries, so it is often difficult to assess for subjective symptoms specific to bladder injury in most instances of bladder trauma. However, symptoms such as suprapubic tenderness, low voided volumes, low abdominal bruising, swelling, and hematoma have been cited as common clinical signs of bladder injury.[6] Guttmann describes a triad of clinical symptoms: hematuria, suprapubic or abdominal pain and difficulty voiding.[8] Gross hematuria is associated with 67–95% of bladder injuries[9,10] and in the instance of blunt trauma bladder rupture, the absence of gross hematuria is rare[6,9] with only 5% of bladder ruptures in the setting of trauma being associated with isolated microhematuria without gross hematuria.[9] The incidence of bladder rupture is extremely rare if urine analysis shows fewer than 25 red blood cells per high-powered field.[8] However, having specific thresholds for bladder evaluation based on number of red blood cells per high-powered field may miss some bladder injuries.[11] Signs of iatrogenic injury to the bladder intraoperatively include clear fluid in the operative field, a visible bladder laceration, and gas distention of the urinary drainage bag during laparoscopic cases.[10]

In the setting of high suspicion for bladder injury, particularly in the setting of gross hematuria and pelvic fracture, bladder cystography is strongly recommended[6] (Grade B level of evidence (LOE)).[12] Equivalence has been demonstrated comparing conventional retrograde cystography and CT cystography with retrograde filling as both are highly specific and sensitive for diagnosing intra- and extraperitoneal bladder injury.[13,14] Carroll and McAninch describe the correct technique required to avoid missing bladder injury when performing conventional retrograde cystography[15]; findings indicative of bladder injury include contrast material visible outside of the bladder, which can vary depending on the location of bladder injury.[13] Intraperitoneal injury reveals contrast material in the abdomen itself, outlining the bowel and intra-abdominal space, whereas extraperitoneal injuries can result in contrast seen in the prevesical space, anterior peritoneal space and tracking to the superficial soft tissues of the anterior and medial thighs.[13]

The association between bladder rupture and pelvic fracture is common; specifically, diastasis of the pubic symphysis greater than 1 cm and fracture of the obturator ring with displacement greater than 1 cm have been shown to be independently predictive of bladder injury.[10,16] Pelvic fractures can cause damage to the bladder neck and prostate, and although more frequently described in pediatrics due to their underdeveloped prostates, these injuries also occur in adults, leading to urinary incontinence and thus mandate surgical repair.[17]

The American Association for the Surgery of Trauma uses a one to five grade scaling system for bladder injury (Table 1).

Management. Absolute indications for immediate primary bladder repair include intraperitoneal injury, penetrating or iatrogenic injury, inability to adequately drain the bladder, bladder neck injury, concomitant rectal or vaginal injury, open pelvic fracture, pelvic fracture requiring open reduction and internal fixation,

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

Table 1. AAST bladder injury scale.[18]

Grade	Description of injury
1*	Contusion, intramural hematoma, partial thickness laceration
2*	Extraperitoneal bladder wall laceration <2 cm
3	Extraperitoneal ≥2 cm, intraperitoneal <2 cm bladder wall laceration
4	Intraperitoneal bladder wall laceration ≥2 cm
5	Intraperitoneal of extraperitoneal laceration extending into bladder neck or ureteral orifice

*Advance one grade if multiple lesions.

and bone fragments projecting into the bladder.[19] Surgical repair of bladder rupture is also indicated in the presence of complicating factors or if the patient is already undergoing a surgical procedure where repair of the bladder is facilitated.[4]

Intraperitoneal injury. Intraperitoneal bladder injury generally requires more acute operative management (LOE – Grade B)[12] because of the likelihood of persistent urine leakage into the abdominal cavity, which can result in urinary ascites and abdominal sepsis. Penetrating and intraperitoneal rupture generally require urgent surgical repair because resulting injuries are less likely to heal spontaneously.[4] In the setting of hemodynamically stable patients with intraperitoneal bladder injury and low suspicion of concomitant injury, rare cases of laparoscopic bladder repair have been described with excellent results.[20]

Extraperitoneal injury. Most extraperitoneal bladder injuries can be managed non-operatively as urine extravasation is usually confined.[4] As an exception, extraperitoneal injuries to the bladder neck and trigone can compromise continence and therefore require repair. In these instances, surgical repair of extraperitoneal bladder injury is typically done open. Repair of extraperitoneal bladder injury using laparoscopic technique has only been described in rare case studies.[21] In open transvesical repairs, intravenous indigo carmine or methylene blue can be used to stage the ureters for patency and to help localize the ureteral orifices.

Post-operative management. After bladder repair, post-operative cystogram is recommended in 10–14 days and has been described as early as 5–10 days after repair.[19,22] When managing bladder trauma conservatively, decompression with a Foley catheter is required followed by interval cystography to assess if the bladder has healed.[19]

Urethral trauma

Classically urethral injuries are described anatomically as posterior or anterior urethral injuries: posterior urethral injuries are those that occur proximal to the perineal membrane or the junction between the membranous and the bulbar urethra. The posterior urethra includes the prostatic segment and the membranous segment. The membranous urethra, which is proximal to the perineal membrane, is easily injured with sufficient external force relative to the prostatic urethra and bladder neck as it is the least anatomically supported portion of the posterior urethra.[23] The anterior urethra consists of the bulbar urethra, the penile or pendulous urethra, and the fossa navicularis. In the anterior urethra, the bulbar segment is more anatomically fixed in place than the penile or pendulous urethra and therefore more vulnerable to crush injury. Distal to the bulbar segment, urethral injury is rare and is typically caused by trauma during sexual activity and in military or urban warfare.[23]

Posterior urethral injuries are four times more common than anterior urethral injuries in industrialized societies, and posterior urethral injuries often occur with pelvic fractures.[1] Pubic symphysis diastasis and displaced inferomedial pubic bone fractures occur in up to 88% of patients with urethral injury.[24] The degree of pubic symphysis diastasis directly correlates with likelihood of urethral injury.[24] Malgaigne, or vertical sheer fractures involve breaks in multiple pelvic bones, including the pubic rami and the wing of the ipsilateral ilium or the sacrum, with associated upper displacement of the hemipelvis.[24] Posterior urethral injuries are particularly common with bilateral versus unilateral pubic arch fractures and sheering force on the urethra generated from Malgaigne fractures.[9]

Epidemiology. Urethral injuries comprise 4% of urologic trauma[25] and can cause substantial morbidity. They are more common in men than women due to the increased length and reduced anatomic mobility of the urethra in men[26]; 65% are complete disruptions and 35% are incomplete.[1] In patients with pelvic fractures, concomitant urethral injuries may be present in as high as 25% of men and 4.6% of women[24] and are most commonly caused by motor vehicle collisons.[23]

Diagnosis. The diagnostic triad of a urethral injury is blood at the urethral meatus, suprapubic fullness from a full bladder, and urinary retention[27]; if present, further investigation is mandatory. If injury is thought to be due to pelvic fracture, rectal exam should be performed to assess for rectal injury (high riding prostate is an unreliable sign), and a vaginal exam to assess for vaginal injury should also be performed in women.[27]

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

Blood at the urethral meatus in the setting of pelvic trauma mandates retrograde urethrogram (LOE – Grade C).[12] Other indications for retrograde urethrogram include unstable pelvis, penile fracture or significant perineal hematoma after straddle injury; if it shows urethral injury, the a suprapubic catheter is required.[23] In the case where there is an obvious pelvic fracture but no blood at the urethral meatus, an attempt at gentle catheterization with a uretheral Foley is acceptable, but if this fails, suprapubic catheter is recommended. In women, in the setting of suspected urethral injury, urethroscopy with a cystoscope is appropriate to assess the bladder neck.[28]

The American Association for the Surgery of Trauma also uses a one to five grade scaling system for urethral injury (Table 2).

Management of posterior urethral injuries

Delayed repair. Initial exploration and anastomotic repair of complete transection of the male posterior urethra is typically not performed as it results in stricture, incontinence, and impotence;[29] most experts agree that placement of a suprapubic catheter is the standard of care to allow for urinary diversion and clean healing of sites of injury prior to open delayed urethroplasty,[9] typically at 3–6 months after the injury when scar formation has stabilized and sufficient healing has occurred.[30] One should also take into account that other non-related injuries have healed appropriately to allow for surgery.

In the setting of delayed repair, imaging is necessary to evaluate the proximal and distal ends of the disrupted urethra which can be achieved with a retrograde urethrogram and a voiding cystogram. In instances where visualization of the bladder neck is poor, flexible cystoscopy can be used through the suprapubic site to gain better visualization.[19] Urethral ultrasound can determine length more accurately than retrograde urethrogram.[31] MRI can be utilized to further characterize the stricture as it can correctly estimate length of defect, the degree of prostatic misalignment and the density of scar tissue.[32]

Table 2. Urethral injury grading.[18]

Grade	Description of Injury
1	Urethral contusion, blood at meatus, retrograde normal
2	Elongation of the urethral without extravasation on urethrography
3	Extravasation of contrast on urethrography at injury site
4	Extravasation of contrast on urethrography at injury site without bladder visualization, <2 cm
5	Complete transection with ≥2 cm separation, extravasation into prostate or vagina

Delayed primary repair. Delayed primary repair has been described with success in a series of 17 patients by Mundy who describes laparotomy with hematoma evacuation 7–14 days after injury with primary suturing to connect the two ends of ruptured urethra. All patients at the time of report did not require subsequent urethroplasty.[33] There is little evidence comparing delayed primary repair and delayed repair of urethral injury.[27]

Primary realignment/Immediate repair. Given advances in instrumentation, most advocate an attempt at endoscopic realignment of the urethra provided the patient has stable injuries that will allow for appropriate positioning (LOE – Grade C).[12] Prolonged attempts at realignment are discouraged. Patients who are successfully realigned require close follow-up as the rate of future stenosis and obstruction approaches 80%.[34] Immediate surgical repair is generally not encouraged in the cases of posterior urethral injury, particularly in cases of compete disruption as extensive hemorrhage and edema can obscure tissue planes and make identification of viable tissue difficult.[27] Furthermore, higher rates of incontinence, impotence, and stricture result with immediate repair.[27]

Management of anterior urethral injuries. Incomplete disruption anterior urethral injuries can be managed with catheter placement. Straddle injuries can damage the bulbar aspect of the anterior urethra and injury in these instances is often not immediately diagnosed and presents as urethral stricture at a later date.[1] The anterior urethra is injured during fracture of the penis infrequently in the USA and Europe but can occur as high as 20–38% in Asia and the Middle East based on mechanism of injury.[1]

In the cases where additional injuries are present that prevent immediate surgical repair, a suprapubic catheter should be placed for urinary diversion followed by interval urethroplasty.[27] Most experts would agree that penetrating anterior urethral injury should be surgically explored and in most cases can be repaired primarily if there is an absence of concomitant serious injuries.[12] In the setting of devastating tissue destruction, suprapubic urinary diversion should be performed and definitive urethral reconstruction pursued at a later date.

Management of urethral injuries in women. In women, the urethra consists only of the posterior urethra.[27] Initial exploration and urethral repair is recommended over delayed repair because the short length of the urethra

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

prevents adequate mobilization after scarring.[27] Primary realignment using endoscopic techniques has been described with success in the setting of female urethral injury.[35] Pelvic fractures and concomitant urethral injuries are less common in men than women, but when they do occur in women vaginal injury is common.[35] When vaginal injuries and bladder neck injuries occur, primary repair encouraged. Goals for management of female urethral injury include preservation of urethral length, minimizing periurethral fibrosis, avoiding trauma to the urethral neck and assurance of vaginal patency.[36]

Male genital trauma

Penile trauma

Penile fracture. Penile trauma accounts for 10–16% of traumatic genitourinary injuries;[37] specifically, penile fracture accounts for 1/175,000 emergency department visits resulting in admission.[1] A recent case series from Hong Kong found the annual incidence of penile fracture to range from 0.29 to 1.36 per 100,000 people.[38] Taghaandan, or the intentional bending of the penis for the purpose of achieving detumescence, is a reported practice in the Middle East.[1] Consequently, penile fractures are more common in the Middle East relative to the USA and Europe, where trauma during sexual intercourse causes the majority of penile fractures.[39] Penile fractures have been reported to occur more frequently during extramarital sexual intercourse and sexual intercourse in atypical locations.[40] These patients often present to the hospital in a delayed fashion due to embarrassment.

Classically, patients with penile fracture report sudden penile pain followed by a popping sensation and detumescence, and examination can reveal the classic ''eggplant'' deformity of the penis if Buck's fascia remains intact.[41] In cases where Buck's fascia tears, blood tracks along Colles fascia and can result in an expansive and characteristic ''butterfly'' hematoma.[42] However, this presentation can be mimicked in cases where there is isolated rupture of the deep dorsal vein, superficial dorsal vein, penile vein or penile artery. These rare cases are referred to as false penile fractures.[43]

Although penile fracture is usually a clinical diagnosis, it can be confirmed with cavernosography but the complications include extravasation of contrast, priapism, and infection.[44] Ultrasonography on the other hand is non-invasive and has a fracture detection rate of 86%.[44] If urethral injury is suspected, retrograde urethrography or flexible cystoscopy can diagnose the injury and locate the specific area of occurrance.[42] Blood at the meatus is a trigger for concern for urethral injury. Fractures are usually in the pendulous portion of the corpora rather than the peritoneal portion of the corpora, and MRI can also be used to precisely locate the exact site of cavernosal injury.[45]

Management of penile fracture or suspicion of penile fracture requires surgical exploration to repair the tunica albuginea and any associated urethral tear (LOE – Grade B).[12] Delays in surgical repair lead to penile abscess, urine extravasation, penile pain, and deformity.[46] There are multiple approaches to fracture repair: the circumcising degloving approach is used to expose, fully explore, and locate the area of fracture[46]; other approaches include scrotal inguinal incisions and small longitudinal incisions directly over the fracture site.[44] Absorbable sutures should be used to close any tunical defects because non-absorbable suture can leave permanent knots that may be a source of pain for the patient in the future.[44] Patients who do not undergo surgical correction have increased rates of erectile dysfunction (0% vs 34% in one series).[47]

Penetrating injuries. Penile injuries represented 33% of penetrating genitoscrotal trauma cases from a large single institution study over a 30-year period.[48] Penetrating penile injuries can involve damage to the urethra, with stab wounds being more likely to involve the urethra than gunshot wounds.[48,49]

Retrograde urethrography should be considered in patients who present with stab wounds or gunshot wounds to the penis.[50] There are reports of retrograde injection of methylene blue or indigo carmine through a Foley catheter to identify urethral injury during penile exploration and repair.[51] Urethral injuries should be repaired using principles of urethroplasty, which may require a staged approach depending on the extent of urethral damage.[19]

Amputation. Penile amputation is rare, and it most commonly occurs as a result of autoamputation in the setting of psychosis, religious extremism, intoxication, or gender self-identification conflict.[52] Reimplantation should be performed as soon as possible, within the first 24 h after amputation.[41] For successful reimplantation, the amputated penis can tolerate a cold ischemic time of 16 h relative to a warm ischemic time of 6 h, but is important that the penis is not placed in direct contact with ice as this can cause hypothermic injury.[19] The penis should be rinsed in saline solution, wrapped in saline soaked gauze, and sealed in a sterile plastic bag. This should then be placed in an ice bath.[19]

Surgical approaches involve repair of the urethra and corporal bodies. Microscopic repair of the dorsal penile vessels and nerves should be performed. There are higher rates of skin loss without concomitant microsurgical repair of the vessels and nerves.[53]

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

Additionally, in microsurgical repair, higher rates of erectile function are reported with repair of the dorsal arteries rather than the cavernosal arteries. Approximation of the dorsal nerve appears to be less important in restoration of erectile function, given patients have high rates of erectile function even in the setting where the dorsal nerves are not approximated.[52] Delayed placement of penile prosthesis 10–25 months after phalloplasty has been described as a means to restore sexual function.[54]

Zipper injuries. Zipper injuries have been reported as the cause of 21.6% of all penile traumas presenting to US emergency departments in the USA.[55] Subgroup analysis also showed that 16.6% of pediatric penile trauma was due to zipper injury while 29.8% of adult penile injuries were due to zipper trauma, making it the most common cause of adult presentation to the emergency department for penile trauma,[55] although 98% of these injuries did not require hospital admission.[55]

In cases of zipper injury, foreskin entrapment is often described. Mineral oil can be placed and unzipping can be attempted.[19] Alternatively, the zipper can be cut and released by cutting across the zipper teeth or at the apex of the zipper with a bone cutter.[56] Circumcision and elliptical skin incisions can also be performed.[56] Management should be determined on an individual case basis depending on location and involvement of the injury. Authors describe varying success rates with each technique.

Toilet seat injuries. Interestingly, toilet seat injuries are the leading cause of penile pediatric trauma presenting to the emergency department.[57] In an analysis by Glass et al., it was found that the mean age for penile crush injury by toilet seat was 3.9 years; it was much less common in adults. The majority of these injuries, 97%, only required treatment in the emergency department and did not result in hospital admission.[57] Toilet seat injuries in toddlers are preventable. Keeping the toilet seat up, using a slow release seat, or using a U-shaped seat would prevent such injuries. Although expensive, MRI can also diagnose cavernosal injuries in these patients.[45]

Strangulation injuries. Strangulation to the penis can occur with hair, thread, rubber bands, or a variety of other objects.[58,59] In the case of children, one must investigate the possibility of child abuse.[60] In adults, these injuries tend to occur in the setting of sexual acts for the purpose of pleasure and augmentation of erections.[59] Various maneuvers using string and other tools have been described to release these strangulation injuries with or without combined glans puncture to drain entrapped blood. Subsequent skin necrosis can usually be managed with conservative care.

Testicular trauma

Epidemiology. Blunt trauma accounts for 85% of all trauma to the testicles and scrotum[1] resulting in hematoma and tunical rupture. It can also cause testicular contusion, torsion, and dislocation. Penetrating scrotal trauma accounts for 40–60% of penetrating GU injuries.[1] Cass and Luxenberg showed that in a series of 91 testicular injuries, penetrating trauma comprised 16% of patients while testicular injuries and blunt trauma accounted for the rest.[61] Twenty-nine per cent of penetrating trauma and 1.4% of blunt trauma resulted in bilateral testicular injury.[61]

Diagnosis. Clinical presentation is not always universal or reliable in diagnosing testicular injury in scrotal trauma. Swelling, ecchymosis, and hematoma are not always present in testicular injury; therefore, scrotal ultrasound is recommended to evaluate the testicles in scrotal trauma.[62,63] Concern for testicular rupture based on ultrasonography includes disruption of the tunica albuginea or heterogeneous appearance of the testicular parenchyma.[64] Guichard et al. documented a 100% global accuracy of finding testis rupture with a sensitivity and specificity of 100% and 65%, respectively, when using criteria of heterogeneous testicular parenchyma, loss of contour, and tunica albuginea breach.[65] Absence of testicle should lead to suspicion of testicular dislocation from the scrotum.

Management. Early surgical exploration is encouraged as it results in increased testicular salvage. Cass and Luxenberg reported an orchiectomy rate of only 6% with early exploration versus a rate of 45% with delayed surgical exploration.[61] Transverse scrotal incision is recommended. Objectives include testicular repair, irrigation, and debridement of extruded seminiferous tubules to prevent infection and hemostasis. Closure of the tunica albuginea is performed with small absorbable sutures.[41] Large hematomas should be explored and drained regardless of presence or absence of testicular injury as this can result in testicular atrophy, infection, or pain.[65] In the case of penetrating scrotal injuries, exploration for testicular and vascular injury is recommended particularly in the case of penetration of the Dartos fascia. In penetrating injuries, contralateral testicular exploration should be considered as bilateral injury consistently occurs in 8–35% of cases. [48,61,66] In the case of blunt injury, excellent results have been reported with rates of salvage greater than 90%.[61,63] In penetrating trauma, gonadal salvage is less successful at 49–65%.[48,66]

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

Genital skin loss

Genital skin loss can result from trauma, burns, and necrotizing infection. Perhaps the most common cause of genital skin loss is due to required debridement following necrotizing soft tissue infections[67] such as Fournier's gangrene, which requires extensive debridement to rid the body of the causative polymicrobial infection. Fournier's gangrene occurs in 1/7500–1/750,000 individuals[68] – 68% of infections are polymicrobial and 39% involve *E. coli*.[69]

In the setting of infection, the diagnosis of Fournier's gangrene can be confirmed with various imaging modalities. Ultrasonography, computed tomography, or plain films reveal subcutaneous air which indicates a necrotizing gas forming infection.[68] Treatment of Fournier's gangrene requires extensive debridements, sometimes with several staged debridements, over many days. Once the infection is eradicated, attention turns to soft tissue and skin coverage. Prior to reconstruction, the wound can be managed with wet to dry dressings or with wound VAC (vacuum-assisted closure) therapy.[70] Both urinary and gastrointestinal diversion should be performed if necessary to accomplish wound cleanliness.[68]

Management. Skin coverage with split thickness skin grafting and advancement flaps for tension free coverage is recommended. Coverage of the penis should be performed with non-meshed split thickness skin grafting as this provides more robust coverage to prevent contracture and facilitate erections.[67] It is important to leave a 1 mm ring proximal to the corona to allow for lymphatic drainage and prevention of circumferential lymphedema causing a doughnut deformity.[71] At the time of skin grafting, tie-over bolster dressings or wound VAC therapy can be applied for graft stabilization.[72] This approach to coverage also applies to coverage of genital burns after resection of burn eschar.[19]

In the case of the scrotum, primary closure of skin defects is recommended and often successful. The general recommendation is that if greater than 50% of scrotal skin is lost, grafting is required.[19,73] Thigh pouches can be utilized for temporary placement of testicles to keep the testicles covered while the rest of the genital wound is being prepared for reconstruction.[68] This should not be performed in the setting of infection to avoid spread of the infection to the thigh. In the case where the scrotum cannot be closed primarily, local skin flaps can be mobilized, and meshed split thickness skin grafts can be used to achieve coverage.[73] To prevent bifid neoscrotum, the testicles and spermatic cord should be sewn together. The tight unnatural appearance of the scrotum will eventually appear more natural in a dependent position after approximately 6–12 months.[74]

Miscellaneous trauma

Animal and human bites. Human bites to the genitals are often delayed in their presentation to the hospital and often present with infection.[48] Bites to the genitals have been reported from a variety of animals but most commonly involve dog bites to young boys.[75] These can cause urethral injuries and should be repaired accordingly. Antibiotic coverage is also important as these bites often result in polymicrobial infections. Recommended antibiotics vary depending on the animal, and tetanus and rabies prophylaxis should be considered.[75] In general, the recommend antibiotic treatment for dog bites includes a beta lactam antibiotic with beta lactamase inhibitor, such as amoxicillin-clavulanic acid, a second generation cephalosporin, or clindamycin with a fluoroquinolone.[19] For human bites, amoxicillin/clavulanic acid or moxifloxacin is recommended.[76]

Military trauma

In modern warfare, genitourinary trauma is reported to be mostly from improvised explosive devices (IEDs). Between 3 and 5% of military admissions to hospitals for trauma in recent cohorts have been genitourinary in nature and 70% of these admissions were from trauma to the lower tracts.[1] Evolution of warfare tactics have caused a shift towards increases in genitourinary trauma as a consequence of explosive injuries and burns rather than gunshot injuries which were historically more common in past military conflicts.[73] In modern day Iraq, recent data reports urologic injuries as occurring in as high as 18% of casualties among civilians and military personnel presenting to the hospital – of these urologic injuries, 43% were lower tract trauma.[77]

Conclusion

Lower genitourinary tract trauma represents a significant portion of the overall burden of traumatic injury. Prompt and appropriate management can minimize morbid and fatal consequences of lower genitourinary tract trauma. Increasing awareness of presentation and context of lower genitourinary tract trauma can reduce delay of diagnosis and morbidity associated with such injuries.

Conflict of interest

None declared.

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Provenance and peer review

Not commissioned, externally peer reviewed.

References

1. McGeady JB and Breyer BN. Current epidemiology of genitourinary trauma. *Urologic Clinics of NA* 2013; 40: 323–334.
2. Centers for Disease Control and Prevention. WISQARS (Web-based injury Statistics Query and Reporting System). National Center for Injury Prevention and Control, http://www.cdc.gov.ucsf.idm.oclc.org/injury/wisqars/index.html (2011, accessed May 2014).
3. Deibert CM and Spencer BA. Trauma/reconstruction/diversion the association between operative repair of bladder injury and improved survival: results from the National Trauma Data Bank. *J Urol* 2011; 186: 151–155.
4. Gomez RG, Ceballos L, Coburn M, et al. Consensus statement on bladder injuries. *BJU Int* 2004; 94: 27–32.
5. Matlock KA, Tyroch AH, Kronfol ZN, et al. Blunt traumatic bladder rupture: A 10-year perspective. *Am Surgeon* 2013; 29: 589–593.
6. Morey AF, Iverson AJ, Swan A, et al. Bladder rupture after blunt trauma: guidelines for diagnostic imaging. *J Trauma* 2001; 51: 683–686.
7. See W. Distal ureteral regeneration after radical trnasurethral bladder tumor resection. *Urology* 2000; 55: 212–215.
8. Guttmann I and Kerr HA. Blunt bladder injury. *Clin Sports Med* 2013; 32: 239–246.
9. Brandes S and Borrelli J. Pelvic fracture and associated urologic injuries. *World J Surg* 2001; 25: 1578–1587.
10. Morgan DE, Nallamala LK, Kenney PJ, et al. CT cystography: radiographic and clinical predictors of bladder rupture. *Am J Roentgenol* 1999; 1–7.
11. Abou-Jaoude WA, Sugarman JM, Fallat ME, et al. Indicators of genitourinary tract injury or anomaly in cases of pediatric blunt trauma. *J Pediatric Surg* 1996; 31: 86–90.
12. Morey AF, Brandes SB, Dugi D, et al. Urotrauma: AUA guideline. *J Urol* 2014; 192: 327–335.
13. Quagliano PV, Delair SM and Malhotra AK. Diagnosis of blunt bladder injury: a prospective comparative study of computed tomography cystography and conventional retrograde cystography. *J Trauma: Injury Infect Critical Care* 2006; 61: 410–422.
14. Peng MY, Parisky YR, Cornwell EE III, et al. CT cystography versus conventional cystography in evaluation of bladder injury. *Am J Roentgenol* 1999; 173: 1269–1272.
15. Carroll PR and McAninch JW. Major bladder trauma: the accuracy of cystography. *J Urol* 1983; 130: 887–888.
16. Avey G, Blackmore CC, Wessells H, et al. Radiographic and clinical predictors of bladder rupture in blunt trauma patients with pelvic fracture. *Acad Radiol* 2006; 13: 573–579.
17. Mundy AR and Andrich DE. Pelvic fracture-related injuries of the bladder neck and prostate: their nature, cause and management. *BJU Int* 2010; 105: 1302–1308.
18. Moore EE, Cogbill TH, Jurkovich GJ, et al. Organ injury scaling: III: Chest wall, abdominal vascular, ureter, bladder, and urethra. *J Trauma* 1992; 337–339.
19. Morey AF and Dugi DD. Genital and lower urinary tract trauma. In: Wein AJ, Kavoussi LR, Novick AC, Partin AW and Peters CA (eds) *Campbell-Walsh Urology*. Vol. 3. Philadelphia, PA: Elsevier, 2012, pp. 2507–2520.
20. Mortelmans D, Messaoudi N, Jaekers J, et al. Laparoscopic repair of intraperitoneal bladder rupture after blunt abdominal trauma. *Urol J* 2014; 11: 1338–1340.
21. Tsai C-H, Wang Y-C, Wu S-C, et al. Laparoscopic repair of extraperitoneal urinary bladder rupture after blunt abdominal trauma. *Am Surg* 2012; 78: E385–E386.
22. Kim FJ, Chammas MF Jr, Gewehr EV, et al. Laparoscopic management of intraperitoneal bladder rupture secondary to blunt abdominal trauma using intracorporeal single layer suturing technique. *J Trauma: Injury Infect Crit Care* 2008; 65: 234–236.
23. Mundy AR and Andrich DE. Urethral trauma. Part I: introduction, history, anatomy, pathology, assessment and emergency management. *BJU Int* 2011; 108: 310–327.
24. Basta AM, Blackmore CC and Wessells H. Predicting urethral injury from pelvic fracture patterns in male patients with blunt trauma. *J Urol* 2007; 177: 571–575.
25. Bariol SV, Stewart GD, Smith RD, et al. An analysis of urinary tract trauma in Scotland: Impact on management and resource needs. *Surgeon* 2005; 3: 27–30.
26. Carter CT and Schafer N. Incidence of urethral disruption in females with traumatic pelvic fractures. *Am J Emergency Med* 1993; 11: 218–220.
27. Kong J. Lower urinary tract injuries following blunt trauma: a review of contemporary management. *Rev Urol* 2011; 13: 119–130.
28. Koraitim MM. Pelvic fracture urethral injuries: The unresolved controversy. *J Urol* 1999; 161: 1433–1441.
29. Koraitim MM. Pelvic fracture urethral injuries: evaluation of various methods of management. *J Urol* 1996; 156: 1288–1291.
30. Mundy AR and Andrich DE. Urethral trauma. Part II: Types of injury and their management. *BJU Int* 2011; 108: 630–650.
31. Buckley JC, Wu AK and McAninch JW. Impact of urethral ultrasonography on decision-making in anterior urethroplasty. *BJU Int* 2011; 109: 438–442.
32. Koraitim MM and Reda IS. Role of magnetic resonance imaging in assessment of posterior urethral distraction defects. *Urology* 2007; 70: 403–406.
33. Mundy AR. The role of delayed primary repair in the acute management of pelvic fracture injuries of the urethra. *Br J Urol* 1991; 68: 273–276.
34. Leddy LS, Vanni AJ, Wessells H, et al. Outcomes of endoscopic realignment of pelvic fracture associated urethral injuries at a Level 1 trauma center. *J Urol* 2012; 188: 174–178.
35. Solanki FS, Hussain S, Sharma DB, et al. Primary endoscopic realignment in female urethral injuries with pelvic

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015

fracture can reduce avoidable morbidity. *Indian J Surg* 2012; 75: 31–33.
36. Dorairajan L, Gupta H and Kumar S. Pelvic fracture-associated urethral injuries in girls: experience with primary repair. *BJU Int* 2004; 94: 134–136.
37. Cerwinka WH and Block NL. Civilian gunshot injuries of the penis: the Miami experience. *URL* 2009; 73: 877–880.
38. Chung C, Szeto YK and Lai KK. ''Fracture'' of the penis: a case series. *Hong Kong Med J* 2006; 12: 197–200.
39. Fergany A, Angermeier KW and Montague DK. Review of Cleveland clinic experience with penile fracture. *Urology* 1999; 54: 1–4.
40. Kramer AC. Penile fracture seems more likely during sex under stressful situations. *J Sexual Med* 2011; 8: 3414–3417.
41. Morey AF, Metro MJ, Carney KJ, et al. Consensus on genitourinary trauma: external genitalia. *BJU Int* 2004; 94: 507–515.
42. Garaffa G, Raheem AA and Ralph DJ. Penile fracture and penile reconstruction. *Curr Urol Rep* 2011; 12: 427–431.
43. Feki W, Derouiche A, Belhaj K, et al. False penile fracture: report of 16 cases. *Int J Impot Res* 2007; 19: 471–473.
44. Sawh SL, O'Leary MP, Ferreira MD, et al. Fractured penis: a review. *Int J Impot Res* 2008; 20: 366–369.
45. Antonini G, Vicini P, Sansalone S, et al. Penile fracture: Penoscrotal approach with degloving of penis after Magnetic Resonance Imaging (MRI). *Arch Ital Urol Androl* 2014; 86: 39.
46. Morris SB, Miller MAW and Anson K. Managment of penile fracture. *J Royal Soc Med* 1998; 91: 427–428.
47. Gamal WM, Osman MM, Hammady A, et al. Penile fracture: long-term results of surgical and conservative management. *J Trauma: Injury Infect Critical Care* 2011; 71: 491–493.
48. Phonsombat S, Master VA and McAninch JW. Penetrating external genital trauma: a 30-year single institution experience. *J Urol* 2008; 180: 192–196.
49. Najibi S, Tannast M and Latini JM. Civilian gunshot wounds to the genitourinary tract: incidence, anatomic distribution, associated injuries, and outcomes. *URL* 2010; 76: 977–981.
50. Miles BJ, Poffenberger RJ, Farah RN, et al. Management of penile gunshot wounds. *Urology* 1990; 36: 318–321.
51. Shaeer O. Methylene blue-guided repair of fractured penis. *J Sex Med* 2006; 3: 349–354.
52. Jezior JR, Brady JD and Schlossberg SM. Management of penile amputation injuries. *World J Surg* 2001; 25: 1602–1609.
53. Bhanganada K, Chayavatana T, Pongnumkul C, et al. Surgical Management of an epidemic of penile amputations in Siam. *Am J Surg* 1983; 146: 376–382.
54. Callens N, De Cuypere G, TSjoen G, et al. Sexual quality of life after total phalloplasty in men with penile deficiency: an exploratory study. *World J Urol* 2014; 33: 137–143.
55. Bagga HS, Tasian GE, McGeady J, et al. Zip-related genital injury. *BJU Int* 2013; 112: E191–E194.
56. Mellick LB. Wire cutters and penis skin entrapped by zipper sliders. *Pediatric Emergency Care* 2011; 27: 451–452.
57. Glass AS, Bagga HS, Tasian GE, et al. No small slam: increasing incidents of genitourinary injury from toilets and toilet seats. *BJU Int* 2013; 112: 398–403.
58. Pomeranz M, Schachter B, Capua T, et al. Hair-thread tourniquet syndrome of labia minor. *J Pediatr Adolescent Gynecol* 2009; 22: e111–e113.
59. Ivanovski O, Stankov O, Kuzmanoski M, et al. Penile Strangulation: two case reports and review of the literature. *J Sexual Med* 2007; 4: 1775–1780.
60. El-Bahnasawy MS and El-Sherbiny MT. Paediatric penile trauma. *BJU Int* 2002; 90: 92–96.
61. Cass A and Luxenberg M. Testicular injuries. *Urology* 1991; 37: 528–530.
62. Ramchandani P and Buckler PM. Imaging of genitourinary trauma. *Am J Roentgenol* 2009; 192: 1514–1523.
63. Buckley JC and McAninch JW. Use of ultrasonography for the diagnosis of testicular injuries in blunt scrotal trauma. *J Urology* 2006; 175: 175–178.
64. Bhatt S and Dogra VS. Role of US in testicular and scrotal Trauma1. *RadioGraphics* 2008; 28: 1617–1629.
65. Guichard G, Ammari El J, Del Coro C, et al. Accuracy of ultrasonography in diagnosis of testicular rupture after blunt scrotal trauma. *Urology* 2008; 71: 52–56.
66. Bjurlin MA, Kim DY, Zhao LC, et al. Clinical characteristics and surgical outcomes of penetrating external genital injuries. *J Trauma Acute Care Surgery* 2013; 74: 839–844.
67. McAninch JW and Laing F. Major traumatic and septic genital injuries. *J Trauma* 1984; 291–298.
68. Shyam DC and Rapsang AG. Fournier's gangrene. *Surgeon* 2013; 11: 222–232.
69. Chen S-Y, Fu J-P, Wang C-H, et al. Fournier Gangrene. *Annals of Plastic Surge* 2010; 64: 765–769.
70. Cuccia G, Mucciardi G, Morgia G, et al. Vacuum-assisted closure for the treatment of Fournier’s Gangrene. *Urol Int* 2009; 82: 426–431.
71. McDougal WS. Lymphedema of the external genitalia. *J Urology* 2003; 170: 711–716.
72. Zagli G, Cianchi G, Degl'Innocenti S, et al. Treatment of Fournier's Gangrene with combination of vacuum-assisted closure therapy, hyperbaric oxygen therapy, and protective colostomy. *Case Rep Anesthesiol* 2011; 2011: 1–4.
73. Williams RJ, Fries CA, Midwinter M, et al. Battlefield scrotal trauma: How should it be managed in a deployed military hospital? *Injury* 2013; 44: 1246–1249.
74. Tan B-K, Rasheed MZ and Wu WTL. Scrotal reconstruction by testicular apposition and wrap-around skin grafting. *Br J Plastic Surg* 2011; 64: 944–948.
75. Gomes CM, Ribeiro-filho L, Giron AM, et al. Genital trauma due to animal bites. *J Urol* 2001; 165: 80–83.
76. Talan DA, Abrahamian FM, Moran GJ, et al. Clinical presentation and bacteriologic analysis of infected human bites in patients presenting to emergency departments. *Clin Infect Dis* 2003; 37: 1481–1489.
77. Al-Azzawi IS and Koraitim MM. Lower genitourinary trauma in modern warfare: The experience from civil violence in Iraq. *Injury* 2014; 45: 885–889.

Downloaded from tra.sagepub.com at UCSF LIBRARY & CKM on August 18, 2015