Lower Urinary Tract Trauma: Bladder, Urethra, Genitalia

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Summary

In this chapter of the AUA core curriculum, we describe common trauma to the lower genitourinary system. We divide the particular inciting trauma into penetrating and blunt. We explore the severity grading of each trauma and the most common evaluation techniques. Once a diagnosis is formulated, discuss various surgical and non-surgical options for management of lower genitourinary trauma. We provide pictures, resources and links to anatomic overviews to assist the reader in accessing information about this acute setting.

1. Bladder Trauma

See Core Curriculum section **Bladder**

1.1 Introduction

The bladder is the second most commonly injured organ in the genitourinary system after the kidney. Overall, bladder trauma accounts for 10% of all genitourinary injuries.[1,2] Broadly, bladder injuries result from blunt or penetrating trauma with most bladder injuries caused by blunt force injury. Pelvic fractures are commonly associated with bladder injury due to their proximity. Those bladder injuries associated with bladder wall disruption are categorized based on the location of urine extravasation, which could be extraperitoneal, intraperitoneal, or combined.

1.2 Definition

Bladder injuries result from multiple types of trauma; however, the underlying principle of blunt trauma is that the source of motion transfers its kinetic energy to the bladder. The amount of energy at impact relates to the significance of the resultant injury. **The impact, complications, and management of bladder injuries are highly variable and greatly dependent on the mechanism,**

involvement of surrounding structures, and severity.

a. Blunt injuries: Contusions, lacerations, and rupture
b. Penetrating injuries: Lacerations and rupture
c. Iatrogenic injuries: Partial and full thickness lacerations and penetrations

1.3 Anatomy

See Core Curriculum section **Anatomy & Physiology Bladder**

The bladder sits deep in the pelvis and is protected from injury by the pelvic ring. Retropubic and perivesical fat surround the bladder anteriorly and laterally.[3] The anterior and lateral anatomic arrangements create the space of Retzius. Posteriorly, the anatomic relationships of the bladder differ in the male and female. In men, the posterior bladder is in approximation to the peritoneal covering of the rectum's anterior surface (rectovesical space). In the female, the posterior bladder is in approximation to the anterior vaginal wall and uterus. When full, the bladder projects superiorly out of the true pelvis and loses the surrounding protection. Furthermore, the urachus and remnant tissue attach the bladder to the anterior abdominal wall. The weakest point of the bladder is the attachment of the urachus to the lumen. [3]

The bladder's blood supply arises from multiple laterally based arteries from the internal iliac (hypogastric) artery. The primary arteries that supply the bladder are the superior and inferior vesical arteries. Due to collateral blood flow within the bladder wall, the internal iliac artery can be unilaterally ligated without compromising blood supply to the bladder.[3] Venous drainage of the bladder parallels the arterial supply.[3]

The innervation of the bladder is diffuse and arises from parasympathetic, sympathetic, and somatic nerves.[4] The parasympathetic nerves arise in the sacral spinal cord and travel anteriorly to the bladder.[4] The primary action of parasympathetic nerves on the bladder is excitatory. The sympathetic nerves originate in the lumbar chain and travel anteriorly to the bladder innervating the bladder's anterior and posterior aspects. [3] The actions of the sympathetic nerves on the bladder are both excitatory and inhibitory. The somatic innervation of the bladder arises from the pudendal nerves and has afferent and efferent sensory function.[3] The primary action of the pudendal nerves is on the external urinary sphincter.

1.4 Etiology

Blunt: **Blunt mechanisms cause the majority of traumatic bladder injuries (80-85%) and usually are accompanied by pelvic fracture (83-95%)**.[5] The most common sources include motor vehicle collisions, falls, and industrial injuries. As previously noted, most bladder injuries occur in association with a pelvic fracture, but few (2-11%) of pelvic fractures are associated with bladder injury. [5] Other causes of blunt bladder trauma include direct blows to the lower abdomen.

Penetrating: Penetrating injuries to the bladder are rare, due to the protected nature of the bladder within the pelvis, but can occur from multiple mechanisms, of which gunshot wound is the most

common. [6] These injuries most often involve an entry and exit wound in the bladder and are often accompanied by injuries to the surrounding structures, including vascular, intestines, and rectum.

Iatrogenic: Iatrogenic bladder injuries are also common. Most iatrogenic injuries result from surgical dissection of organs surrounding the bladder with loss of the anatomic planes. Abdominal surgeries that are the most common causes of bladder injury are hysterectomy, followed by Cesarean section and general surgical procedures in the pelvis. [6] Rarely inguinoscrotal hernias will contain the bladder. Since these are frequently asymptomatic, they may be discovered intraoperatively. The risk of bladder injury in these cases is reported to be as high as 12%. Risk factors for bladder involvement in inguinal hernias include: obesity, age over 50, and urinary obstruction. Bladder injuries can result in urine leak or fistula formation if not recognized. In high-risk patients a thorough preoperative workup should be undertaken.[7]

1.5 Presentation

Most bladder injuries resulting from an external etiology present in the context of multisystem trauma. As bladder injuries are not immediately life-threatening, evaluation and resuscitation follow standard trauma protocols. The initial steps in the evaluation include the ABCs - airway, breathing, and circulation.

In the setting of multisystem trauma, providers cannot always obtain information from the patient. However, it is essential to identify the mechanism of injury (blunt versus penetrating) and critical details about the mechanism, e.g., high-speed motor vehicle collision. Physical exam findings are nonspecific and not always helpful in diagnosing a bladder injury, particularly in patients with impaired sensorium, neurologic deficits, or prior lower urinary tract surgery. Nonetheless, a careful abdominal, genital, digital rectal, and vaginal exam are essential to assess for concomitant injuries.

Gross hematuria is the hallmark sign of injury to the bladder. **In patients with sustained blunt force trauma, the combination of pelvic fracture and gross hematuria is associated with a bladder injury in 16-27% of cases**.[8] Bladder rupture in patients with microscopic hematuria and no other overt signs of lower urinary tract injury after blunt trauma is unlikely, so cystogram should not be routinely performed in these patients.[9,10] Penetrating injuries to the bladder do not always produce gross hematuria and need to be evaluated based on the injury's suspected trajectory.[6]

1.6 Diagnosis and Imaging Studies

Figure A: CT Cystogram demonstrating active intraperitoneal extravasation of contrast material. Courtesy of Dr. Faris.

Bladder injury can be diagnosed with imaging or intraoperative evaluation. When performed properly, a stress cystogram is the most accurate test for bladder rupture. Techniques using plain film and computed tomography (CT) are acceptable.[9] **At a minimum, three images of the anterior/posterior pelvis are necessary: views with a scout, when the bladder is filled, and post-drainage. A critical step in performing cystography is adequate distention of the bladder with 300-400 cc of contrast and obtaining images following retrograde contrast administration.** Ideally, patients should have lateral/oblique views of the bladder as well.

A CT cystogram has the same sensitivity as a plain film cystogram when appropriately performed.[10] In a CT cystogram, the bladder is filled with 300-400 cc of dilute contrast, and the Foley catheter is clamped while a CT scan of the pelvis is performed. **It is important to note that CT scans without active distension of the bladder with the retrograde instillation of contrast do not have adequate sensitivity or specificity to diagnose bladder trauma**.[11]

Intraoperative exploration is appropriate and utilized during damage control surgery in hemodynamically unstable trauma patients taken directly to the operating room without imaging. **Exploration mainly serves to diagnose intraperitoneal injuries at the dome and superior bladder. Surgical exploration of the space of Retzius or the deep pelvic retroperitoneum is not advisable immediately after severe blunt force pelvic trauma due to the risk of exsanguination from myriad pelvic veins** .

Another diagnostic test that can be helpful in the intraoperative evaluation of bladder injury is cystoscopy. Direct visualization of the bladder lumen reveals subtle tears or the presence of a foreign body like a bullet or penetrating bone fragments. In some circumstances, retrograde pyelograms may be indicated to evaluate for ureteral injury, especially with penetrating injuries to the bladder base.

Furthermore, in patients with anterior pelvic ring fractures, such as inferior rami and pubic symphysis diastasis, one should consider evaluation of the urethra with a retrograde urethrogram to diagnose unrecognized urethral injury in a patient with hematuria and no evidence of bladder injury on diagnostic imaging.

1.7 Management

See Reference 12

General Concepts:

Extraperitoneal injuries are the most common, occurring approximately 63% of the time, followed by intraperitoneal in 32% of cases. Combination injuries are seen in 4.2% of cases.[13]

Intraperitoneal injuries: Intraperitoneal injuries that result from external trauma need to be surgically repaired as soon as feasible.

Extraperitoneal Injuries: Extraperitoneal injuries, in contrast, can often be managed conservatively by catheter drainage. Smaller extraperitoneal injuries heal rapidly with catheter drainage. Due to the invariable bacterial colonization that will occur with an indwelling catheter, surgeons should provide antibiotics with gram-negative coverage.[14]

However, not all extraperitoneal bladder injuries should be managed conservatively. Complications are most likely to develop for those ruptures managed conservatively with concomitant urethral or bladder neck injury.[15] **Therefore, contra-indications to non-operative management of extraperitoneal bladder rupture include inadequate catheter drainage (e.g., clots, persistent leak), vaginal or rectal injury, and bladder neck or urethral injury.**[9,16] Ongoing hematuria can lack adequate drainage of the bladder due to obstructing clots and poor wound healing. Concomitant rectal or vaginal injury can result in a vesicle fistula with long term sequelae. Massive pelvic trauma with extensive bladder injuries can result in urinary extravasation into perineal injuries or the medial thigh. Again, these injuries may fistulize outside the body, and initial repair is advisable at the time of the injury or shortly after.[16] There are a variety of ways the bladder neck can be lacerated ranging from a simple linear laceration through the bladder neck and prostate to complete avulsion of the bladder neck. **Bladder neck involvement can result in bladder neck incompetence causing persistent incontinence or internal fistulae; thus repair is warranted**.[17] A formal bladder repair is warranted when extraperitoneal bladder injuries are associated with protruding pelvic bone fragments or an intraluminal foreign body (bullet or shrapnel). These findings will compromise the healing of the bladder. A repeat bladder repair is warranted when patients have persistent urinary extravasation from the original bladder repair. The decision to re-operate depends upon the degree of persistent extravasation, the possibility of an unrecognized injury, and the

patient’s clinical state.

Penetrating injuries, such as gunshot wounds, are explored and repaired immediately due to the high likelihood of injury to surrounding structures. These indications include: the need for accurate assessment of the ureters, treatment of both the entry and exit wound, and evaluation and repair of injuries to the rectum, bowel, or named vascular structures. [6] The recent WSES-AAST Kidney and Urotrauma Guidelines state that some uncomplicated penetrating extraperitoneal bladder injuries may be managed conservatively. [18]

Relative indications for bladder repair are patients undergoing laparotomy for other reasons or orthopedic hardware placement into the pelvis in areas of bladder injury. The latter is essential due to the disruption of the space of Retzius from pelvic injury and poor containment of urinary leak or the potential for contamination of the pelvic hardware.

Operative repair of bladder injury:

The lower abdominal midline approach is the preferred operative approach to intraperitoneal and extraperitoneal bladder injuries. Intraperitoneal injuries should be readily apparent along the peritoneal surface of the bladder at the bladder dome. **In patients with concomitant pelvic fracture, it is crucial to open the intraperitoneal injury wide enough to confirm that there are no concomitant extraperitoneal injuries that require repair**. Combined intraperitoneal and extraperitoneal injuries can occur in severe pelvic trauma. [19] **The safest approach to repairing extraperitoneal injuries in patients with pelvic fracture is transvesical or through the bladder lumen**. The surgeon can accomplish the exposure by creating a sizeable anterior cystotomy along the bladder’s peritoneal surface that allows visualization of the bladder’s entire lumen. [20] The ureteral orifices can then be visualized and if there is concern for ureteral injury, ureteral stents can be placed or a retrograde imaging can be performed.

In this fashion, the pelvic hematoma is left undisturbed lessening the chance of severe and uncontrollable bleeding. It is advisable to wait in hemodynamically unstable patients until the patient is fully resuscitated to repair these injuries. [21]

Most surgeons will close the bladder in multiple layers using absorbable suture to prevent calculi formation on permanent suture exposed to urine. The surgeon may also use a flap of peritoneum or omentum as an adjunct to tenuous repairs or if the repair is near another injured organ to aid in wound healing and avoid fistulization by providing a well-vascularized tissue layer. After closure, a closed suction drain should be left in the perivesical space to alert the surgeon to continued urinary extravasation and delayed infection risk. A suprapubic cystotomy tube is usually not needed for uncomplicated repairs to the bladder. [9,22] Suprapubic tubes should be considered in patients with complicated repairs, significant hematuria, or in patients who are likely to need prolonged [9] catheterization. Surgeons may utilize additional antibiotic therapy after bladder repair, given the inherent contamination associated with an indwelling catheter.

Follow up imaging of bladder injury:

Radiologic follow-up confirms that a bladder injury has healed regardless of whether the bladder

injury was repaired or managed conservatively. **Imaging is typically done in 10-14 days but can be extended to 3 weeks for severe injuries**.[23] Post-injury testing or imaging can include a cystogram, a CT cystogram or cystoscopy.[24] Cystoscopy may be the least sensitive for small leaks along a suture line.

1.8 Complications

The most common complication of bladder injury is persistent urinary extravasation usually due to poor wound healing, technical error in bladder repair, or unsuccessful conservative management (**Table 1**). Often, small persistent leaks will heal through additional catheter drainage without sequelae.[19] Severe long-term complications may result from persistent urinary extravasation and ultimately can require urinary diversion in rare cases.[25] When the surgeon identifies persistent urinary extravasation, they should further investigate for bony spicules or a foreign body within the bladder. Unrepaired urine leaks can result in communication of the surgical site containing pelvic orthopedic hardware or fistulization to the bowel, vagina, or skin.

Table 1: Extraperitoneal injuries and the rate of conservative management and the associated complications

Studies	Total	Conservative	Complications	Major Complications
Wirth et al,[26]	22	10 (45%)	2 (20%)	Osteomyelitis and leak (1) Persistent leak and hematuria (1)
Kotkin et al,[25]	36	29 (81%)	7 (26%)	Persistent urinary extravasation (4) Vesico-cutaneous fistula (2) Infected pelvic hematoma (1)
Cass et al,[27]	87	34 (40%)	2 (6%)	Persistent urinary extravasation (2)
Corriere et al,[23]	62	41 (66%)	5 (12%)	Persistent urinary extravasation (5)
Total	**203**	**114 (56%)**	**16 (14%)**	

Other complications can include urinary incontinence or neurogenic bladder from pelvic nerve injury. Bladder dynamics mirror those in pelvic nerve injury from cauda equina or after low colorectal surgery. In these patients, the bladder becomes non-compliant or fibrotic and the urinary sphincter may either be dyssynergic or incompetent. Overall mortality rate for bladder rupture is 8%.

Long-term complications include pelvic pain, hematuria, or infections due to eventual erosion of pelvic hardware or bony callous into the bladder. Patients may present many years or even decades after pelvic fracture and require surgical management for correction.

2. Urethra Trauma

2.1 Introduction

The urethra is not commonly injured from external violence and accounts for 4% of all genitourinary trauma.[28] The vast majority of urethral injuries are the result of blunt force trauma; however, a minority of injuries do result from penetrating trauma. [29] For anatomic categorization in instances of injury, the urethra is divided into the anterior and posterior segments at the level of the genitourinary diaphragm. [29] **Due to anatomic location, each segment has very different sources of injury and initial treatment options.** Most urethral injuries occur in men due to the longer overall urethral length and higher incidence of traumatic injuries in men.[9] Based on single center series, common mechanisms of blunt urethral trauma are motorcycle crash and sexual injury with a majority of men presenting with concomitant scrotal injury.[30]

2.2 Definition

Urethral injuries result from many different trauma sources, and some are unique to this segment of the lower urinary system. These injuries are dependent on the anatomic location (anterior versus posterior), etiology, and severity of the traumatic injury. **The impact, complications, and management of urethral injuries are highly variable and greatly dependent on the mechanism, involvement of surrounding structures, and severity.**

a. Blunt injuries: Contusion, and avulsions.
b. Penetrating injuries: Laceration, transection, and blast injury with delayed stenosis.
c. Iatrogenic: Result from endoscopic injuries and instrumentation. These range from minor mucosal abrasions to lacerations and penetrations, and thermal injury.

2.3 Anatomy

See Core Curriculum section: **Anatomy & Physiology Penis, Female, Urethra**

The male urethra is anatomically divided into two areas: anterior and posterior. As both the anterior and posterior segments are attached to the genitourinary diaphragm, this is the point of anatomic differentiation. [31] The anterior urethra, from distal to proximal, is comprised of the fossa navicularis, penile or pendulous, and bulbar segments. The penile urethra and fossa navicularis comprise slightly more than half of the distal anterior urethra and are external to the body in the

penis. This location limits injury to this segment of the urethra. The posterior urethra is composed of two segments, membranous and prostatic. These segments are intimately related to the bony pelvis and are injured more frequently in pelvic fractures. [31]

The blood supply to the urethra arises proximally from the internal pudendal artery.[3] This artery becomes the common penile artery that terminates into the bulbourethral artery. The common penile and bulbourethral arteries are the main blood supply to the urethra. **The bulbourethral arteries arborize in the glans of the penis to provide retrograde perfusion of the urethra when the bulbar arteries are transected.** The urethra is further supplied by small perforating arteries that pass through the corporal bodies and enter the dorsal urethra at its attachment along the dorsum or inferior aspect of the corporal bodies. The venous outflow of the urethra parallels the arterial supply.

2.4 Etiology

Blunt: **The majority of urethral injuries are the result of blunt force trauma. The anterior urethral segment most commonly injured is the bulbar urethra, which occurs in 85% of anterior urethral injuries**.[29,31] Typically, these injuries result from a straddle type fall or direct blow to the perineum and are usually isolated injuries. During a penile fracture, the force tearing the corporal body could injure the pendulous urethra's corpus spongiosum. Posterior urethral injuries due to blunt mechanisms are almost uniformly associated with pelvic fracture. **Approximately 3-6% of male and female patients with pelvic fracture have associated posterior urethral injuries**.[24] This injury results from stretching and shearing forces at the level of the membranous urethra resulting in bulbomembranous disruption.[32,33] Patients that sustain a urethral injury after blunt pelvic fracture are often severely traumatized suffering multi-system trauma and having high injury severity scores.[34,35] These patients can have a high mortality rate in the acute trauma setting.[35]

Penetrating: Most penetrating injuries to the male anterior urethra result from gunshot wounds or stab wounds. Approximately 3% of gunshot wounds to the genitourinary system involve the anterior urethra.[36] **Additionally, 40-50% of patients with penetrating wounds to the penis have concomitant injuries to the urethra.**[37] Penetrating posterior urethral injuries have a similar mechanism to anterior, although impalement injuries can occur in this area. Furthermore, penetrating injuries in this location are associated with injuries to surrounding structures such as the rectum and pelvic vasculature.

Iatrogenic: Injuries to the male anterior urethra and female urethra often are the result of urethral catheter placement. No true incidence is known but analysis have shown an incidence of 3.2 per 1000 patients.[28] Male posterior urethral injuries are more often related to instrumentation of the urethra during primarily endoscopic surgical procedures.[31]

2.5 Presentation

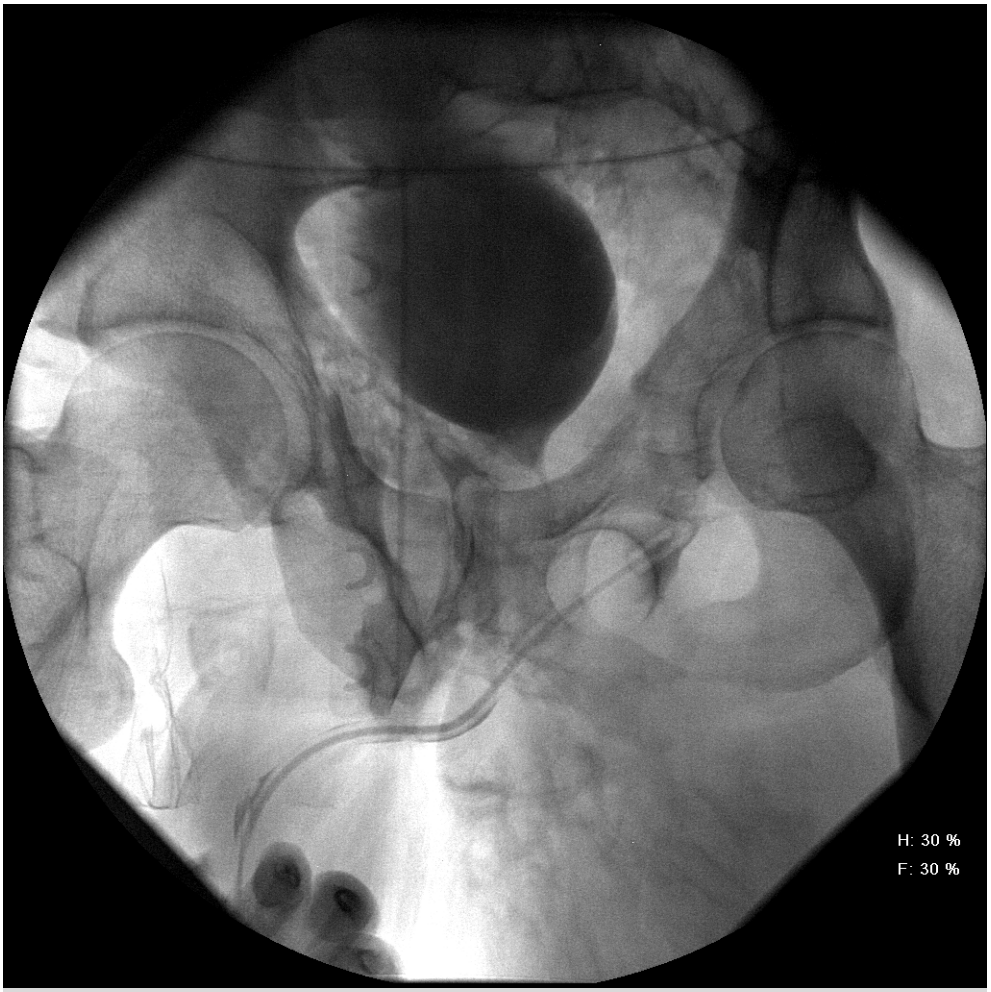

Figure 1: Inadvertent placement of Foley catheter into pelvic hematoma

Based on the anatomic differentiation of the male urethra, urethral injuries have a variable presentation.

Anterior: Blunt urethral injuries secondary to straddle injuries or direct blows to the perineum may present as isolated injuries, and these patients relate a history of perineal trauma. **Most of these injuries are located in the mid-perineum, where the urethra is crushed against the pubic arch.** A subset of these injuries result when the penis is crushed against the pubic symphysis causing a distal pendulous urethral injury. Penetrating injuries present with obvious wounds to the perineum or penis.

Posterior: Posterior urethral injuries from external violence present in the context of severe multisystem trauma. Urethral injuries are not immediately life-threatening and patient evaluation should follow AAST (American Association for the Surgery of Trauma). The initial steps in the evaluation include the ABCs - airway, breathing, and circulation. Although patients may not be directly interviewed, providers should obtain information concerning mechanism of injury, blunt versus penetrating, and details of that mechanism, i.e. high speed motor vehicle collision or high velocity missile injury. Physical examination of these patients is difficult, especially in blunt trauma, as posterior urethral injuries are highly associated with pelvic fracture, and up to 15% of these have

associated bladder injury. [9] **Patients with the combination of blood at the urethral meatus, inability to void, and pelvic fracture should be presumed to have a posterior urethral injury.**

Female: Female urethral injuries are associated with 0-6% of patients with pelvic fracture.[14] Females with urethral injury may have hematuria or vaginal lacerations. Other associated findings may include labial edema or urethrorrhagia.[29]

Physical Exam Findings:

The classic triad of blood at the urethral meatus, inability to void, and a palpably distended bladder is uncommon in clinical practice. Blood at the urethral meatus is variable in presentation and occurs in 37-93% of patients.[38] However, in those patients who do present with blood at the urethral meatus, especially in pelvic trauma, evaluation of the urethra is mandatory.[9] Patients with bulbar urethral injuries may present with a perineal hematoma. This hematoma is confined by Colles' fascia, which is continuous with Scarpa's fascia and contiguous with the dartos fascial layers.[39] **The hematoma can have a classic appearance of a butterfly within the perineum, due to rupture of Buck's fascia, and can spread into the scrotum or up the abdomen along the layers of Dartos and Scarpa's fascia**. Patients with posterior urethral injuries may have a "high-riding" or ballotable prostate on exam if the apical prostate has been detached from the genitourinary diaphragm from severe pelvic trauma.

The inability to pass a catheter following pelvic trauma can be a hallmark of a severe urethral injury. In this instance, the catheter is passed inadvertently into the pelvic hematoma before the urethral injury is recognized. (**Figure 1**)

2.6 Diagnosis and Imaging Studies

Figure 2: A full transection of the posterior urethral from pelvic fracture

Imaging:[40,41]

Male urethral injury, both anterior and posterior, is typically assessed with radiologic imaging. **When a urethral injury is suspected, a retrograde urethrogram is performed**. This studies key element is the placement of the patient in a 30-45% lateral decubitus position to ensure adequate visualization of the entire urethra.[29] Partial injuries to the urethral lumen will reveal some contrast extravasation coupled with the passage of a variable amount of contrast into the bladder's lumen. There is a dramatic bloom of urinary contrast extravasation at either the bulbomembranous junction or the prostatic apex in patients with complete urethral transection. (**Figure 2**)

Another key consideration in urethral injury imaging is the pattern of pelvic fracture. In its simplest form, pelvic fractures that produce urethral injury involve the anterior arch of the pubis. The anterior pelvic arch can be disrupted in various combinations, either involving the diastasis of the symphysis pubis, fracture of the rami of the anterior pubic arch, or a combination of both.[42] **Specific fractures associated with a greater risk of urethral injury are pubis symphysis diastasis and inferior pubic rami fracture, especially in the medial aspect of the rami**.[43,44] Recognizing these high-risk fractures can help in raising the suspicion of injury, along with the other signs of urethral injury.

In patients with a urethral injury accompanied by a pelvic fracture, it is essential to evaluate for a

concomitant bladder injury. **Combined bladder and urethral injury is found in 10-29% of patients with bladder injury and pelvic fracture.**[45] Providers should evaluate patients with persistent gross hematuria following catheter or suprapubic tube placement with plain film or CT cystogram.

Diagnostic testing:
Cystoscopy may also diagnose a urethral injury. If a patient is hemodynamically unstable or has penetrating trauma and is taken directly to the operating room, limited cystoscopy can be performed to inspect the urethra.[39] In patients with partial urethral injury, cystoscopy may also facilitate Foley catheter placement.

Surgeons should consider a concomitant rectal injury in patients with penetrating injuries to the posterior urethra. Anoscopy is often performed to rule out a rectal injury in this circumstance. In female patients with pelvic fracture, surgeons should include examination and evaluation for a urethral injury. In this patient population, retrograde urethrogram is not technically feasible for assessing the urethra in pelvic trauma. **The best diagnostic test is a direct examination by cystoscopy using either a flexible cystoscope or specialized rigid scope without a cutback beak** .[46]

2.7 Management

See Reference 47,48

Anterior urethra: The initial management of anterior urethral injuries varies based on mechanism. In blunt urethral injuries, the primary objective is a urinary diversion performed using either urethral Foley catheter placement or suprapubic cystostomy tube placement. [9,49] Often, catheter placement requires cystoscopic guidance or realignment.

Penetrating injuries should have an immediate operative intervention. Patients with limited tissue loss and injury from either a low-velocity gunshot or stab wound, primary surgical repair are indicated.[9,49] Surgeons repair penetrating injuries by creating a spatulated primary repair using absorbable suture. For injuries with significant tissue loss, urinary diversion only is performed.[50] Furthermore, hemodynamically unstable patients should be fully fluid resuscitated prior to surgical intervention for urethral injuries.

Posterior urethra: The location of pelvic fracture urethral injuries can vary within the posterior urethra. These injuries occur distally beyond the external sphincter or can involve the prostatic apex, just proximal to the external sphincter.[51,32] he location of the injuries is mainly dependent upon the nature and location of the pelvic fracture and the ligamentous attachments to the prostate.[17] The immediate goal in the management of complete urethral disruption is to obtain urinary drainage, usually with suprapubic tube placement.[9] Although controversial, some advocate endoscopic realignment of the urethra when stable from their pelvic injury.[9] Primary realignment may decrease the risk of stricture formation, but It is unclear if there is significant benefit and experts do not recommend prolonged efforts to accomplish realignment.[52] If realignment is attempted, it may require the use of both retrograde and antegrade endoscopy.[53] Indeed, **urotrauma guidelines recommend clinicians**

perform percutaneous or open suprapubic tube (SPT) placement as initial management for most pelvic fracture urethral injury (PFUI) cases.[54] Given the high rate of stricture formation even when primary realignment is performed, continued suprapubic catheter for a time period after the foley is removed should be considered.

Immediate operative repair of posterior urethral injuries is not indicated. Posterior urethral injuries are well suited to “damage control” maneuvers, and many adjunct and reconstructive procedures are well-described options.[21] Most experts agree that immediate repair of these injuries can be dangerous and leads to an unacceptably high restenosis rate.[14] Exceptions to this are bladder neck injuries or extension of a bladder or bladder neck injury into prostatic urethra’s anterior portion within the pelvis.[55]

Surgical technique

Given the complexity of repair of a pelvic fracture urethral injury, this should be undertaken by an experienced surgeon in a high-volume center. Urethroplasty should be delayed for at least 6 to 12 weeks to allow for decrease in inflammation. A perineal approach is normally sufficient, but occasionally abdominal access is also required. Depending on the length of the defect there are several additional maneuvers that can be utilized including: urethral mobilization, coporal splitting, pubectomy, and urethral rerouting. These are employed in a stepwise fashion depending on the additional length needed. Using this approach success rates of over 90% can be achieved.[56]

Female urethra: Due to frequent association with vaginal lacerations, female urethral injuries are repaired at the time of presentation unless the patient is hemodynamically unstable. **Repair is recommended during the initial hospital course to minimize the chance of post-injury urinary incontinence or the development of a urethrovaginal fistula**.[57] Injuries of the distal female urethra may be managed expectantly or formalized and made hypospadiac as the continence mechanism is usually spared.

2.8 Complications and Long-term Outcomes

Podcast: **AUA 2019 Crossfire Controversies in Urology Primary Bulbar Stricture DVIU**

Urethral: Serious long-term sequelae often accompany traumatic urethral injury. Although some injuries, especially partial urethral injuries, can heal without subsequent scarring, most urethral injuries are associated with dense fibrosis in the intervening gap created by transection. Urethroplasty is the most appropriate therapy to reestablish a patent urethra after traumatic injury.[34,56,58,59] The outcomes of posterior urethroplasty are excellent with an average success rate of approximately 89%. (**Table 2**)

Other complications include formation of a diverticulum, infected urinoma or fistulization to the perineum or rectum.

Table 2: Outcomes posterior urethroplasty after pelvic fracture.

Study	N	Follow-up (mean)	Strict Success
Johnsen, et al, 2019	122	7 months	91%
Cooperberg, et al, 2007[34]	134	2.75 years	86%
Kizer, et al, 2007[58]	142	> 1 year	92%
Koraitim 2005[59]	155	13 years	90%
Flynn, et al, 2003[56]	122	5.3 years	89%
Corriere 2001[60]	63		63%
Ennemoser, et al, 1997[61]	31	9.2 years	100%
Mundy 1996[62]	82	> 5 years	88%
Webster, et al,1991[63]	74		96%
Total	803		89%

The overall success of the operations was greater as men with recurrent strictures were often treated successfully with endoscopic treatments or re-do urethroplasty.

View Image.

Erectile dysfunction: Erectile dysfunction is common after pelvic fracture associated urethral injury, but the published incidence varies considerably, and likely reflects differences in patient populations and definitions of erectile dysfunction (**Table 3**).[64,65,66] Typically, erectile dysfunction after pelvic fracture is attributed to injury to the parasympathetic nerves as they travel along the lateral border of the prostate. Rarely, erectile dysfunction in these patients is purely arteriogenic, resulting from damage to the internal pudendal artery from trauma or embolization. [67] It is important to identify these patients, as they are at a higher risk of failure after urethroplasty. Erectile dysfunction may recover over time but can take up to 2 years to occur. [68]

Table 3: Percentage of men with erectile dysfunction after posterior urethral injury and recovery of erectile function post operatively

Study	N Total	Pre-op ED	Post-op recovery
Koraitim 2005[59]	110	44 (40%)	29/44 (66%)
Flynn, et al, 2003[56]	117	65 (56%)	6/65 (9%)
Corriere 2001[60]	60	29 (48%)	9/29 (31%)
Morey, et al, 1997[69]	82	44 (52%)	15/44 (34%)
Webster, et al, 1991[63]	52	33 (63%)	3/33 (9%)
Total	**421**	**215 (51%)**	**62/215 (29%)**

View Image.

Incontinence: Incontinence is a rare consequence of urethral injury. While the external urinary sphincter is damaged in nearly all cases – because of the initial trauma or the urethroplasty – the bladder neck is typically intact. However, if there is an initial concomitant bladder neck or serious pelvic nerve injury, incontinence can occur after posterior urethroplasty for pelvic fracture-related urethral injury.[70] Close attention to the pre-operative voiding cystogram may reveal an incompetent bladder neck and predict this problem pre-operatively.

3. Genitalia

3.1 Introduction

Genital trauma encompasses a wide variety of injuries making it difficult to classify and standardize treatment. Genitourinary trauma includes blunt and penetrating sources. Examples of genitourinary trauma include burns, bites, and avulsions involving the penis, testicles, scrotum, and perineum in the male and vulva in the female. Few epidemiologic studies exist to determine the incidence of genital trauma, and the incidence varies widely. Approximately 28-68% of patients with injuries to the genitourinary system have injuries the external genitalia. [28] The majority of external genital trauma is blunt; however, 40-60% of penetrating injuries to the genitourinary system involves the external genitalia.[71] **While these injuries are rarely life-threatening, the long-term sequelae of the injuries – impaired fertility, decreased sexual function, physiologic endocrine changes, and psychiatric – in a predominately young population require prompt treatment and close follow-up**.

3.2 Definition

As noted above, external genital injuries encompass a wide spectrum of types, etiologies and severity of injuries. **The impact, complications, and management of external genital injuries are highly variable and greatly dependent on the mechanism, involved structure or organ, and severity.**

a. Blunt injuries: Contusion, avulsion, and burns
b. Penetrating injuries: Laceration, amputation, and bites

3.3 Anatomy

See Core Curriculum **Anatomy & Physiology Testis, Epididymis, Vas Deferens**

The male external genital structures lie external and inferior to the bony pelvis. The male genital structures are connected to the body through the anterior perineum, specifically the male genitourinary triangle. The scrotum is attached to the anterior apex of the triangle and overlies Colles' fascia. The root of the penis, consisting of the paired corporal bodies and the corpus spongiosum, attaches medially to Colles' fascia. The testes lie within the scrotum and are suspended by the spermatic cords, which enter the groin from the inguinal rings bilaterally. The epididymis is a paired structure lying posterolateral on the testis and has an internal structure of a tubule or duct that

coalesces to become the vas deferens.

The internal iliac artery provides the majority of the blood supply to the perineum through the primary feeding branch is the internal pudendal artery. The venous drainage mirrors the arterial inflow. **The exception is the blood supply to the testicles and adjacent structures, which are supplied by the testicular arteries that branch directly off the aorta in the retroperitoneum.**

Innervation of the genitalia is more complex, reflecting the overlapping nature of the nervous system. **The majority of nervous supply arises in the lumbosacral plexus.** The perineum, posterior scrotum, and penis are innervated by the pudendal nerve branching from the sacral plexus. The sensory input from the anterior scrotum and tunica vaginalis is supplied by the genitofemoral nerve arising from the lumbar plexus. The visceral nerve supply to the testes and epididymii arise from the aortic and renal plexuses or the pelvic plexus which supplies the vas deferens.

3.4 Etiology

See Reference 72,73

Penis:
Penile injury is uncommon due to the flaccid and mobile nature of the penis and scrotum. Penile injuries fall into one of three categories: blunt, penetrating, or amputation.

Blunt: Blunt injury to the erect penis may result in penile fracture or tear of the corpora cavernosa, which is the most common form of penile injury requiring surgical intervention. Many fractures result from the erect penis striking the pubic bone or perineum during sexual intercourse.[14] Another well-described injury occurs during “taghaandan”, in which detumescence is achieved by forcibly pushing the erect penis down.[74] There has been an increase in penile fractures in patients who have undergone treatment with Collagenase Clostridium Histolyticum for Peyronie’s disease. Corporal fractures can be seen in 0.5-4.9% of patients after injection.[75]

Penetrating: Penetrating injuries to the penis most commonly result from gunshot wounds, though stab wounds comprise more than 40% of penile injuries in some series. In a civilian environment, most gunshot wound injuries result from low-velocity missiles, which impart less kinetic energy transfer. The majority of these patients have associated non-urologic injuries, 54-80%.[37,71]

Amputation: Amputation injuries are usually self-inflicted and associated with severe, untreated mental illness.[9]

Testis:
The testes are protected from trauma by the scrotum’s mobility, a dense surrounding sheath (tunica albuginea), and the retractile nature of the cremasteric muscles.[76] Nonetheless, testicular injury can result in loss of fertility and sexual function if not treated promptly. The diagnosis and management of suspected testicular trauma vary depending on the type of trauma.

Blunt: Testis injuries are usually the result of blunt trauma and can involve a spectrum from a contusion to total parenchymal loss. Blunt trauma accounts for 50-85% of testicular injuries, and

many injuries are the result of sports and athletic activities.[9,76]

Penetrating: Although less common, penetrating testicular injuries are often more severe, associated with bilateral injuries in up to 30% of patients and non-genital associated injuries in up to 80% of patients.[14,77] Blast trauma is an uncommon cause of penetrating testicular injury in the civilian setting, but accounts for up to 10% of injuries in combat environments and often involves both testicles.[28]

Scrotum:
Genital and scrotal skin injuries are typically the result of either mechanical shearing injury or burn injury. A burn injury can be the result of thermal, chemical, or electrical injury. In combat environments, significant blast and penetrating injuries can result in skin loss.

Blunt: Blunt injuries to the scrotum are often the result of direct impact during athletic activities.[76] More significant skin injuries can result from severe motor vehicle collisions or industrial accidents.[78]

Penetrating: Scrotal trauma from penetrating injuries can result from gunshots, stab wounds or other projected missiles. Due to the scrotum's external location, a unique penetrating injury to the genitalia are bite injuries from both human and animal sources with resultant skin loss.[71,79,80] In a military setting, the nature of injuries has changed due to the increased use of improvised explosive devices (IED's). Military medical professionals more commonly evaluate injuries from projectile fragments, rather than bullets, or other fired missiles.[81,82]

Burns/Infection: As the scrotum is an externalized structure covered with hair-bearing skin, the scrotum is susceptible to the same burn injuries elsewhere on the body, including thermal, chemical, and electrical. Furthermore, progressive infections of the skin and subcutaneous tissues can result in significant skin loss.

Perineum:
Blunt: The perineum is susceptible to the same injuries and mechanisms as scrotal trauma. However, due to the location of the perineum, isolated avulsion and shearing injuries of the perineum are uncommon.

Penetrating: Perineal injuries are very rare and usually involve penetrating mechanisms, most commonly gunshot wounds. Due to the size and location of the perineum, these injuries often involve surrounding structures.[83] The most common associated injuries are to the anus and rectum.[84]

3.5 Presentation

Figure C: Penile injury involving wood shard. Courtesy of Dr. Faris

Figure B: Classic eggplant deformity associated with penile fracture. Courtesy of Dr. Faris

See Reference 85

See **AUA Update Series: Diagnosis and Management of the Acute Scrotum**[85]

Penis:

Blunt: **The classic patient history of a penile fracture includes the description of popping or cracking sound followed by rapid detumescence, pain and penile swelling** The classic physical

exam appearance is referred to as an “eggplant” deformity because of the severe swelling and ecchymosis that invariably occurs deep to Buck’s fascia after a penile fracture. In cases where the urethra is also injured, there may be blood at the urethral meatus or inability to urinate.

Penetrating: Penetrating trauma may involve surrounding structures. This is most commonly the soft tissues of the thigh, although urethral and scrotal structures may be involved. **Up to 40-60% of penetrating injuries to the genitourinary system involves the external genitalia**. Providers should evaluate for urethral injury in patients who present with blood at the urethral meatus or the inability to urinate.

Testis:
Blunt: Blunt trauma directly to the scrotum can present with scrotal ecchymosis, swelling, and potentially hematoma. The historical details usually reveal a significant strike to the scrotum directly, or glancing blows from the thigh or groin. Industrial or shearing injuries present with significant genital skin loss and exposed testes either with or without intact tunica vaginalis.

Penetrating: Civilian penetrating injuries typically present with focal scrotal tissue damage and similar physical findings of scrotal ecchymosis, swelling, and potentially hematoma. **When surgeons explore a penetrating scrotal wound, 40-60% of patients also have a penetrating injury to the testis**.[9]

Scrotum:
Scrotal injuries have a very similar presentation to blunt and penetrating testicular injury. Patients who have burn injuries should be evaluated as a patient sustaining a thermal, electrical, or chemical burn. Scrotal and genital skin loss is usually dramatic and often associated with significant multisystem trauma.

Perineum:
We divide perineal injuries into blunt and penetrating mechanisms. Blunt perineal injuries usually present similarly to scrotal injuries and involve significant trauma with skin loss. Isolated burns to the perineum are rare and usually present in association with larger body surface area burns.[78] More frequently (although still uncommon), perineal injuries result from penetrating trauma and result from missiles or impalement of the perineum.

3.6 Diagnosis and Imaging Studies

See Reference 86,87,88,89,90,91

See **AUA Update Series: Genitourinary Trauma, Vol 34, Lesson 18, 2015**

See **AUA Update Series: Injuries and Wounds of the External Genitalia, Vol 37, Lesson 4, 2018**

See **AUA Update Series: Lessons Learned in Military Urotrauma, Vol 38, Lesson 24, 2019**

Evaluation of the patient sustaining genital trauma should include history and physical examination, laboratory evaluation (urinalysis), and radiologic imaging (plain films, ultrasonography, and CT scan) as appropriate. Physical examination of male genitalia following pelvic, perineal, or lower extremity

trauma is the most important aspect of patient evaluation. Key physical findings include ecchymosis or hematoma of the any of the external genitalia (penis, scrotum, or perineum) and injury or loss of the overlying skin. **It is important to remember that history and physical examination in trauma patients are guided by ATLS principles, and initial assessment of airway, breathing, and circulation (ABCs) are paramount. In trauma limited to the external genitalia, further evaluation is not always indicated**.

Specific evaluation of the penis and urethra resulting from a traumatic injury usually are dictated by history and physical findings. More importantly, however, it is for the treating physician to remember that in severely injured patients with multisystem trauma, life threatening injuries dictate evaluation and management.

It is imperative that evaluation of urethral, rectal and bladder injury is performed early in the patient's hospital course. Appropriate methods of evaluation for urethral injuries include retrograde urethrogram and urethroscopy. Rectal and bladder injuries can be evaluated with direct endoscopic inspection or directed radiographic studies, i.e. cystography for bladder injuries and contrast enhanced cross sectional imaging for rectal evaluation.

Penis:

Blunt: In those patients with severe discomfort or an equivocal physical examination and history, ultrasonography or magnetic resonance imaging can assist with diagnosis and evaluation of the integrity of the corpora cavernosa. **In patients with hematuria or inability to void, a qualified medical professional should perform a urethral evaluation by either retrograde urethrogram or cystoscopy.**

Penetrating: The team should strongly consider a urethral evaluation using retrograde urethrogram in patients with penetrating penile injuries or those patients with injuries in proximity to the urethra and inability to void or hematuria. If radiographic imaging will delay treatment in these patients, cystoscopy in an operative setting can adequately evaluate the urethra's integrity.

Testis/Scrotal:

Blunt: Initial evaluation of blunt testicular injury should include a detailed history and focused physical exam, though examination in these patients can be difficult due to scrotal swelling, pain, and ecchymosis. **In these patients, the use of ultrasound provides significant adjunct findings, including heterogeneous echotexture of the parenchyma, hematocele and testicular contour loss**.[9,92] In patients with concerning physical exam findings and equivocal ultrasound examinations, experts recommend surgical exploration.[76]

Penetrating: The clinical presentation dictates the evaluation of the patient with penetrating testicular trauma. Those who are hemodynamically stable can undergo full historical and physical examination. Hemodynamically unstable patients will require tailored evaluation for life-threatening injuries. It is imperative that evaluation for urethral, rectal and bladder injury is performed early in the patient's hospital course. Ultimately, there is a high rate of testicular injury for penetrative trauma and very

limited sensitivity of ultrasound. [54]

3.7 Management

True penile injuries typically require operative management to improve sexual function outcomes and cosmesis. [9]

Penis:

Blunt: When a penile fracture has been confirmed or cannot be ruled out, a urologist should perform prompt surgical exploration and repair.[9] Conservative management results in an increased risk of erectile dysfunction, curvature,[93] and painful erections. The surgeon exposes the injured corpus cavernosum to fully visualize the injury. The exposure is typically attained through a circumcising or midline ventral scrotal incision that is extended laterally at the distal end of the incision ("hockey stick"). The latter approach is particularly useful for proximal injuries. Surgeons repair the corporal injury with slow absorbing suture. If a urethral injury is also present, it should be repaired with absorbable suture and a catheter left in place. There is debate among experts about whether surgical repair is needed in penile fractures after injection with Collagenase Clostridium Histolyticum, with some opting for conservative management. [94]

Penetrating: Management of these injuries requires surgical exploration of the wound with debridement and repair of the associated corpora cavernosal injury and overlying skin. As with blunt injuries, repair is performed with slow absorbing suture. If repair is not feasible, irrigation, debridement, and packing the wound with delayed coverage and repair is appropriate.

Amputation: Proper handling of the amputated segment is critical. The amputated appendage should be wrapped in saline-soaked gauze, in a plastic bag and placed on ice during transport. The gauze prevents the penis from coming into contact with ice and suffering thermal damage. Operative management includes careful debridement of the wound, followed by macroscopic repair of the corpora cavernosa, urethra, and corpus spongiosum. Repair should be performed with slow absorbing suture. When microsurgical expertise is available, the dorsal vascular and nerve structures should be re-approximated. This repair should be performed within 24 hours. If the amputated segment is not available, the wound should be formally closed similar to a partial penectomy. [9]

Testis:

Blunt: **In those patients with testicular fracture or large hematoma, scrotal exploration and repair is performed**. Repair of the injury is accomplished with limited debridement of the seminiferous tubules and closure of the tunica albuginea using absorbable suture. In cases of significant loss of the tunica albuginea, a tunica vaginalis flap can be used. [14]

Penetrating: Due to the frequent involvement of adjacent structures and limitations of non-operative diagnostic tools, penetrating scrotal and testicular injuries should be managed with surgical exploration. Urologic surgeons can perform exploration and repair similarly to blunt trauma. In certain circumstances (pediatric patients and patients with solitary testicles), microscopic repair and re-anastomosis is possible and may be considered. [80]

Scrotum:

Blunt and Penetrating: Blunt and penetrating scrotal wounds are managed similarly. Burn wounds are managed differently due to the progressive changes and effects to the scrotal skin.

Open wounds should be explored in the operating room with wound cleansing and limited debridement of grossly non-viable skin. Many scrotal wounds can be closed primarily once the wound bed is healthy, even with skin loss of up to 60%.[95] Electrical burns should be cautiously debrided as these wounds can evolve. Urinary diversion is rarely required unless the wound involves the urethra or the burn is full thickness and involves the urethra. Larger wounds and burn injury should be managed with either regular dressing changes and topical antibiotic (e.g. Silvadene) or negative pressure dressings. Delayed wound closure with skin grafting or local skin flaps may be required once the patient is stable and the wound bed healthy.

Split-thickness skin grafts can be used for coverage and usually have good graft take and satisfactory cosmetic results.[96] Alternatively, if there is extensive skin loss and reconstruction cannot be performed, the testicles can be placed in thigh pouches.

Key Takeaways

- Trauma to the lower urinary tract can be the result of blunt, penetrating, or iatrogenic injuries.
- Management depends on the stability of the patient and presence of additional injuries.
- In most cases penetrating injuries to the lower urinary tract should undergo immediate surgical exploration.
- Pelvic fracture urethral injuries are complex and should be managed at high-volume centers with experienced surgeons.
- Early repair is recommended in female patients with urethral injuries to decrease the risk of incontinence or fistula formation.
- Imaging has limited utility in penetrating scrotal injuries, and these patients should undergo surgical exploration.
- Penetrating penile injuries and blunt injuries concerning for penile fracture require operative management to improve sexual function outcomes.

Videos

Penile Entrapment by Metal Ring: A Video Guide to Surgical Removal

Iatrogenic Ureteral Injury Repair: Robotic-Assisted End-to-End Distal Ureteroureterostomy

Presentations

Bladder, Urethra, Genitalia Presentation 1

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