

**American College of Radiology  
ACR Appropriateness Criteria®  
Penetrating Trauma–Lower Abdomen and Pelvis**

**Variant 1:** Penetrating trauma, lower abdomen and pelvis. Suspected lower urinary tract trauma.  
Initial imaging.

| Procedure   | Appropriateness Category | Relative Radiation Level |
|---|--------------------------|--------------------------|
| Fluoroscopy retrograde cystography                          | Usually Appropriate      | ☼☼☼                      |
| CT pelvis with bladder contrast (CT cystography)            | Usually Appropriate      | ☼☼☼☼                     |
| CT pelvis with IV contrast                                  | May Be Appropriate       | ☼☼☼                      |
| Radiography pelvis  | May Be Appropriate       | ☼☼                       |
| Fluoroscopy retrograde urethrography                        | May Be Appropriate       | ☼☼☼                      |
| CT pelvis without IV contrast                               | May Be Appropriate       | ☼☼☼                      |
| CT pelvis without and with IV contrast                      | Usually Not Appropriate  | ☼☼☼☼                     |
| Arteriography with possible embolization abdomen and pelvis | Usually Not Appropriate  | Varies                   |
| Radiography intravenous urography                           | Usually Not Appropriate  | ☼☼☼                      |
| US pelvis (bladder and urethra)                             | Usually Not Appropriate  | ○                        |
| MRI pelvis without and with IV contrast                     | Usually Not Appropriate  | ○                        |
| MRI pelvis without IV contrast                              | Usually Not Appropriate  | ○                        |
| MAG3 renal scan   | Usually Not Appropriate  | ☼☼☼                      |

## PENETRATING TRAUMA—LOWER ABDOMEN AND PELVIS

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### **Summary of Literature Review**

#### **Introduction/Background**

Lower urinary tract injury is most commonly the result of blunt trauma but can also result from penetrating or iatrogenic trauma [1]. Lower urinary tract injury that is due to blunt trauma will be discussed in a separate upcoming ACR Appropriateness Criteria<sup>®</sup> topic on “Major Blunt Trauma” and will be made available on the [ACR website](#) when completed. Clinical findings in patients with a mechanism of penetrating trauma to the lower urinary tract include lacerations or puncture wounds of the pelvis, perineum, buttocks, or genitalia; gross hematuria; or inability to void [2]. Penetrating bladder injury may result in extraperitoneal extravasation, intraperitoneal extravasation, or combined extravasation of urine. Penetrating bladder injuries that are apparent clinically are typically treated with emergent exploration and repair [1]. In hemodynamically stable patients in whom penetrating bladder injury is suspected, either radiographic cystography or CT cystography can be performed with retrograde filling of the bladder with water-soluble contrast media; both types of cystography are endorsed in the guidelines of the American Urological Association (AUA) and the European Association of Urology (EAU) [2,3]. However, CT cystography offers 2 advantages: 1) assessment of osseous, vasculature, and nonurinary viscera for coexisting injuries, and 2) no need for repeat imaging after bladder drainage.

Most of the contemporary literature concerning urethral injury deals with posterior urethral injuries associated with pelvic fractures, which are most commonly due to motor vehicle accidents [4]. In male patients with suspected penetrating trauma of the urethra, the anterior urethra is most often affected. Penetrating injury to the anterior urethra is typically surgically repaired in the acute setting [1,2]. Evaluating the degree of disruption of the anterior urethra is an important factor in operative planning. Penetrating posterior urethral injury is treated with immediate exploration via a retropubic approach and primary repair; if coexisting severe injuries preclude direct urethral repair initially, suprapubic diversion with delayed urethroplasty can be performed [1]. Retrograde urethrography (RUG) has traditionally been the standard diagnostic imaging method for evaluation of urethral trauma endorsed by the EAU and AUA [1-3]. Penetrating trauma of the female urethra is uncommon because of its anatomy and is typically diagnosed with urethroscopy [1].

#### **Bladder Injury**

Bladder injuries have been reported to occur in 1.6% of patients sustaining blunt trauma [2]; bladder injury that is due to penetrating trauma occurs less commonly, although its prevalence is not well known. The Consensus Panel of the Société Internationale D’Urologie has classified bladder injury into 4 categories [5]:

- Type I: bladder contusion
- Type II: intraperitoneal rupture
- Type III: extraperitoneal rupture
- Type IV: combined injury

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A bladder contusion (type I) is an incomplete tear of the bladder mucosa following blunt injury. An intraperitoneal rupture (type II) occurs when there is a sudden rise in intravesical pressure resulting from a blow to the lower abdomen of a patient with a distended bladder.

Types III and IV bladder injuries can be the result of penetrating pelvic injury. Extraperitoneal rupture represents approximately 60% of major bladder injuries that are due to blunt trauma [3,6]; the incidence of extraperitoneal versus intraperitoneal rupture that is due to penetrating bladder trauma is not known. Sandler et al [7] further subdivided extraperitoneal rupture into 2 groups. With simple extraperitoneal rupture, contrast extravasation is limited to the pelvic extraperitoneal space. With complex extraperitoneal rupture, contrast material extravasation may extend into the anterior abdominal wall, the penis, the scrotum, and the perineum. The presence of a complex extraperitoneal injury implies that the injury has disrupted the fascial boundaries of the pelvis. Such findings should not be mistaken as evidence of a coexisting urethral injury. A combined bladder injury (type IV) results when both intraperitoneal and extraperitoneal bladder injuries are present. Penetrating bladder injuries are typically repaired surgically in the acute setting unless coexisting life-threatening injuries are present [1].

Alternatively, the American Association for the Surgery of Trauma has developed an organ injury severity scale for bladder trauma [3]:

- Grade 1: Hematoma, partial thickness laceration
- Grade 2: Extraperitoneal bladder wall laceration <2 cm
- Grade 3: Extraperitoneal bladder (>2 cm) or intraperitoneal bladder (<2 cm) laceration
- Grade 4: Intraperitoneal bladder wall laceration >2 cm
- Grade 5: Intraperitoneal or extraperitoneal bladder wall laceration extending into the bladder neck or ureteric orifice

### **Urethral Injury**

Injuries to the male urethra have been traditionally classified into 2 main categories according to their mechanism of injury: 1) those associated with a fracture of the anterior pelvic arch (usually involving the membranous urethra) and 2) those occurring as the result of a straddle injury (usually involving the bulbous urethra); both of these types of male urethral injury are more commonly found after blunt trauma, but can also result from penetrating trauma. The penile urethra is injured less frequently than the bulbar and membranous segments of the urethra overall; however, the penile urethra is more commonly injured with penetrating trauma because of its entirely external location.

Male urethral trauma was originally classified by Colapinto and McCallum [8] based on the appearance of the RUG. This classification has been expanded by Goldman to include all urethral traumas [9,10] and is the most widely accepted classification:

- Type I: posterior urethra stretched but intact
- Type II: urethra disrupted at the membranous-prostatic junction above the urogenital diaphragm
- Type III: disruption of the membranous urethra, extending below the urogenital diaphragm and involving the anterior urethra
- Type IV: bladder neck injury, with extension into the proximal urethra
- Type IVa: injury to the base of the bladder, with periurethral extravasation simulating a type IV urethral injury
- Type V: isolated anterior urethral injury

An alternative classification has been set forth by American Association for the Surgery of Trauma in which urethral injuries are classified by the treatment required and the degree of urethral disruption, regardless of location [9]:

- Grade I: Contusion
- Grade II: Stretch injury
- Grade III: Partial disruption (visualization of bladder during RUG)
- Grade IV: Complete disruption (<2 cm urethral disruption; nonvisualization of bladder during RUG)
- Grade V: Complete disruption (>2 cm urethral disruption or extension into prostate or vagina)

Female urethral injuries are rare and are usually associated with pelvic fracture or vaginal laceration [2,9,11]. The rarity of female urethral injury is due to the relatively shorter length, internal location posterior to the osseous

pubic arch, relatively increased mobility, and lack of significant attachment to the pubic bone [9,11]. The EAU recommends urethroscopy for diagnosis of suspected injury of the female urethra [1,3].

## **Discussion of Procedures by Variant**

### **Variant 1: Penetrating trauma, lower abdomen and pelvis. Suspected lower urinary tract trauma. Initial imaging.**

#### **Radiography Pelvis**

There is no relevant literature regarding the use of radiographs in the evaluation of penetrating trauma to the lower urinary tract. Radiography of the pelvis plays an ancillary role by identifying radiopaque foreign bodies associated with penetrating injuries and in identifying pelvic fractures. Pelvic radiography can be combined with RUG.

#### **CT Pelvis with Bladder Contrast (CT Cystography)**

Schneider [12] stated that either retrograde cystography or CT is the diagnostic procedure of choice for a suspected bladder injury, and Horstman et al [13] found that both types of imaging examinations equally detected all types of bladder injury in blunt trauma patients. The authors indicated that contrast instillation during CT can provide the adequate bladder distention needed to demonstrate contrast extravasation from the injury site. Since then, CT cystography has become the first-line evaluation for bladder injury in the acute trauma setting [4]. This technique refers to the retrograde instillation of a minimum of 350 cc of diluted contrast media into the bladder, followed by axial and coronal CT images of the pelvis [6,14]. Unlike conventional cystography, no postdrainage CT images are needed. In a study that included patients who sustained blunt and penetrating trauma, there was 100% sensitivity and 99% specificity for intraperitoneal bladder rupture; additionally, the specific site of bladder dome injury was found in 4 of the 18 patients and was identified only with multiplanar reconstructed images [14]. An advantage of CT cystography is the ability to diagnose injuries to other pelvic viscera, osseous structures, and vasculature.

Contrast-enhanced CT with excretory phase imaging is not a reliable means to diagnose bladder rupture, even after a urethral catheter has been inserted and clamped [2,15,16]. Excretory phase imaging is defined as antegrade filling of the urinary bladder that is due to excretion of intravenous (IV) contrast material through the kidneys. Although intraperitoneal and extraperitoneal fluid can be detected during excretory phase CT, the etiology of the fluid cannot be determined because the bladder is usually inadequately distended to cause extravasation through a bladder laceration or perforation. Although the absence of pelvic fluid is strong evidence against a bladder rupture, a negative study does not exclude bladder injury [17].

The literature suggests that both conventional and CT cystography are equivalent, with physician preference and diagnostic protocols generally defining the method used [2,13,18]. Although CT is not the technique of choice for urethral injuries, it is performed so frequently that urethral injuries are inevitably identified when performed for pelvic trauma. Chou et al [19] described the results of CT voiding urethrography using 16-multidetector CT in 13 men and found a high correlation between the results of conventional RUG and CT voiding urethrography for evaluating traumatic and nontraumatic urethral conditions. Findings of penetrating urethral trauma on CT voiding urethrography include extravasation of contrast media, irregularity of the urethral lumen, and hematomas.

#### **CT Pelvis**

Pelvic CT without IV contrast provides limited evaluation for suspected penetrating injury to the lower urinary tract because of nonopacification of the urinary bladder lumen and lack of enhancement of the pelvic viscera [18]. However, it may be useful in detecting fluid or hematoma adjacent to the urinary bladder, prompting a follow-up evaluation with radiographic or CT cystography. Pelvic CT without IV contrast may be occasionally considered for evaluation of urethral or periurethral foreign body.

Pelvic CT with IV contrast allows improved assessment of the pelvic viscera and vessels compared with CT without IV contrast. However, evaluation for bladder injury remains limited because of suboptimal distension and nonopacification of the urinary bladder lumen. The use of antegrade cystography, during which the urinary bladder is gradually opacified by excretion of IV contrast, provides inadequate evaluation of bladder injury that is due to suboptimal distension of the bladder lumen, dilution of excreted contrast material by urine, and the time delay required for excretion of IV contrast [2].

Pelvic CT without and with IV contrast is suboptimal compared with CT cystography because of the reasons described in the previous 2 paragraphs. Specifically, pelvic CT without and with IV contrast does not provide

adequate distension of the bladder, thereby limiting sensitivity for detection of leak. Pelvic CT without and with IV contrast results in increased radiation dose incurred by performing 2 scans of the pelvis. Additionally, pelvic CT without IV contrast is further limited by lack of enhancement of the pelvic viscera.

### **MRI Pelvis**

There is no relevant literature regarding the use of MRI in the evaluation of penetrating trauma to the lower urinary tract. MRI plays an ancillary role in the initial imaging evaluation of penetrating lower urinary tract injury that is due to the difficulty of monitoring a seriously injured patient in a strong magnetic field. MRI has been described for follow-up evaluation of urethral injury as an adjunctive tool for assessing complex urethral anatomic derangements [20,21].

### **Radiography Intravenous Urography**

There is no recent relevant literature regarding the use of an IV urogram in the evaluation of penetrating trauma to the lower urinary tract. An IV urogram is typically inadequate for evaluating the bladder and urethra after penetrating trauma because the contrast material within the bladder is diluted and the resting intravesical pressure is simply too low to demonstrate a small tear [15].

### **Fluoroscopy Retrograde Urethrography**

Patients with penetrating trauma to the penis should undergo RUG as the primary diagnostic procedure because of concern for injury of the anterior urethra [22]. Because posterior urethral injuries can also result from penetrating trauma to the pelvis and perineum, and are associated with pelvic fractures, a RUG should be performed before inserting a catheter [7,10,18]. In the past, a diagnosis of acute urethral injury often was based loosely on the clinical triad of 1) blood at the urethral meatus, 2) inability of the patient to void, and 3) a palpable urinary bladder. An inability to pass the catheter into the bladder was also considered diagnostic of a posterior urethral injury. It is now well established, however, that diagnostic catheterization is to be avoided, as it may convert a partial injury into a complete disruption [2,22]. In female patients with a suprapubic catheter in place, a descending or voiding urethrography may be sufficient; a RUG may also be performed with a small-caliber catheter pressed against, or slightly beyond, the urethral meatus [9].

### **Arteriography**

There is no relevant literature regarding the use of arteriography in the evaluation of penetrating trauma specific to the lower urinary tract. Arteriography can be useful in identifying an occult source of bleeding and can guide its subsequent therapeutic embolization [15]. Angioembolization has been described as a useful diagnostic and therapeutic tool in trauma patients with pelvic fractures and vascular injuries.

### **US Pelvis**

Transabdominal ultrasound (US) findings in bladder rupture and urethral evaluation with an endorectal probe have been described in the setting of blunt trauma [15], but US has not been routinely used for evaluating penetrating trauma of the lower urinary tract. Conversely, most or all seriously injured trauma patients will likely be evaluated with CT because of its speed and accuracy of evaluation.

US can be used to evaluate associated visceral lesions, such as solid or hollow organ rupture, and nonspecific peritoneal fluid [15]. The detection of peritoneal fluid in the presence of normal viscera or the failure to visualize the bladder after the transurethral introduction of saline are considered highly suggestive of bladder rupture [15]. As a practical matter, US is not definitive in bladder or urethral trauma and is almost never used for this diagnosis.

### **Fluoroscopy Retrograde Cystography**

The diagnosis of bladder rupture is usually easy with cystography, when the injected contrast is identified external to the bladder. Prior to the widespread acceptance of CT cystography as an equivalent alternative in evaluating bladder trauma, retrograde cystography has been called the “procedure of choice” [23], “mandatory” [24], “the only way” [18], and the “examination of choice” [22].

Adequate distention of the urinary bladder is crucial to detecting a perforation, especially in instances of penetrating trauma, as most instances of a false-negative retrograde cystogram were found in this situation [24,25]. To exclude bladder injury, a filling volume of at least 350 to 400 mL of contrast should be achieved. The catheter balloon should not be tightly maintained against the bladder neck because it could tamponade against a disruption and prevent detection of a leak in this region.

Retrograde cystography requires a scout radiograph, bladder distension views, and a postdrainage radiograph, at minimum [2]. Fluoroscopic visualization during early filling should be obtained to avoid additional distension if a gross disruption is identified. Oblique views are useful to avoid missing a small anterior or posterior injury. In approximately 10% of cases [18], bladder injury can be identified only with the postdrainage image. Cystography has an accuracy rate of 85% to 100% for detecting bladder injury [25]. However, only a properly performed cystogram should be used to exclude bladder injury [22].

### MAG3 Renal Scan

There is no relevant literature regarding the use of a nuclear renal scan in the evaluation of penetrating trauma to the lower urinary tract. Because of its low resolution of the urinary bladder and inability to reliably depict the urethra, the nuclear renal scan is not a practical imaging tool to evaluate penetrating trauma of the lower urinary tract.

### Summary of Recommendations

- **Variation 1:** Fluoroscopy retrograde cystography or CT pelvis with bladder contrast (CT cystography) is usually appropriate for the initial imaging evaluation of suspected penetrating trauma to the lower urinary tract. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient’s care).

### Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

### Appropriateness Category Names and Definitions

| Appropriateness Category Name     | Appropriateness Rating | Appropriateness Category Definition  |
|-----------------------------------|------------------------|--|
| Usually Appropriate               | 7, 8, or 9             | The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.  |
| May Be Appropriate                | 4, 5, or 6             | The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal. |
| May Be Appropriate (Disagreement) | 5                      | The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel’s recommendation. “May be appropriate” is the rating category and a rating of 5 is assigned.                   |
| Usually Not Appropriate           | 1, 2, or 3             | The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.  |

### Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for

pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [26].

| Relative Radiation Level Designations |                                     |   |
|---------------------------------------|-------------------------------------|---|
| Relative Radiation Level*             | Adult Effective Dose Estimate Range | Pediatric Effective Dose Estimate Range |
| ○                                     | 0 mSv                               | 0 mSv                                   |
| ☼                                     | <0.1 mSv                            | <0.03 mSv                               |
| ☼☼                                    | 0.1-1 mSv                           | 0.03-0.3 mSv                            |
| ☼☼☼                                   | 1-10 mSv                            | 0.3-3 mSv                               |
| ☼☼☼☼                                  | 10-30 mSv                           | 3-10 mSv                                |
| ☼☼☼☼☼                                 | 30-100 mSv                          | 10-30 mSv                               |

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.