

# Trauma Reports

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*Injuries to the genitourinary system occur in 10% to 20% of patients sustaining major trauma.<sup>1-3</sup> The majority of these injuries are not immediately life-threatening and may not be as dramatically obvious as are other injuries. Unfortunately, the failure to identify them can lead to significant morbidity and, occasionally mortality.*

*Since many injuries of the urologic system are subtle, it is important that the examining physician not only recognize the signs of these injuries, but also develop an organized approach to their diagnosis and management.*

*This article reviews the mechanisms of injury, patient presentation, diagnostic approach, and management strategies for injuries to the urethra, urinary bladder, ureter and kidney.*

— The Editor

## Urethral Injuries

**Definition of the Problem and Epidemiology.** Urethral injuries are rare, constituting about 10% of all injuries to the genitourinary system. However, they have the potential to be among the most debilitating type of urologic injuries because of the incidence of complications including impotence, incontinence and urethral strictures.<sup>1</sup> Urethral injuries are almost always the result of blunt trauma such as motor vehicle or bicycle accidents, falls or pedestrian injuries and are often seen in relation to pelvic fractures.<sup>1-3</sup> Uncommonly, urethral injuries are the result of penetrating trauma, such as a gunshot wound, stabbing, or a bite from an animal or human. Occasionally these injuries can be caused by foreign body insertion (which is often self-inflicted) or strangulation.<sup>1,4</sup> Urethral injuries are seen almost exclusively in the male population, with a higher incidence in

## Genitourinary Trauma: Etiology, Imaging, and Emergency Management

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males 15-25 years of age.<sup>1</sup> Within the female population, urethral injuries almost always occur in relation to pelvic fractures or vaginal lacerations.<sup>5,6</sup>

**Mechanism and Pathophysiology.** Injuries to the urethra are classified as penetrating (gunshot wound or stabbing), blunt (straddle injury or penile fracture), or iatrogenic (caused by insertion of a urinary catheter or other foreign body).<sup>7</sup> Often these injuries are further classified by anatomical region. The male urethra is divided by the urogenital diaphragm into the anterior and posterior divisions. (See Figure 1.) The posterior division of the urethra is further divided into the prostatic and membranous sections, while the anterior division is divided into the pendulous and bulbous urethra regions.

Injuries to the posterior urethra usually occur as a result of a shearing force across the prostatomembranous junction. Since the prostatic urethra is maintained in a fixed position by the attachments of the puboprostatic ligaments, fracture of the bony pelvis can lead to stretching or tearing of the membranous portion of the urethra. Dreitlein and colleagues report "it is estimated that disruption of the posterior urethra accompanies 10% to 25% of pelvic ring fractures and 80% to 90% of posterior urethral injuries occur in combination with pelvic fractures."<sup>8</sup> While the majority of posterior urethral injuries occur in the setting of pelvic ring disruption, injury has taken place in the complete absence of pelvic fracture and in the setting of simple symphyseal diastasis.<sup>9,10</sup> The degree of pubic symphysis diastasis and amount of displacement of inferomedial pubic bone fracture fragments were recently identified as independent predictors of urethral injury.<sup>11</sup> Posterior urethral

**Figure 1. Anatomic Depiction of the Urethra**

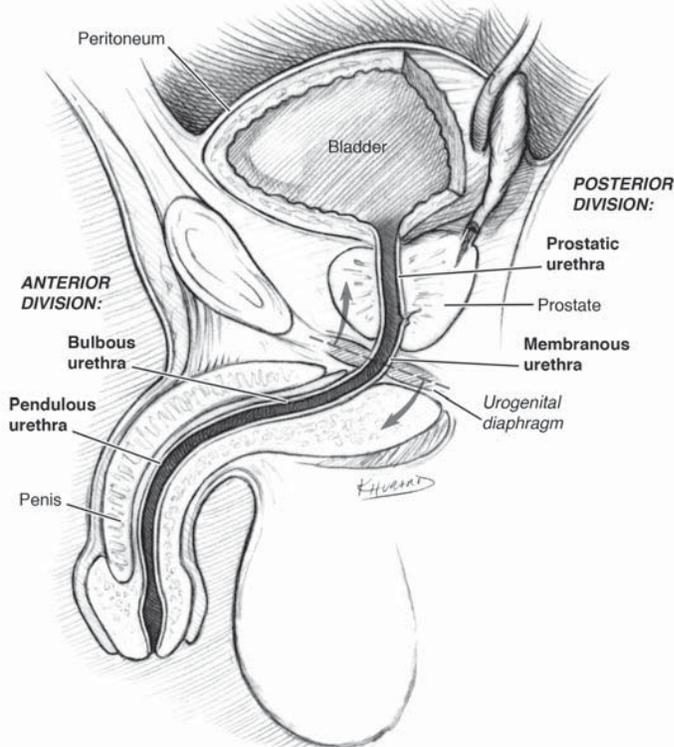


Illustration courtesy of Knox Hubbard©

injuries are also associated with vaginal lacerations in women and up to 35% of bladder injuries.<sup>8</sup>

Unlike posterior urethral injuries, anterior injuries usually occur in isolation and most often result from blunt force trauma to the perineum that causes a crushing effect on the tissues of the urethra against the symphysis pubis.<sup>8</sup> Anterior urethral injury should be suspected in any person who presents to the emergency department (ED) with a history of straddle injury or direct trauma to the perineum. It has been suggested that most cases of bulbar strictures are the result of anterior urethral injury, in which case men may present to a physician years after the injury.<sup>7</sup>

Varying degrees of urethral injuries can also occur in 10% to 38% of patients who present with penile fracture, a rare condition that occurs when the corpora cavernosa ruptures as a result of blunt trauma, most commonly during sexual intercourse or masturbation.<sup>7,12-13</sup> Patients present to a physician after hearing a cracking or popping sound associated with a sudden, sharp penile pain. These symptoms are followed by detumescence, swelling, voiding difficulties, discoloration, and deviation of the penis.<sup>14-15</sup> Approximately one third of patients in these cases have complete urethral transection, and these injuries are often confirmed and repaired during the repair of the tunica and corpora cavernosa.<sup>16</sup>

**Clinical Features.** When the urethra is ruptured, blood is present at the urethral meatus in the majority of patients.<sup>4,9</sup> Other signs of urethral injury may include a patient's inability or difficulty with voiding; a palpable, distended bladder; or the inability to pass a urinary catheter into the bladder.<sup>4,17</sup> The presence of a hematoma in

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a sleeve distribution along the shaft of the penis indicates a distal urethral injury in which Buck's fascia remains intact, while the presence of a "butterfly" hematoma with extravasation into the scrotum also indicates distal urethral injury but occurs when Buck's fascia is ruptured.<sup>7</sup> Injury must also be suspected in the presence of a palpable rectal mass in association with urine or blood extravasation in the perineal region or in the presence of a cephalad or "high riding" prostate during digital rectal examination.

The diagnosis of urethral injury is much more difficult in females due to the length of the female urethra and its resistance to injury. Most females with an injury to the urethra present with incontinence. Additionally, the diagnosis of urethral injury must be entertained when the vaginal exam demonstrates a hematoma on the urethra or urine leak into the vagina.<sup>18</sup> There should also be a high suspicion of urethral injury in the presence of a pelvic fracture, regardless of whether or not there is blood at the introitus or one is able to pass a Foley catheter.<sup>19</sup> Many times the diagnosis can only be made in an operative setting during the repair of a pelvic fracture.<sup>8</sup>

**Diagnosis and Imaging.** In the past, the diagnosis of urethral injury was often based solely on the presentation of blood at the meatus accompanied by a difficulty or inability to void and a full, palpable bladder. Furthermore, the inability to pass a catheter into the bladder was also used as a diagnostic tool for urethral injury. Currently, many institutions consider diagnostic urethral catheterization inappropriate because it may introduce infection, lead to an increased incidence of stricture formation or convert a partial urethral rupture to a complete rupture.<sup>2</sup> Some sources in the urological literature currently suggest a single attempt to gently pass a urinary catheter into the bladder in the presence of blood at the meatus, or if there is any suspicion of urethral injury. If attempted, this should only be tried by an experienced clinician.<sup>4</sup>

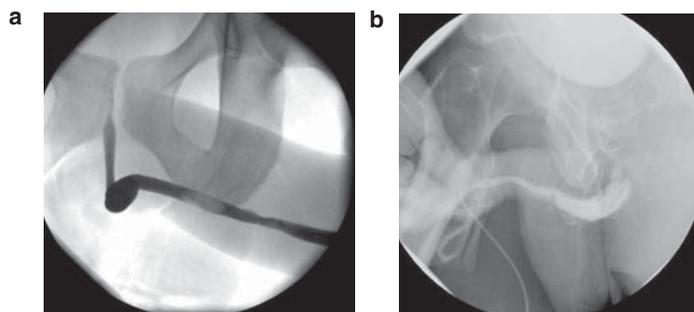
The retrograde urethrogram is the standard imaging study for the evaluation of urethral injury. (See Figure 2a.) It is performed by injecting 30 mL of contrast into the urethral orifice, ideally under fluoroscopic evaluation. Traditionally, the injury is evaluated by obtaining an oblique radiograph of the penis and abdominal region. In the setting of pelvic fracture, some authors recommend conducting the entire urethrogram in the supine position in order to maintain the integrity of a stable retropubic hematoma that may have formed.<sup>19</sup> The extravasation of contrast anywhere along the course of the urethra confirms the presence of disruption. (See Figure 2b.) If bladder filling is present, the disruption is classified as partial, whereas if no contrast reaches the bladder, the disruption is complete. In female urethral injuries, urethrography may be able to detect extravasation of contrast from areas of disruption, but often urethral evaluation is best accomplished by uretheroscopy.<sup>20</sup> Unfortunately, this makes the diagnosis of acute urethral injury in women difficult, and is the reason this diagnosis is often made only at the time of surgical repair of a pelvic fracture.

**Table 1. Classification, Location, and Description of Urethral Injuries**

CLASSIFICATION	LOCATION	DESCRIPTION
Type I	Posterior urethra	Stretched without disruption
Type II	Posterior urethra	Laceration above urogenital diaphragm
Type III	Anterior and posterior urethra	Partial or complete laceration with disruption of urogenital diaphragm
Type IV	Posterior urethra and bladder neck	Bladder neck laceration with extension into the prostatic urethra
Type IVa	Bladder base	Injury to bladder base simulating type IV injury due to periurethral extravasation
Type V	Anterior urethra	Partial or complete laceration of anterior urethra

Adapted from Goldman S, Sandler C, Corriere J, et al. Blunt urethral trauma: A unified anatomical mechanical classification. *J Urol* 1997;157:85-89.

**Figure 2a-b. Retrograde Urethrograms**



a. Normal retrograde urethrogram with air bubble in urethra  
b. Retrograde urethrogram demonstrating contrast extravasation

**Management.** The initial management of urethral trauma should be made in the context of other injuries in coordination with other specialists including urologists and orthopedic surgeons. The primary goal of treatment should be achieving urinary continence while minimizing stricture formation and sexual impotence.

For partial tears that fail primary catheterization, or complete type II, III, and IV injuries, multiple surgical options exist. (See Table 1.) These include initial placement of a suprapubic catheter with delayed repair, endoscopic primary alignment or initial surgical exploration with bladder drainage and urethral realignment occurring at a later time.<sup>8,21</sup> Some practitioners consider immediate suprapubic catheterization with later repair the "gold standard" of treatment. Recent studies have suggested that complications to posterior urethral injury, such as sexual and voiding dysfunction, both related and unrelated to pelvic fracture, are more likely to be a result of the injury itself and not the method of management.<sup>2,9,22</sup> Furthermore, many of the latest studies show that early endoscopic or fluoroscopic realignment of posterior urethral injuries offers an effective option for repair, with similar or even improved functional outcomes (mainly decreasing the severity of stricture), when

**Figure 3. Anatomic depiction of the bladder**

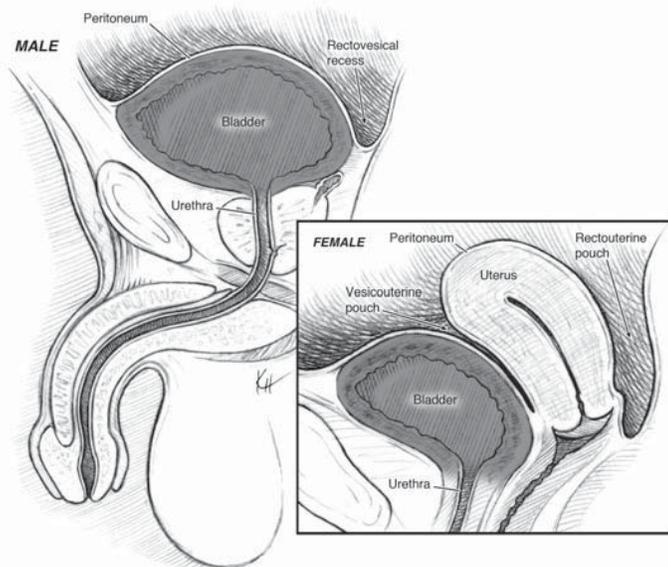


Illustration courtesy of Knox Hubbard©

compared to suprapubic cystostomy and delayed repair.<sup>22-26</sup> In general, these sources suggest that, when it is practical, early realignment of urethral disruption should be performed, especially in hemodynamically stable patients.<sup>25</sup>

The treatment of injuries confined purely to the anterior urethra is similar to posterior treatment, with urethral catheterization and follow-up voiding cystourethrogram for minor contusions. Initial suprapubic cystostomy is the treatment of choice for most blunt crushing injuries to the anterior urethra, although bulbous urethral disruption has been successfully managed by immediate primary urethral realignment.<sup>4,7,27</sup> For penetrating anterior urethral wounds, early urethral realignment is the treatment of choice, with complete disruptions undergoing primary repair unless other major associated injuries or hemodynamic instability of the patient are present.<sup>7</sup>

## Bladder Injuries

**Definition of the Problem and Epidemiology.** Bladder injuries represent one of the most common injuries involving the urinary tract and are frequently associated with severe multi-system trauma.<sup>28</sup> Blunt abdominal trauma is the most common cause of bladder injury, with most injuries occurring in males between the mean ages of 30 and 40 years.<sup>29-31</sup> Historically, injury to the bladder has been linked to a high rate of mortality, although most deaths are caused by accompanying non-urological injuries.<sup>31-32</sup> The recognition and treatment of bladder injuries is an important aspect of care for a victim of multiple trauma because of the relationship between bladder injury and mortality.

**Mechanism and Pathophysiology.** The empty adult bladder lies almost entirely in the minor pelvis and is therefore almost

completely protected by the pelvic bones. As the bladder fills with urine, the fundus distends, the dome of the bladder rises out of the true pelvis into the abdominal cavity reaching the level of the umbilicus, and the bladder becomes more susceptible to injury.<sup>33-34</sup> For this reason, most injuries to the bladder occur as the result of either a direct blow to the lower abdomen when the bladder is distended or an associated pelvic fracture.<sup>34</sup>

Additionally, it is important to note the anatomy of the bladder in relation to the peritoneum. The peritoneum covers the superior surface of the bladder, which anteriorly continues to the abdominal wall. In males it reflects posteriorly to the abdominal wall creating the rectovesical recess, while in females, it travels over the uterus forming both the vesicouterine and rectouterine pouches before meeting the posterior wall of the abdomen.<sup>35</sup> (See Figure 3.) A bladder rupture occurring above the peritoneal reflection permits extravasation of urine into the intraperitoneal space, while injuries below the peritoneal reflection result in extraperitoneal extravasation.<sup>36</sup>

Common mechanisms of injury to the bladder include motor vehicle accidents, pedestrians struck by automobiles, falls, industrial accidents, gunshots, stabbings or direct trauma to the suprapubic region. Most bladder injuries caused by motor vehicle collisions can be classified as deceleration injuries and are seen in passengers wearing seatbelts or when occupants are thrown against an uncompromising object.<sup>4</sup> Fatal isolated bladder ruptures resulting from minor blunt trauma are documented in the medical literature, although a high percentage of these injuries are extraperitoneal and related to pelvic fractures.<sup>37</sup>

The vast majority of bladder ruptures are associated with pelvic disruption (83% to 90%), while bladder rupture is only seen in approximately 6% to 10% of patients with pelvic fracture.<sup>8,21,29,38-40</sup> In the setting of abdominal trauma, the normal protection of the pelvic ring may be lost due to the distention of the bladder above the pelvic ring or due to fracture of the ring itself, leading to laceration of the bladder. Widening of the sacroiliac joint and pubic symphysis diastasis, as well as fractures of the sacrum, iliac, and superior ramus, are fractures commonly associated with injury to the bladder. Multiple studies suggest that a widened symphysis pubis is the strongest predictor of bladder injury.<sup>37,40-41</sup>

**Clinical Features.** Gross hematuria is the hallmark finding in the patient with bladder injury, with an incidence at or approaching 100% in many recent studies.<sup>30,34,42</sup> Although gross hematuria is common, bladder injury can also present with minimal urinalysis findings, as is the case with spontaneous bladder rupture.<sup>32</sup> The majority of patients complain of lower abdominal or suprapubic pain and/or an inability to urinate.<sup>32</sup> The presence of gross hematuria or the presence of both pelvic fracture and microscopic hematuria together are the usual indications for either plain film or computed tomography (CT) cystography.<sup>43</sup>

Occasionally, bladder rupture is isolated and occurs without significant external trauma. Some penetrating bladder trauma, for instance, may have minimal findings on urinalysis due to the smaller size of the bladder laceration. In cases of isolated bladder rupture, presentation tends to be delayed and is often associated

with an increase in serum blood urea nitrogen and creatinine, abdominal distention, fever, or signs of an acute abdomen.<sup>30</sup> Most often, these patient present days after the associated trauma with complaints of ill-defined abdominal discomfort. They often have a history of head injury or alcohol intoxication contributing to a delay in diagnosis.<sup>44</sup>

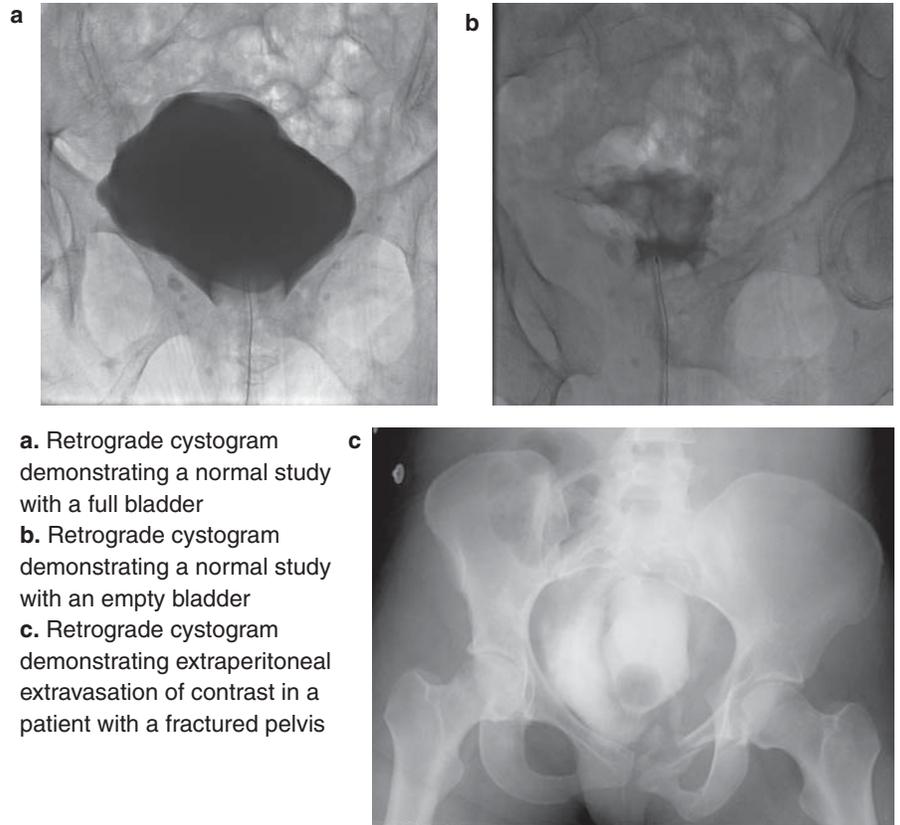
**Imaging and Diagnosis.** Traditionally, plain film cystography is accepted as the most accurate radiologic study to diagnose bladder rupture. With the increased availability and use of CT imaging for trauma patients, many centers use either plain film cystography or CT imaging to evaluate injury to the bladder.<sup>45</sup> CT cystography is especially useful in stable trauma patients who are already undergoing CT evaluation for other trauma related injuries. Recent studies demonstrate that CT cystography is an accurate method for evaluation of bladder injury when performed in conjunction with routine CTs of the abdomen and pelvis.<sup>40,43,46</sup>

The procedure for doing a plain film cystography starts after an initial pelvic radiograph is obtained. If there is clinical suspicion of urethral injury, a retrograde urethrogram must be performed prior to the placement of the urinary catheter. After successful catheter placement, approximately 100 mL of contrast material is placed into the bladder via the urinary catheter and a plain film is taken to check for gross bladder extravasation. If this is negative, an additional 200–250 mL of contrast material (the total amount of contrast needed is approximately 5 mL/kg) is placed until the bladder is filled completely, and a radiograph of the entire abdomen is obtained. (See Figure 4a.) After obtaining the radiograph, the bladder is drained and a post-drainage radiograph is obtained to check for contrast extravasation behind a formally distended bladder.<sup>34</sup> (See Figures 4b and 4c.) Plain cystography is nearly 100% sensitive in detecting bladder rupture if films are obtained after both fully distending and emptying the bladder.

Like plain film cystography, CT cystography is done by performing retrograde filling of the bladder with a minimum of 350 mL of contrast material. Multiple studies demonstrate that 10 mm axial images obtained from the dome of the diaphragm to the perineum are adequate and sensitive for detecting bladder injuries.<sup>47</sup> (See Figure 5a.) Post-drainage images through the decompressed bladder are not necessary, as contrast extravasation behind the bladder will be seen on the axial sections.<sup>34,40,47</sup>

Plain film cystography with extravasation completed prior to

**Figure 4a-c. Retrograde Cystogram**



**a.** Retrograde cystogram demonstrating a normal study with a full bladder  
**b.** Retrograde cystogram demonstrating a normal study with an empty bladder  
**c.** Retrograde cystogram demonstrating extraperitoneal extravasation of contrast in a patient with a fractured pelvis

**Table 2. Classification and Description of Bladder Injuries**

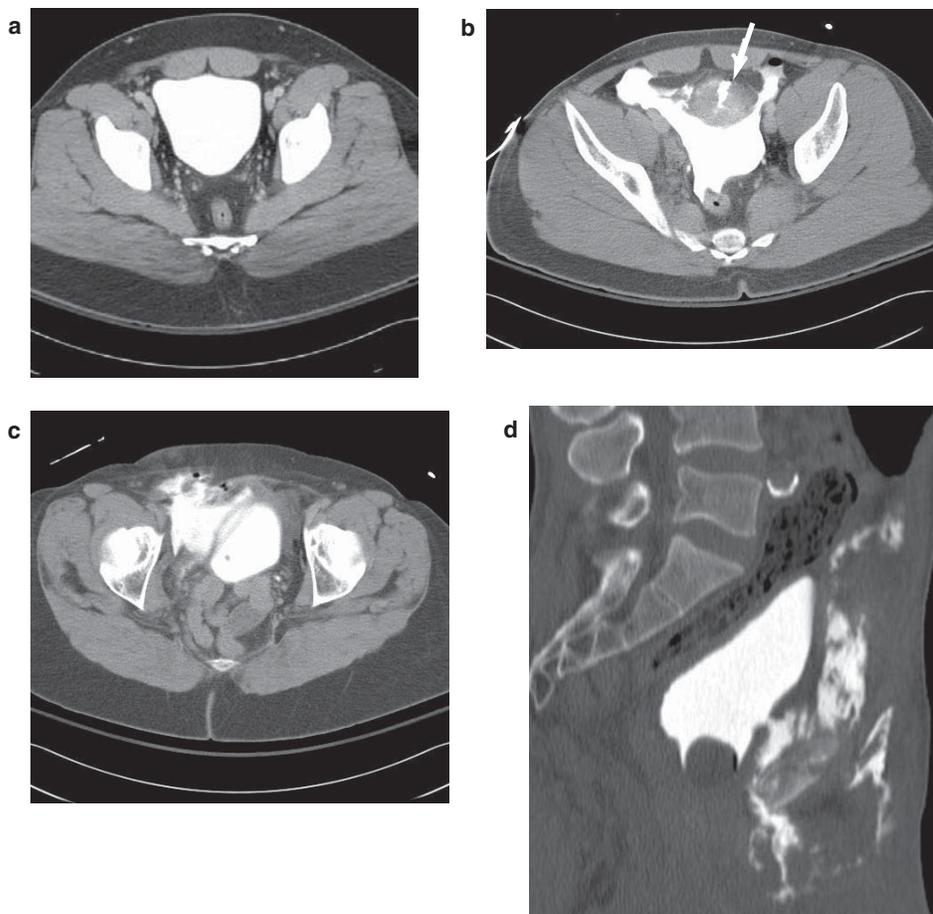
CLASSIFICATION	DESCRIPTION
Type I	Simple contusion or incomplete tear of mucosa
Type II	Intraperitoneal injury with urinary extravasation into the abdomen
Type III	Extraperitoneal rupture with urine extravasation limited to the perivesicular space
Type IV	Both intraperitoneal and extraperitoneal rupture present

Adapted from Sandler C, Hall J, Rodriguez M, et al. Bladder injury in blunt pelvic trauma. *Radiology* 1986;158:633-638.

routine CT scan of the abdomen and pelvis may hamper identification of pelvic arterial hemorrhage in some patients.<sup>48</sup> This is important to note because a delay in diagnosis may lead to delay in definitive treatment of ongoing bleeding. Practitioners should be wary when performing conventional cystography and consider waiting to perform the test until after routine abdomen and pelvis CT scans have been completed on stable patients. For similar reasons, retrograde filling of the bladder with contrast for CT cystogram prior to completion of a CT scan of the pelvis should be avoided.<sup>48</sup>

The bladder injury classification system based on cystography was revised in 2004.<sup>49,50</sup> (See Table 2.) The type of injury is deter-

**Figure 5 a-d. CT Cystogram of Bladder**



**a.** Normal CT cystogram  
**b.** CT cystogram demonstrating intraperitoneal extravasation of contrast material and bladder rupture. The hole in the bladder is seen in this view and highlighted by the arrow.  
**c.** CT cystogram demonstrating extraperitoneal extravasation of contrast material and bladder rupture  
**d.** Sagittal reconstruction of a CT cystogram with extraperitoneal extravasation of contrast material

mined by both the location of the injury and the degree of bladder wall involvement. The diagnosis of type 1 injuries, or bladder contusions, is typically a diagnosis of exclusion in patients with hematuria following blunt pelvic trauma for which no other cause can be found. Plain film and CT cystography will be normal. Type 2 injuries, or intraperitoneal bladder ruptures, show contrast material extravasation into the paracolic gutters, between mesenteric folds and around bowel loops. (See Figure 5b.) Approximately 25% of these injuries occur without associated pelvic fracture. Type 3 injuries, show extravasation either limited to the perivesical space (simple extraperitoneal rupture) or with extravasation beyond the perivesical space and via a variety of fascial planes into the anterior abdominal wall, penis, scrotum, or perineum (complex extraperitoneal bladder ruptures). (See Figures 5c and 5d.) Radiographic imaging of type 4 injuries, or combined bladder ruptures usually demonstrates patterns of extravasation consistent with both intraperitoneal and extraperitoneal injuries.<sup>28,50</sup>

catheterization alone instead of suprapubic and transurethral catheters together.<sup>53</sup> Type 3 injuries (extraperitoneal bladder ruptures) often can be successfully managed by urinary catheter drainage alone. However, if the patient with a suspected type 3 injury is to be surgically explored because of associated injuries, formal bladder repair should be performed.<sup>34,42</sup> Combined bladder injuries (type 4) require surgical repair with a combination of the surgical procedures mentioned above.

### Ureteral Injuries

**Definition of the Problem and Epidemiology.** The ureters are the least often injured component of the urological system, with injury occurring in less than 4% of penetrating and 1% of blunt trauma.<sup>4</sup> Overall, ureter injuries account for less than 1% of all external traumatic injuries to the genitourinary system.<sup>54-55</sup> Although rare, if the injury is unrecognized at the time of patient presentation, it can be devastating. Delays in diagnosis are associ-

**Management.** The first priority in the treatment of patients with suspected bladder injury is stabilization of the patient and treatment of associated life-threatening injuries.<sup>8,50</sup> The operative management of these patients usually involves multi-specialty cooperation between trauma surgeons, orthopedic surgeons and urologists. Further classification of these injuries is not needed in the case of penetrating trauma, as all penetrating abdominal injuries with suspected bladder involvement require operative exploration. However, with blunt bladder injury, further subdivision consisting of the type of injury (contusion vs. rupture) and the location of injury (intraperitoneal vs. extraperitoneal) is necessary when dictating treatment.

Bladder contusions (type 1 injuries) are deemed minor injuries and usually do not require therapy unless there is significant hemorrhage. Treatment involves placement of a large-bore urinary catheter (22-24F) which remains in place until the urine clears (usually in 1-4 days).<sup>34,50</sup> All intraperitoneal bladder ruptures (type 2) require operative management for multi-layer closure. Traditionally, this has been done by laparotomy, but there are multiple reports of successful laparoscopic repair of intraperitoneal rupture.<sup>42,50-52</sup> Urine should be diverted using either suprapubic drainage or a large-bore urinary catheter, which can be removed once the urine is clear, usually after 10-14 days.<sup>20</sup> A recent study by Parry and colleagues suggests that similar outcomes and complication rates can be obtained via transurethral

**Figure 6. Anatomy of the Ureters**

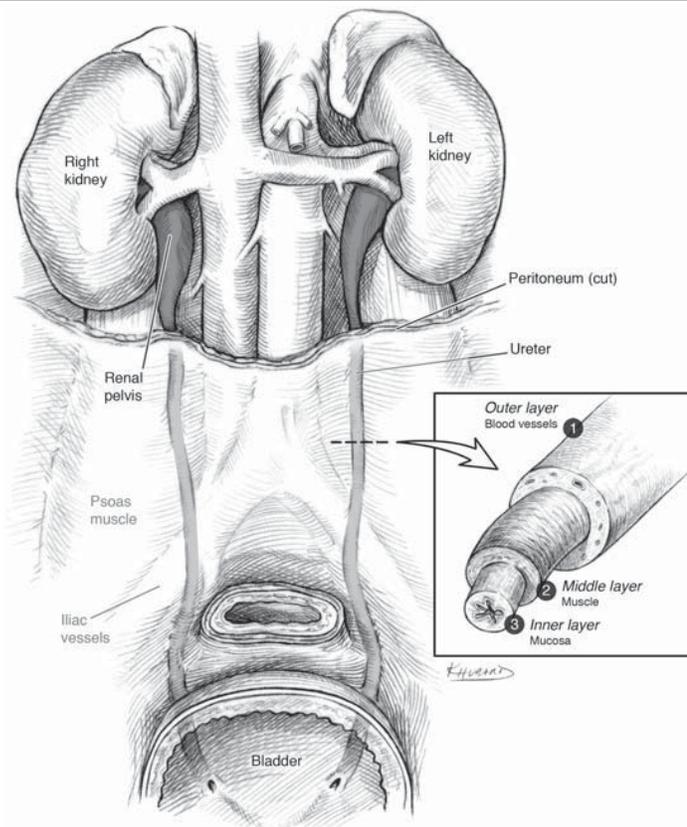


Illustration courtesy of Knox Hubbard©

ated with morbidity from urinomas, fistulas, strictures, sepsis, the loss of renal function and renal destruction.<sup>56-57</sup> In general, adult patients with ureteral injuries tend to be young men injured by penetrating trauma.<sup>56,58-59</sup> Ureteral injuries seldom occur in isolation. Anywhere from 50% to 100% of patients have associated co-existing abdominal injuries to the small and large bowel, liver, kidney, bladder and iliac vessels.<sup>57,60-61</sup> The co-existing injuries and the critical condition of these patients make diagnosis of ureteral injuries difficult. Often these injuries are only discovered intraoperatively or when complications, such as fever, sepsis, leukocytosis, abdominal pain, or urinoma occur, which increases the morbidity of the condition.

**Mechanism and Pathophysiology.** The anatomy and mobility of the ureters help to protect them from trauma.<sup>60</sup> The ureters are bilateral, peristaltic, expandable muscular tubes that run between the renal pelvis and the posteriosuperior angle of the bladder. A ureter is composed of three layers: an outer layer, which harbors blood vessels; a medial layer, which consists of both longitudinal and circular smooth muscle; and an inner mucosal layer.<sup>60</sup> (See Figure 6.) The abdominal portion of both ureters lies in the retroperitoneum, adhering closely to the parietal peritoneum and anterior to the psoas major muscle. As the ureters pass into the pelvis minor, they cross the rim of the pelvis, traveling anterior to the origins of the external iliac arteries and then posteroinferiorly

on the lateral wall of the pelvis. In males, the ureters then run lateral to the ductus deferens and enter the bladder superior to the seminal vesicle. In females, the ureters run close to the fornix of the vagina before entering the posteriosuperior bladder.<sup>62</sup>

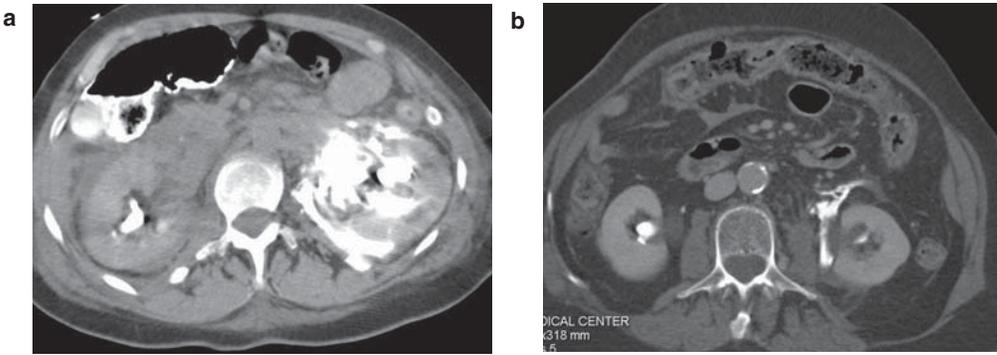
The majority of ureter injuries (80% to 95%) are caused by penetrating rather than blunt trauma, with the most common cause being gunshot wounds (accounting for 88% to 95% of penetrating wounds), followed by stabbings.<sup>8,56,59-60,63</sup> In gunshot wounds to the back, abdomen, or flank, the occurrence of ureteral injury is estimated to be between 2% and 5%.<sup>8,56-57</sup> Penetrating ureteral injury is thought to be the result of either ureteral transection or by disruption of the intramural blood supply which over time leads to necrosis of the ureter wall. These injuries occur both by direct trauma causing tissue injury or from the temporary cavitation or “blast effect” created by most fast moving missiles, such as bullets and shotgun pellets.<sup>60</sup> Cavitation injury causes microscopic vascular injuries that may not be apparent on initial visualization of the ureter and are thus difficult to identify, often resulting in a delayed diagnosis of injury and increased morbidity.<sup>63-64</sup> Additionally, shotgun pellets can migrate, causing acute ureteral obstruction days after the initial injury.<sup>65</sup>

Blunt ureteral injuries are rare and usually occur in the setting of acceleration/deceleration trauma such as those caused by automobile collisions. In these cases, severe hyperextension of the trunk or a direct blow to the L2–L3 region may result in a shearing of the ureter away from the renal pelvis at the ureteropelvic junction.<sup>57</sup> Ureteral injury should be highly suspected in any patient with thoracolumbar spinal dislocations or fractured lumbar processes.<sup>4</sup> Although a majority of blunt ureteral injuries occur at the ureteropelvic junction, cases of ureteral injuries from blunt trauma occurring below the ureteropelvic junction are documented in the literature, and this must be considered in all cases of acceleration/deceleration trauma.<sup>66</sup>

**Clinical Features.** The clinical presentation of ureteral injury is difficult to recognize, and the key to successful recognition is maintaining a high index of suspicion. Injuries to the iliac vessels, bladder, sigmoid colon, renal pelvis and the transverse processes of the lumbar spine should raise suspicion of ureteral trauma, as well as any patient who presents with hemodynamic instability due to abdominal, flank or back trauma.<sup>57</sup> Furthermore, patients who develop leukocytosis, fever, abdominal pain, or an unexplained intra-abdominal fluid collection should be further evaluated for the possibility of ureteral trauma.<sup>8</sup> Since hematuria is often absent, it is not a reliable sign of ureteral injury.<sup>19,57,60,67</sup> Frequently, patients with ureteral injury are critically ill and have multiple associated injuries which may delay recognition of the injury. Since clinical features of ureteral injury are nonspecific and inconsistent, ureter injuries are often only found intraoperatively.<sup>58-59</sup>

**Diagnosis and Imaging.** The diagnosis of ureteral injury remains elusive and is complicated by the absence of clinical and laboratory findings specific for ureteral injury.<sup>57</sup> Urinalysis may show gross or microscopic hematuria in 53% to 75% of patients, but hematuria is hardly specific for ureteral injury and may be absent in 30% to 60% of patients.<sup>56-58,60,67</sup> Ureteral injuries are also difficult to diagnose radiographically. The key to successful diag-

## Figure 7 a-b. Urinary Extravasation



a. CT of the abdomen and pelvis with delayed images demonstrating urinary extravasation from the kidney/proximal ureter  
b. CT scan of the abdomen with delayed images demonstrating extravasation of urine

the setting of blunt trauma, its use in penetrating trauma has not yet proven to be better than intravenous pyelogram or IVP, as penetrating abdominal trauma is usually brought directly to surgery for exploratory laparotomy. (See Figure 8.) Intraoperative one-shot pyelography is still recommended in these cases.<sup>71</sup>

Initial urinary tract imaging can also be accomplished by obtaining an intravenous urogram. Contrast extravasation is diagnostic. Unfortunately, in many cases, an intravenous urogram may simply show dilatation or deviation of the affected ureter and is therefore only diagnostic in approximately 14% to 54% of studies.<sup>58-60,72</sup> Other imaging modalities,

## Figure 8. Normal Intravenous Pyelogram



nosis is maintaining a high index of suspicion based on mechanism of injury, location of injury, and associated injuries.

CT, specifically delayed image CT and pyelography, is becoming the primary diagnostic tool used in the evaluation of ureteral injury. CT is a valuable diagnostic tool because it helps in the assessment of other abdominal injuries and evaluates the presence of intra-abdominal fluid collections related to trauma.<sup>57</sup> The most common finding is the extravasation of contrast into the medial perirenal space, which may or may not be associated with urinoma.<sup>57,60</sup> (See Figure 7.) While the absence of contrast material in the distal ureter can be diagnostic for complete ureteral transection, care must be taken to capture delayed (5–20 minutes after contrast injection) images with quality tracings of the entire course of both ureters.<sup>57,68-70</sup> Although CT is helpful in diagnosing ureter injury in

such as retrograde pyelogram, nuclear renal scans, and magnetic resonance imaging (MRI), can be used to evaluate ureteral injury, but these studies are not always logistically possible in the acute setting of a patient with multi-organ trauma common with ureteral injury. (See Figure 9.)

Many ureter injuries, including most caused by penetrating trauma, are diagnosed during laparotomy performed for the treatment of associated abdominal injuries.<sup>60</sup> In the operative setting, direct visualization of the ureter and the surrounding tissue is possible. In fact, according to Azimuddin and colleagues, direct visualization and “exploration of the retroperitoneum remains the only definitive method of excluding ureteric injuries.”<sup>58</sup> Intraoperative recognition can be aided by intravenous or intraureteral injection of indigo carmine or methylene blue, which may demonstrate leakage from a transected ureter, although the efficacy of this test can be limited by renal hypoperfusion or hypotension.<sup>59-60</sup> Curiously, many clinicians are now abandoning preoperative radiographic studies altogether, instead favoring intraoperative exploration in patients who warrant laparotomy. Studies by both Digiaco and Medina demonstrate that preoperative radiographic staging of ureteral injuries is unwarranted in patients who will undergo exploratory surgery. They suggest that direct ureteral visualization and retroperitoneal exploration during laparotomy are sufficiently accurate to avert preoperative radiographic examination.<sup>56,73</sup>

**Management.** The appropriate management of ureteral trauma depends not only upon the grade and location of injury but also the overall condition of the patient, his or her past medical history and co-morbidities, as well as the time of diagnosis. The severity of ureteral injury can be classified using the grading system developed by Moore and colleagues for the American Association for the Surgery of Trauma.<sup>74</sup> (See Table 3.) Additionally, the complexity of ureteral repair secondary to trauma was recently found to correlate with the number of associated injuries and increasing American Association for the Surgery of Trauma-Organ Injury Scale (AAST-OIS) injury grade.<sup>54</sup> The ideal management option for penetrating ureteral trauma is primary repair; however, this is not

always possible because of the co-existing injuries of the patient.<sup>75</sup> In these cases, repair should be deferred until the associated injuries and inflammation have resolved.<sup>60</sup> Ureteral injuries with a significant delay in definitive treatment should initially be managed by either percutaneous nephrostomy or endoscopic ureteral stenting. At the appropriate time, debridement of devitalized tissue and the performance of the appropriate repair can occur.

Minor ureteral contusions without devascularization (grade I injuries), should be treated with stent placement. Often, diversion of the urine stream via stent or nephrostomy may be the only treatment needed.<sup>57</sup> Care must be taken to fully evaluate these injuries, as microvascular injury can lead to stricture or ureteral necrosis resulting in urine leakage and patient morbidity. Severe or large areas of contusion should be treated with excision and ureteroureterostomy.<sup>4</sup> Most grade II–IV lacerations are managed surgically.<sup>57,60,76</sup> Postoperative stenting is usually recommended for up to two weeks after ureteral surgery or until radiographic evidence of an open anastomosis can be obtained.<sup>60</sup>

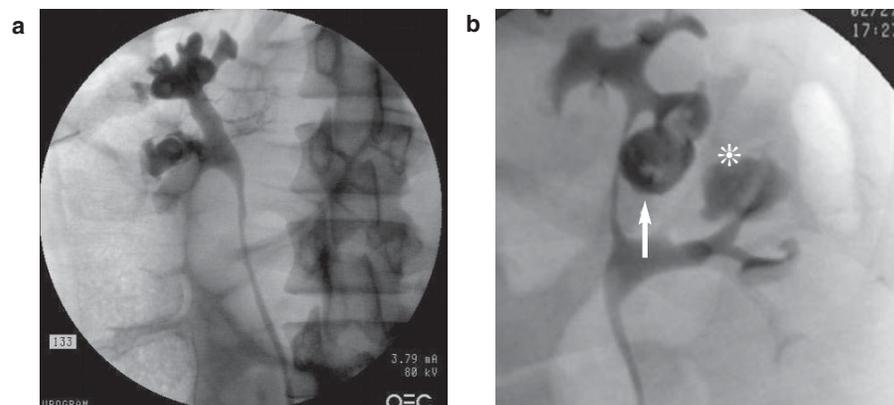
## Renal Injuries

### Definition of Problem and Epidemiology.

The kidneys are the most commonly injured genitourinary organs. Up to 10% of trauma patients will sustain injuries to the urologic system and one-half to two-thirds of these injuries will involve the kidneys.<sup>71,77-79</sup> Approximately 80% of these are the result of blunt trauma, most commonly occurring during motor vehicle collisions, falls, assaults, or sports events.<sup>71,77,80</sup> Fortunately, most renal injuries from blunt mechanisms are classified as minor (> 90%).<sup>71,79</sup> Penetrating mechanisms account for about 5% of injuries and are associated with varying degrees of renal lacerations which often require operative interventions. Renal pedicle injuries account for about 2% of kidney injuries. In blunt trauma, the most common pedicle injury is thrombosis of the renal artery. Arterial or venous lacerations and venous thrombosis are also seen.

The majority of renal injuries are not immediately life-threatening and may not be obvious on presentation. However, multi-organ involvement is the rule when renal injuries are found (occurring in 80%–95% of penetrating and 75% of blunt mechanisms) and these associated injuries may be significant and severe.<sup>71,79,81</sup> These more obvious and life-threatening injuries can result in the delayed diagnosis of kidney injuries. To further complicate the diagnosis of kidney injuries, the presence or degree of hematuria does not correlate with the presence or severity of renal injury. This realization, along with the development of better imaging modalities, has resulted in a change in our diagnostic approach to the patient with presumed renal injuries in the last two decades.

**Figure 9a-b. Kidney Pyelogram**



a. Normal retrograde pyelogram.

b. Abnormal retrograde pyelogram demonstrating urinoma (arrow) and urine extravasation from calyx (\*).

**Table 3. Classification and Description of Ureteral Injuries**

CLASSIFICATION	DESCRIPTION
Grade I*	Simple contusion or hematoma
Grade II*	Laceration with less than 50% transection
Grade III	Laceration with greater than 50% transection
Grade IV	Complete ureter transection with 2 cm of devascularization
Grade V	Ureteral avulsion with greater than 2 cm of devascularization

\* If bilateral injuries present, advance one grade until reaching Grade III classification.

Adapted from Moore E, Cogbill T, Jurkovich G, et al. Organ injury scaling III: Chest wall, abdominal vascular, ureter, bladder and urethra. *J Trauma* 1992;33:337-339.

**Mechanism and Pathophysiology.** The kidneys are paired retroperitoneal organs surrounded by adipose and loose areolar connective tissue. The kidney is composed of an outer cortex and an inner medulla. The inner medulla contains renal papillae which drain the renal calyces. Lying against the diaphragm superiorly and the psoas muscles posteriorly, the kidneys are adjacent to the lower two thoracic and first four lumbar vertebrae.<sup>78</sup> The upper portions of the kidneys are protected by the ribs, but the lower poles are often inferior to them and consequently more vulnerable to injury.<sup>82</sup> (See Figure 10.) The right kidney is injured more commonly than the left because of its inferior displacement by the liver.

The kidneys are not fixed in the retroperitoneum and move with the diaphragm and with movement of the patient. They are supported by the renal vasculature, the perinephric fat, and a fibrous layer of fascia (Gerota's fascia). The renal artery, renal vein, and the ureter make up the renal pedicle at the indented medial border (hilum) of the kidney. Rapid decelerations, like those seen in motor vehicle collisions and falls from heights, can result in shearing injuries to the renal pedicle and vasculature because the hilum does not move as freely as the kidney.<sup>81,83</sup>

**Figure 10. Anatomy of the Kidney**

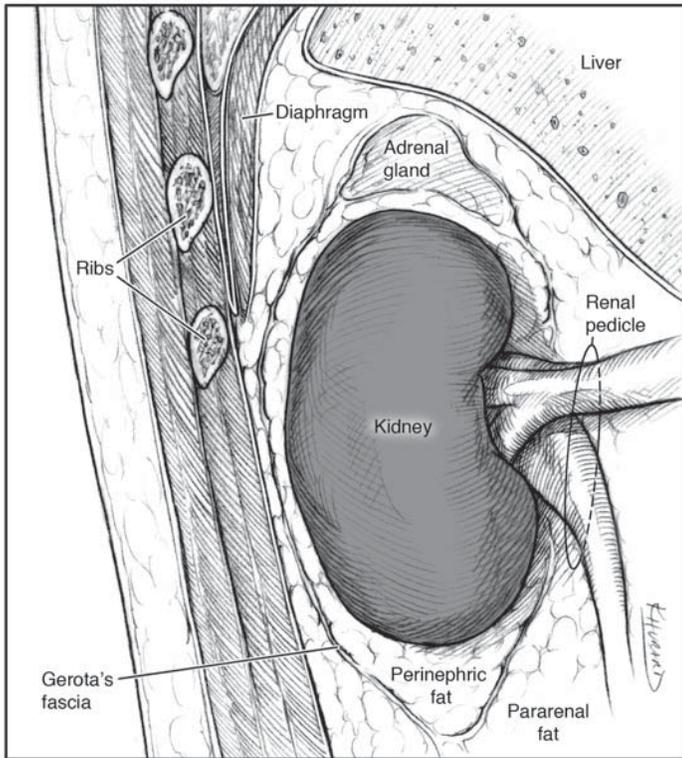


Illustration courtesy of Knox Hubbard©

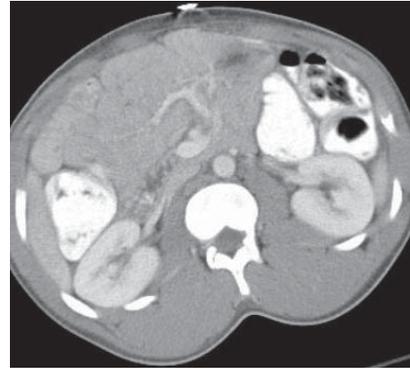
When viewed in context with the mechanism of injury, the anatomical relationship of the kidneys with surrounding structures and the mobility of the kidney compared to the hilum can offer important clues regarding the possibility of renal injury. Significant deceleration mechanisms should always lead to suspicion of a shearing injury, while penetrating mechanisms to the abdomen, back or flank should always raise the suspicion of direct renal trauma.<sup>81</sup>

**Clinical Features.** Renal injuries are seldom immediately life-threatening and may not be obvious in the setting of multiple trauma. Deceleration mechanisms of injury or penetrating trauma in close proximity to the kidneys should certainly alert the clinician to the possibility of renal trauma. Similarly, tenderness or ecchymosis of the abdomen or flank should arouse suspicion. Radiographic evidence of lower rib or thoracolumbar fractures should also trigger further investigation.

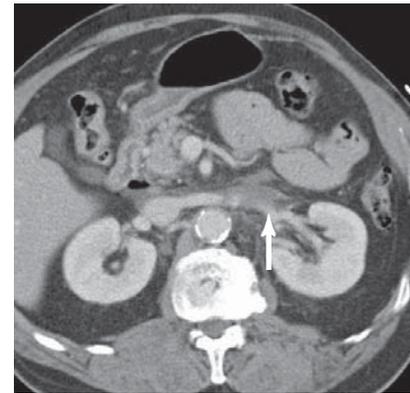
Hematuria is the best indicator of urinary tract injury. Over 95% of patients sustaining renal trauma will have some degree of hematuria (> 5 RBC/HPF) but the degree of hematuria is not related to the severity or extent of injury. Renal artery lacerations, complete renal avulsions and other pedicle injuries may not generate any hematuria at all.<sup>71,77,78,82</sup> Particular attention should be paid to any signs of hemodynamic instability. Hypotension, even if transient, in the setting of hematuria mandates imaging of the kidneys.<sup>83,84,85</sup>

**Diagnosis and Imaging.** A prospective study based at San

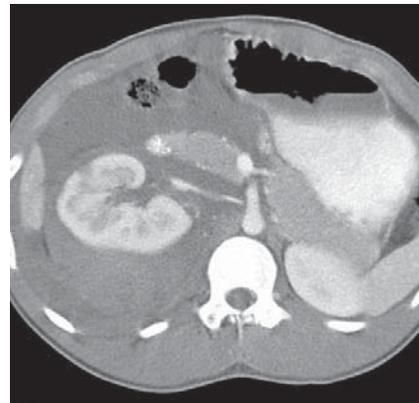
**Figure 11a-d. CT Scans of the Kidney**



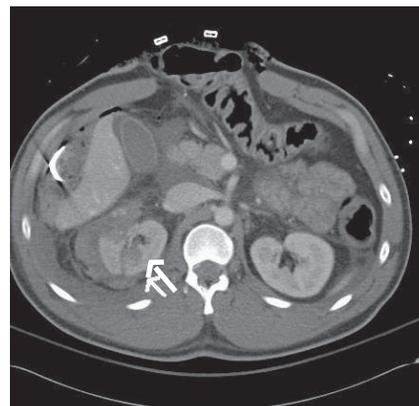
**a. Normal CT scan of the kidneys**



**b. CT scan of the abdomen demonstrating a left renal vein injury noted by stranding marked by the arrow**

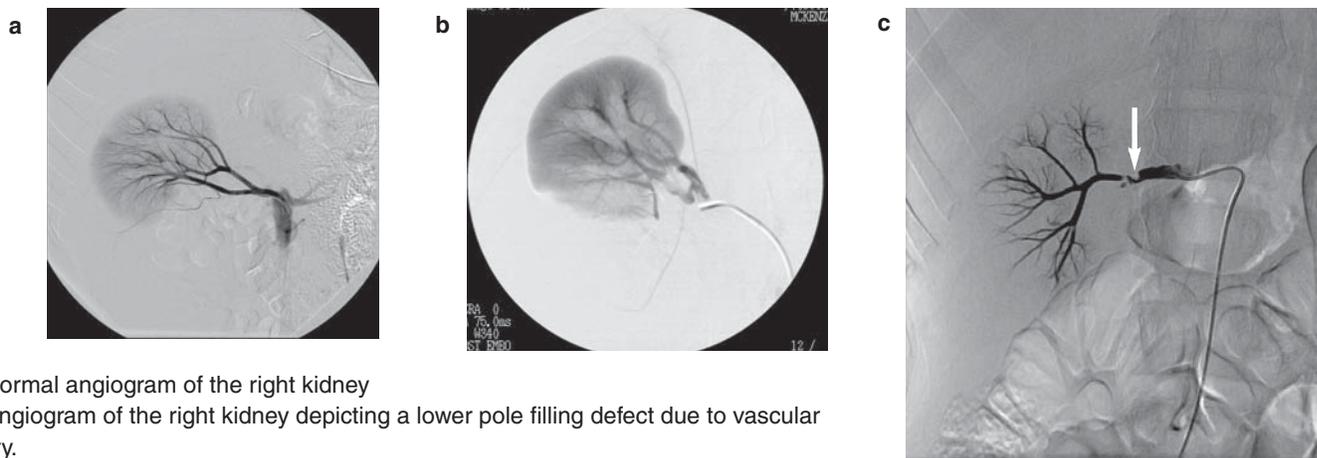


**c. CT scan of the abdomen demonstrating right renal laceration with a large surrounding hematoma**



**d. CT scan of the abdomen demonstrating a right renal laceration with significant renal parenchymal damage**

**Figure 12a-b. Angiograms of the Kidney**



- a. Normal angiogram of the right kidney
- b. Angiogram of the right kidney depicting a lower pole filling defect due to vascular injury.
- c. Angiogram that shows right renal vascular injury where there is a filling defect between the catheter tip and the kidney body (arrow)

Francisco General Hospital established indications for radiographic imaging of the kidneys in the setting of presumed renal trauma. This study demonstrated that patients requiring imaging for presumed renal trauma present with either gross hematuria or microscopic hematuria with shock.<sup>83-85</sup> Shock was defined as a systolic blood pressure of less than 90 mmHg at any time, even if this hypotension was only transient in nature. Conversely, microscopic hematuria is unlikely to represent significant blunt renal injury in the absence of hemodynamic instability. After reviewing the existing literature, Ahn and colleagues concluded that patients with microscopic hematuria without evidence of hemodynamic compromise had a significant renal injury in only one out of 500 patients.<sup>86</sup> Therefore, patients with microscopic hematuria in the absence of hypotension do not require emergent imaging of their kidneys.

The presence or absence of hematuria is not predictive of renal injury in the setting of penetrating trauma. The location of the penetrating wound in relationship to the kidney is the most important factor in determining the need for radiographic studies. Significant injuries to the kidney can occur in penetrating trauma without hematuria.<sup>19</sup>

The San Francisco studies demonstrate that contrast enhanced CT scanning is the imaging study of choice in the evaluation of presumed renal trauma. Subsequent studies have shown this study to have diagnostic accuracy of up to 98% for injuries to the kidneys.<sup>87</sup> CT scans provide precise delineation of renal lacerations, determine the presence and location of renal hematomas with or without extravasation, and also indicate the presence of urinary extravasation or devascularized parenchymal segments.<sup>87</sup> (See Figure 11.) The advent of helical CT and improved multi-detector

**Table 4. Classification and Description of Renal Injuries**

CLASSIFICATION	DESCRIPTION
Grade I	Hematuria +/- normal imaging study or subcapsular non-expanding hematoma
Grade II	Non-expanding perirenal hematoma confined to retroperitoneum OR <1 cm laceration of renal cortex without urinary extravasation
Grade III	> 1 cm renal cortex laceration that does not involve collecting system or urinary extravasation
Grade IV	Lacerations involving cortex, medulla, or collecting system OR Renal artery or vein injuries with contained hemorrhage
Grade V	Completely shattered kidneys OR Injuries involving renal hilum that devascularize the kidney

Adapted from American Association for the Surgery of Trauma. Abstracts, 49th annual session. American Association for the Surgery of Trauma. Chicago, Illinois, October 5-7, 1989. *J Trauma* 1989;29:1024-1040.

array scanners have decreased the time needed to perform the studies and improved resolution. However, CT scans do not define renal venous injuries well. If suspicion for this injury exists, angiography or MRI may be more accurate.<sup>71</sup>

Injuries of the ureteropelvic junction (UPJ) are best diagnosed with delayed imaging techniques that allow contrast to be excreted into the collecting system and ureter. Therefore, delayed scans performed 5-10 minutes after the initiation of intravenous contrast is the preferred method of evaluating the renal collecting system.<sup>88-90</sup> A UPJ injury is indicated by an intact renal parenchyma with extravasation in the medial perirenal space with or without contrast in the ureter distal to the point of injury.<sup>89,91</sup>

Before CT scans were readily available, the imaging procedure

of choice for presumed renal trauma was intravenous pyelography.<sup>78,90</sup> (See Figure 8.) IVPs allow for an assessment of both the anatomy and function of the kidneys, however, they are frequently time consuming and are less sensitive than CT scans for defining the nature and extent of the injury. For these reasons, CT has replaced IVP as the imaging modality of choice for renal trauma. However, the IVP may still have a role in evaluating the unstable patient in the operating room where a limited or “one-shot” study can be performed to assess the gross function and anatomy of a presumed uninjured kidney prior to the removal of a significantly injured one.<sup>78</sup>

The use of angiography in the evaluation of renal injuries has diminished in the current era of high-resolution CT scanners. (See Figure 12.) Selective renal angiography still provides more detailed information regarding the exact location of a vascular injury than a CT scan, and it remains the gold standard for evaluation of suspected renal vein injury, particularly in the setting of penetrating trauma. Increasingly, angiography with embolization or stent placement is being utilized in the therapy of renal artery injuries.<sup>92</sup> Angiography may also be indicated for additional clarification when there is no evidence of renal function on either a CT or IVP.<sup>78,87,92</sup>

Ultrasound has little role in the evaluation of renal trauma other than to identify the presence of two kidneys and to demonstrate free fluid in the hepatorenal or splenorenal recesses. Contrast-enhanced ultrasonography has been assessed in small studies and may show future promise in the evaluation of kidney injuries.<sup>93</sup>

MRI is rarely used as a first-line imaging modality due to its greatly increased time of study when compared to CT. However, it can be used in patients with a known contrast allergy or when a CT is not available. MRI has demonstrated a level of sensitivity similar to the CT for renal trauma. In fact, in some instances, it is superior to CT. MRI can differentiate intrarenal from perirenal hematoma more accurately than CT. It can also reveal focal lacerations and non-viable renal segments more accurately than CT in the setting of a perirenal hematoma. MRI may also be the follow-up imaging study of choice for victims of multi-organ trauma in order to decrease the cumulative radiation dose of CT scans.<sup>94</sup>

**Management.** A variety of grading systems have been developed to classify renal injuries through the years. The most commonly utilized system at present was developed by the American Association for the Surgery of Trauma (AAST) and is based on the depth of injury and the involvement of vessels or the collecting system.<sup>95</sup> (See Table 4.) Multiple studies have confirmed the value of this grading system. The higher the grade of injury, the more likely a complication will arise that requires surgical intervention, and the need for follow-up imaging studies will be greater.<sup>81,96,97</sup> However, just as our diagnostic approach to renal trauma has changed, so has our therapeutic approach.<sup>78</sup>

A more conservative approach to the treatment of renal injuries has evolved over the last two decades, and there has been a decline in the rate of both immediate repair of renal injuries and nephrectomy.<sup>78</sup> Non-operative management is advocated for most blunt renal injuries, many renal stab wounds and selected gunshot wounds.<sup>79</sup> Grade I and II injuries have been handled non-opera-

tively for some time. This management includes observation, fluid hydration, serial hemoglobin checks, and serial urinalysis monitoring for the resolution of hematuria. Nearly all of these injuries will heal spontaneously without sequelae. For example, an adult patient with microscopic hematuria in the absence of hypotension and without evidence of coexisting major organ or lower urologic injury requiring imaging or observation, may be safely discharged from the ED without any imaging studies. However, follow-up is mandatory to determine that the microscopic hematuria has cleared. If it does not, then contrast-enhanced CT or MRI is required.<sup>19,83-86</sup>

In the past, surgical intervention was often the rule for major injuries (Grade III–V). Today, the only absolute indications for surgical intervention are persistent renal bleeding with hemodynamic instability, active extravasation of intravenous contrast, or an expanding or pulsatile perirenal hematoma, which suggests a Grade V vascular injury.<sup>71</sup> Injuries to the ureter or renal pelvis are also indications for repair. Relative indications include urinary extravasation, nonviable tissue, delayed diagnosis of arterial injury, segmental arterial injury and incomplete staging.<sup>71,79</sup>

It is now routine to manage Grade III injuries non-operatively. In a meta-analysis of 16 published reports, 90% of 324 Grade IV blunt renal injuries were effectively managed non-operatively with only 4.6% ultimately requiring nephrectomy. Even Grade V injuries have been managed non-operatively. Bozeman and colleagues reviewed the management of blunt trauma patients with either Grade IV or V renal injuries that were managed either conservatively or surgically. This small study demonstrated no statistically significant difference in morbidity between the two groups.

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The only significant predictor of the failure of conservative management was the presence of another solid organ injury.<sup>98</sup> Altman et al reported fewer ICU days, transfusions and complications in a small number of Grade V patients managed conservatively.<sup>99</sup>

Conservative management of selected victims of penetrating injuries has also been advocated. Multiple studies have demonstrated the ability to expectantly manage hemodynamically stable victims of stab or gunshot wounds.<sup>79</sup> Patients selected for non-operative management undergo serial hemoglobin determinations and CT scans. Embolization via angiography can prevent surgical management in cases of continued bleeding.<sup>100</sup>

The drawback of expectant management in major renal injuries is an increased complication rate.<sup>100</sup> Renal injuries with a significant amount of devitalized parenchyma are more likely to develop short term complications such as continued hemorrhage, continued urinary extravasation and abscess formation and long term complications such as hypertension. Husmann and colleagues reported that major renal lacerations extending into the collecting system with devitalized fragments comprising a quarter of the kidney have an 80% complication rate including perinephric abscess, infected urinoma or continued hemorrhage.<sup>101</sup> Interestingly, in the setting of renal artery thrombosis or avulsion, the kidney can be safely left in place to atrophy over time with a low risk of complications.<sup>77</sup>

With modern management techniques, renal salvage rates approach 85% to 90%.<sup>82</sup> Although the trend for conservative management has extended into Grade IV injuries, nephrectomy for Grade V injuries occurs in 90% of cases and is often needed to control hemorrhage and to improve hemodynamic stability. Even under ideal circumstances and prompt surgical repair, the kidney salvage rate for pedicle injuries is less than 20%.<sup>79,100,102,103</sup>

## Conclusion

Serious genitourinary injuries are often well hidden among other more life-threatening injuries, making them difficult to diagnose and treat. The mechanism of trauma should raise or lower a practitioner's index of suspicion and guide imaging and treatment. Management goals are focused primarily on the prevention of long-term morbidity, and initial interventions are often temporizing due to the urgency of repairing a patient's more immediate life-threatening injuries.

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## CME/CNE Questions

1. The next step in management of a trauma patient with an identified partial urethral tear should be:
  - A. Urologic consult if the urine does not clear within 24 hours
  - B. One attempt to carefully pass a catheter
  - C. Placement of a suprapubic catheter
  - D. Abdominal CT to look for associated injuries
  - E. Proceed to operating room for repair
  
2. A 25-year-old male presents with a gunshot wound to the left flank. Vital signs are stable. A urine dipstick is negative for blood. Which of the following statements is correct regarding analysis of the urine in this case?
  - A. More than 5 RBC/hpf is considered significant if the patient was hypotensive at any time.
  - B. Only gross hematuria is of significance.
  - C. The presence or absence of hematuria is not a helpful screen for injury.
  - D. The presence or absence of hematuria is more important than anatomic location of the injury in guiding further evaluation.
  
3. A 35-year-old male arrives at the emergency department after having been ejected from his automobile. He has an obvious pelvic fracture, gross hematuria, and an expanding retroperitoneal hematoma. He also has a large abdominal wound with small bowel protruding. Vital signs are blood pressure 90/40 mmHg, pulse 130, and respirations 30/min. Which of the following is correct regarding evaluation of the urinary system in this patient?
  - A. A single-shot IVP done in the trauma bay is adequate to demonstrate the vascular integrity of the kidneys.
  - B. CT using IV contrast should be performed to assess the full extent of abdominal injury before operative management.
  - C. A retrograde urethrogram should be performed before taking the patient to the operating room.
  - D. A bladder rupture should be assumed, and a suprapubic catheter should be placed to monitor urine output.
  - E. Intraoperative "one shot" IVP should be performed to evaluate the integrity of the kidneys if the patient is stable enough to tolerate the procedure.

## CNE/CME Objectives

Upon completing this program, the participants will be able to:

- a.) discuss conditions that should increase suspicion for traumatic injuries;
- b.) describe the various modalities used to identify different traumatic conditions;
- c.) cite methods of quickly stabilizing and managing patients; and
- d.) identify possible complications that may occur with traumatic injuries.

## CME / CNE Instructions

Physicians and nurses participate in this CME/CNE program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge. To clarify confusion surrounding any questions answered incorrectly, please consult the source material. **After completing this activity, you must complete the evaluation form provided and return it in the reply envelope provided in order to receive a letter of credit.** When your evaluation is received, a letter of credit will be mailed to you.

4. Which of the following statements is most accurate regarding bladder rupture?
  - A. Most extraperitoneal bladder ruptures are associated with femur fractures.
  - B. Plain film cystogram is the most accurate study to evaluate for bladder rupture.
  - C. The classification of bladder rupture as intraperitoneal or extraperitoneal is academic because the management options are the same.
  - D. In patients with a pelvic fracture, the absence of gross hematuria virtually eliminates the possibility of bladder rupture.
  
5. An 18-year-old male presents with a straddle injury that occurred while riding a bike. He has blood at the meatus but is able to urinate. You suspect an anterior urethral contusion. Considering the long-term outcome and morbidity any injury like this might have on him, what is your disposition?
  - A. Discharge home with follow-up if any problems develop.
  - B. Discharge home with follow-up with a urologist in two weeks.
  - C. CT scan with contrast
  - D. Discharge home after placement of a Foley catheter by urology with follow-up in two weeks.
  
6. A 35-year-old male prisoner arrives in the ED with a complaint of urinary retention. While obtaining a history, he notes he placed a pen's ink cartridge in his urethra two days ago and has not been able to urinate since. His bladder is palpable and enlarged. Bladder scan demonstrates approximately 500 mL of urine. The ink cartridge is palpable on the ventral aspect of the penis and easily removed. Two hours later, the patient is still unable to void and attempts at passing a Foley fail. What is the next step?
  - A. Psychiatric consult
  - B. Discharge for care at the prison
  - C. Retrograde urethrogram
  - D. Both A and C
  
7. A 39-year-old female presents with an unstable pelvic fracture after being thrown from and stepped on by a horse. She has blood in the vagina on bimanual exam but denies recent menses. Vital signs are: blood pressure 90/60 mmHg, heart rate 125, respirations 14/min, pulse ox 99% RA. What is the next appropriate course of action?
  - A. Attempt to insert a Foley catheter
  - B. Emergent urologic consult
  - C. Insert a Foley catheter and obtain a retrograde urethrogram in the ED before ordering an abdomen and pelvis CT
  - D. Send the patient to interventional radiology (IR) and perform cystogram and retrograde urethrogram in IR
  
8. A 25-year-old female involved in a high speed motor vehicle crash presents with the following vital signs: blood pressure 110/75 mmHg, heart rate 90, respirations 15, pulse ox 99%. The pelvis is

stable on exam but a plain film of the pelvis shows widening of the pubic symphysis. A bedside FAST exam demonstrates free fluid in both the RUQ and LUQ. Secondary to pain and the patient's pannus you are unable to adequately view the bladder with US. There is gross hematuria in the Foley, which was passed on first attempt. What injury do you suspect and what do you expect to see on CT cystogram?

- A. Intraperitoneal rupture of bladder with extravasation of contrast into the abdomen
  - B. Intraperitoneal bladder rupture with extraperitoneal extravasation of contrast
  - C. Extraperitoneal rupture of bladder with extravasation of contrast into the abdomen
  - D. Extraperitoneal rupture of bladder with no contrast extravasation
- 
9. A 56-year-old male presents with multiple stab wounds to the lower back. Vital signs are stable. The patient is stable and the decision is made to obtain a CT scan of the abdomen and pelvis to assess the extent of retroperitoneal injuries. What additional imaging, if given the opportunity for an additional study of your choice, would you request?
    - A. CT cystogram
    - B. None. Abdomen and pelvis CT should adequately evaluate for renal laceration and extravasation.
    - C. None. The patient needs to go directly to the OR regardless and renal injury is best evaluated for under direct exam intraoperatively.
    - D. IV pyelogram
  
  10. A 25-year-old male is struck in the flank with a baseball bat. His systolic blood pressure is always above 100 mmHg in the ED and his exam is only remarkable for a flank hematoma without abdominal tenderness. In which scenario is imaging required?
    - A. He requires imaging because of the mechanism of injury and the location of the hematoma.
    - B. Clear urine with dipstick positive for blood.
    - C. Clear urine dipstick positive for blood and medic report of transient systolic blood pressure of 88 mmHg.
    - D. Clear urine with dipstick positive for blood that has resolved by primary care physician follow up in one week.

**Answers:** 1. B; 2. C; 3. E; 4. B; 5. D; 6. D; 7. A.; 8. A; 9. B; 10. C.

**PLEASE NOTE:** If your correct name and address do not appear below, please complete the section at right.

Please make label address corrections here or **PRINT** address information to receive a certificate.

Account # \_\_\_\_\_  
 Name: \_\_\_\_\_  
 Company: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 City: \_\_\_\_\_  
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 E-mail: \_\_\_\_\_

**CNE/CME Evaluation — Vol. 11, No. 2: Genitourinary Trauma**

Please take a moment to answer the following questions to let us know your thoughts on the CNE/CME program. Fill in the appropriate space and return this page in the envelope provided. **You must return this evaluation to receive your letter of credit. ACEP members — Please see reverse side for option to mail in answers.** Thank you.



1. In which program do you participate?  CNE  CME
2. If you are claiming physician credits, please indicate the appropriate credential:  MD  DO  Other \_\_\_\_\_
3. If you are claiming nursing contact hours, please indicate your highest credential:  RN  NP  Other \_\_\_\_\_

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
<b>After participating in this program, I am able to:</b>						
4. Discuss conditions that should increase suspicion for traumatic injuries.	<input type="radio"/>					
5. Describe the various modalities used to identify different traumatic conditions.	<input type="radio"/>					
6. Cite methods of quickly stabilizing and managing patients.	<input type="radio"/>					
7. Identify possible complications that may occur with traumatic injuries.	<input type="radio"/>					
8. The test questions were clear and appropriate.	<input type="radio"/>					
9. I detected no commercial bias in this activity.	<input type="radio"/>					
10. This activity reaffirmed my clinical practice.	<input type="radio"/>					
11. This activity has changed my clinical practice.	<input type="radio"/>					

If so, how? \_\_\_\_\_

12. How many minutes do you estimate it took you to complete this activity? Please include time for reading, reviewing, answering the questions, and comparing your answers with the correct ones listed. \_\_\_\_\_ minutes.
13. Do you have any general comments about the effectiveness of this CNE/CME program?  
 \_\_\_\_\_

**I have completed the requirements for this activity.**

Name (printed) \_\_\_\_\_ Signature \_\_\_\_\_

Nursing license number (required for nurses licensed by the state of California) \_\_\_\_\_

**Optional for ACEP members:** In accordance with ACEP requirements, below we provide the option for ACEP members to submit their answers for this CME activity. If you wish to submit answers for this activity, please refer to this issue (Vol. 11, No. 2) and circle the correct responses.

- |      |      |      |
|------|------|------|
| 1. A | 5. A | 9. A |
| B    | B    | B    |
| C    | C    | C    |
| D    | D    | D    |
| E    |      |      |

- |      |      |       |
|------|------|-------|
| 2. A | 6. A | 10. A |
| B    | B    | B     |
| C    | C    | C     |
| D    | D    | D     |

- |      |      |
|------|------|
| 3. A | 7. A |
| B    | B    |
| C    | C    |
| D    | D    |
| E    |      |

- |      |      |
|------|------|
| 4. A | 8. A |
| B    | B    |
| C    | C    |
| D    | D    |