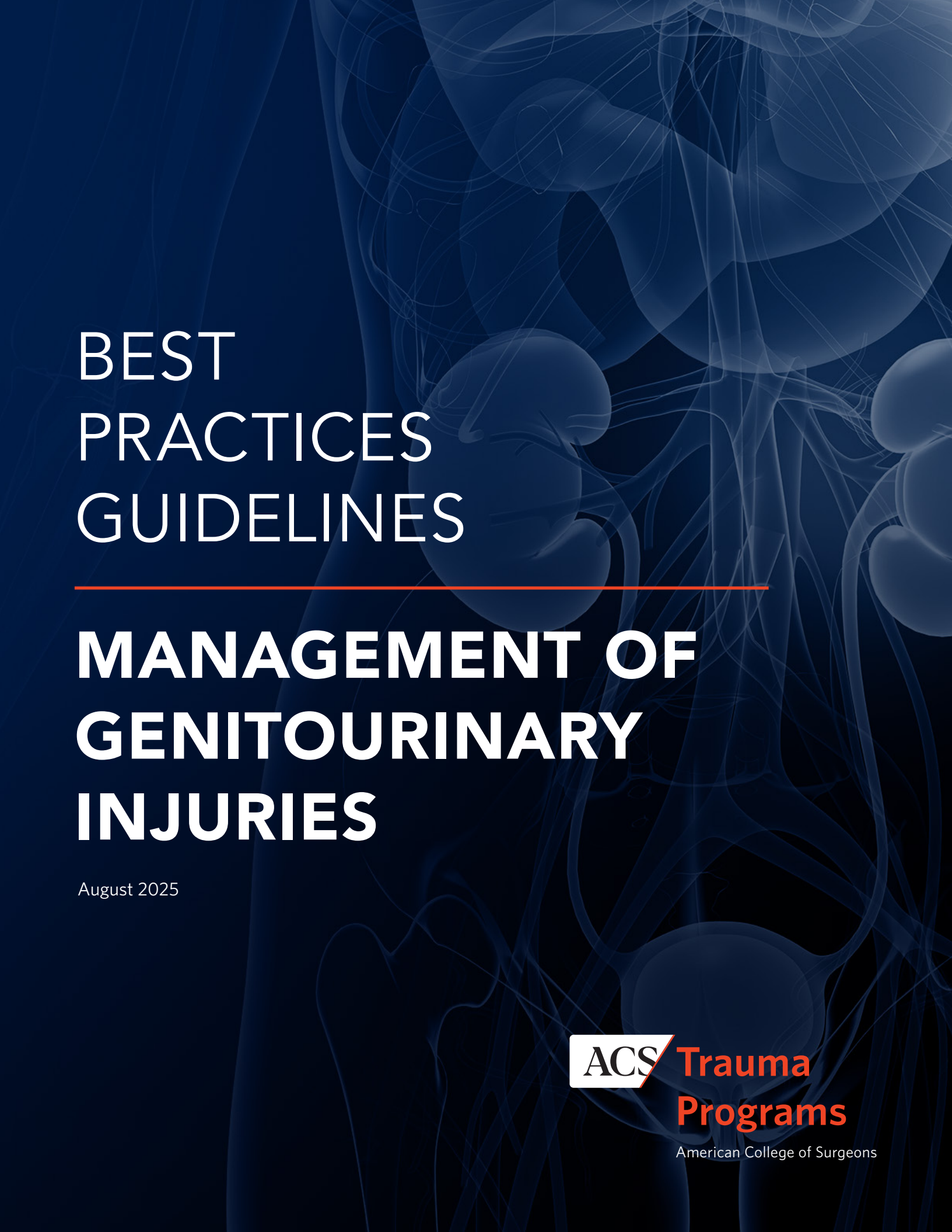

BEST PRACTICES GUIDELINES

MANAGEMENT OF GENITOURINARY INJURIES

August 2025

ACS Trauma Programs

American College of Surgeons

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BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

GENITOURINARY INJURY OVERVIEW

INTRODUCTION

Traumatic genitourinary (GU) injuries are identified in up to 10% of trauma patients presenting to emergency departments nationwide, and they are a source of significant morbidity and mortality.[1] Renal injuries are the most common GU injuries and have the highest risk for life-threatening hemorrhage. Injuries to the remainder of the GU system put patients at significant risk for long-term urinary, renal, and sexual health complications. As such, appropriate early identification, triage, and multidisciplinary management of these injuries is paramount to ensuring optimal outcomes for these patients.

A number of specialty societies have created evidence-based guidelines for the management of GU injuries. However, broad dissemination of these GU guidelines to the leadership of trauma systems, who are responsible for establishing and implementing protocols and practices for the management of these patients, has been lacking.[2–5] Because the initial triage and diagnostic workup is most commonly performed by emergency physicians and trauma surgeons, it is necessary to establish Best Practices Guidelines (BPGs) that incorporate GU system evaluation and management protocols targeted to urologists and all clinicians who face these relatively common injuries. Because many trauma centers do not have 24-hour urologic surgery call coverage, this BPG was designed to guide all trauma centers and clinicians, regardless of American College of Surgeons (ACS) certification level, in the appropriate triage, management, and transfer criteria for patients with GU injury.

The *ACS Trauma Quality Programs (TQP) Best Practices Guidelines for the Management of Genitourinary Injuries* provides a comprehensive overview and insight into the management of GU injury patients and was prepared by a collaborative and multidisciplinary panel of national experts, both civilian and military. The aim of this BPG is to provide evidence-based recommendations that are adaptable to the particular resource availability of a trauma center, with special emphasis on criteria for patient transfer to a higher level of care. Notably different from other existing GU trauma guidelines are specific recommendations for the care of pediatric and geriatric patients, as well as for both male and female anatomy. When the evidence for a particular practice was insufficient, clear recommendations based on expert opinions were provided. Taken together, this BPG aims to elevate the practices of all trauma centers by providing the most comprehensive, practical, and interdisciplinary recommendations for the care of patients with GU injury.

IMPORTANT NOTE

The intent of the *ACS TQP BPGs* is to provide healthcare professionals with evidence-based information regarding care of the trauma patient. The BPGs do not include all potential options for prevention, diagnosis, and treatment, and they are not intended as a substitute for the provider's clinical judgment and experience. Responsible providers must make all treatment decisions based upon their independent judgment and the patient's individual clinical presentation. Although these BPGs have been reviewed with significant care, they are provided as is and without liability. The ACS and any entities endorsing the guidelines shall not be liable for any direct, indirect, special, incidental, or consequential damages related to the use or misuse of the information contained herein. The ACS may modify the TQP BPGs at any time without notice. This *ACS TQP Best Practices Guidelines for the Management of Genitourinary Injuries* is not intended to be a comprehensive guide to all services, personnel, and processes needed to conduct quality complex genitourinary trauma care. The guidance herein does not constitute a standard of care and is not intended to replace the medical judgment of the physician or health care professional in individual circumstances.

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INJURY OVERVIEW

KEY POINT

- Motor vehicle collisions, falls, and penetrating injuries are the most common mechanisms of GU trauma.

Of all GU injuries, the kidney is the most commonly injured organ, occurring in up to 3% of all civilian trauma patients, with over 90% of these injuries occurring following blunt trauma. In contrast, ureteral injuries are the least common, present in about 1% of the GU trauma population.[1]

Mechanism of Injury

Mechanisms of injury that carry the highest risk for GU trauma in adults include deceleration injuries from a motor vehicle collision,[2,3] fall from height, and penetrating injuries from gunshot or stab wounds.[4] Testicular trauma most often results from penetrating injuries or motorcycle or bicycle crashes.[2] Other urologic injury mechanisms include straddle injury, blunt assault or other direct blow to the flank or the external genitalia, and sexual assault, which may result in both external and internal GU tract injuries.

In patients with penetrating trauma, the presence of stab wounds to the abdomen, suprapubic area, the bilateral flanks, or the lower back carries the risk of GU trauma. The trajectory of gunshot wounds to the abdomen and pelvis may also raise the index of suspicion for GU trauma.

Injuries Associated with Genitourinary Trauma

Blunt Trauma

In blunt trauma, injury to the left kidney may be associated with a splenic injury, while on the right, it may be associated with a liver injury.[5] Blunt bladder injuries indicate a significant force and are often associated with pelvic fractures and other intra-abdominal injuries. Vaginal bleeding may indicate the presence of a comminuted pelvic fracture, and this carries a high risk for a bladder and/or urethral injury.[6]

Penetrating Trauma

Gunshot wounds to the kidneys are almost always associated with other injuries, including:[7,8]

- On the right side—the liver, duodenum, and ascending colon
- On the left side—the diaphragm, stomach, spleen, pancreas, and colon

The incidence of these injuries associated with stab wounds is lower. The ureters are more prone to injury with penetrating trauma, commonly resulting in injuries to adjacent structures as well, including major vessels and the small and large bowel.

Pediatric Considerations

Pediatric patients most often present with GU trauma after pedestrian–motor vehicle crashes, recreational motor vehicle crashes (e.g., all-terrain vehicles), contact sports, bicycling, and falls in bathtubs, at the playground, or from a trampoline.[9–12]

Older Adult Considerations

Geriatric trauma is rising with the aging baby boomer population, with trauma now the ninth leading cause of death in this population.[13,14] Urologic injuries represent 9% of the total injuries among older adults.[13] Blunt trauma (e.g., falls and motor vehicle collisions) is the most common mechanism of injury sustained by the older adult, while penetrating trauma is rare.[14,15]

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BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

GENITOURINARY TRAUMA ASSESSMENT

INITIAL EVALUATION

KEY POINTS

- When GU trauma is suspected based on mechanism of injury, as well as specific physical signs and symptoms, additional assessment is required, including imaging and/or endoscopic evaluation.
- Consider obtaining a retrograde urethrogram (RUG) prior to insertion of an indwelling urinary catheter when a urethral injury is suspected, especially when resources are readily available in the trauma bay.

Primary Survey

The initial evaluation of trauma patients with suspected GU trauma follows the principles of Advanced Trauma Life Support® (ATLS®).[1] Life-threatening conditions that require immediate intervention are identified during the primary survey. Identification of specific injuries to the external or internal GU tract is not required during this initial phase of assessment and management.

Although exceedingly rare, significant bleeding from external GU trauma is initially managed with the application of direct pressure and/or packing. Significant vaginal bleeding may indicate the presence of a comminuted pelvic fracture, and rapid identification of such injury is crucial.[2] When a decision is made during the primary survey for emergent exploratory laparotomy in patients presenting with hemorrhagic shock, peritonitis, or evisceration, GU injuries may be identified intraoperatively. However, isolated GU trauma rarely results in hemorrhagic shock requiring emergent surgical intervention; if this does occur, renal vessel injury is usually involved.[2]

Adjuncts

Initial Imaging

Clues to the presence of GU trauma may be seen on radiologic imaging. The presence of a pelvic fracture on an anteroposterior view pelvic x-ray raises the index of suspicion for injury to endopelvic organs, especially the bladder and/or urethra.[3] Low posterior rib fractures on a chest x-ray raise the index of suspicion for renal trauma.

A positive focused assessment with sonography for trauma (FAST) exam may indicate the presence of intraperitoneal bladder rupture. However, the FAST exam is neither sensitive nor specific in identifying GU trauma. Additionally, the FAST exam is not suitable for the identification of fluid in the retroperitoneal space, which can be related to renal, ureteral, or extraperitoneal bladder injuries.

Urethral Catheter Placement

Indwelling urinary catheters are commonly used to monitor urine output and guide resuscitation. The presence of gross hematuria or blood at the urethral meatus may suggest the presence of GU trauma, including injury to the kidneys, ureters, bladder, and/or urethra.[4] However, the absence of these findings does not entirely rule out these injuries.

> **Caution:** When a urethral injury is present, blind placement of an indwelling urinary catheter may result in the creation of a false passage or complicate existing urethral tears. A best practice is to perform a bedside RUG before placing an indwelling urinary catheter when the index of suspicion for a urethral injury is very high (e.g., blood at the urethral meatus in a patient with a pelvic fracture).[5] This option may be readily available in the trauma bay. In situations where a catheter is needed and imaging not readily available, a single attempt at indwelling urinary catheter placement by an experienced trauma team member may be appropriate. Only limited data exist to suggest that this will worsen any potential injuries; otherwise, urological consultation is advised.[6] Urological consultation is also advised when a urethral injury is suspected in a trauma patient with female anatomy, although this is very rare.

Indwelling Urinary Catheter Placement: Practical Considerations

Sterile technique is a best practice. Use of a Foley catheter with a straight end is preferred. Other types of catheters, including those with a coudé tip (curved end), are not recommended. Abort the procedure if any resistance is encountered during advancement of the catheter or if urine is not obtained, and consider additional workup with a RUG. Inflate the balloon only after urine is seen draining in the tubing and the catheter is fully inserted in the patient

with male anatomy; otherwise, there is a risk of iatrogenic urethral injury.[7] A best practice is to prevent inadvertent or self-extraction of the catheter by securing it with tape to the thigh or using a commercial product for this purpose.[8]

Retrograde Urethrogram: Practical Considerations

Perform this exam either in the trauma bay or in a delayed fashion in the radiology suite using sterile technique. The sequence of the RUG and computed tomography (CT) scan needs to be considered. If the patient has a pelvic fracture and the CT scan is being used to evaluate for possible arterial extravasation, it is best to defer the RUG and perform the CT scan first. This sequencing limits the possibility of significant artifact from the extravasation of urethral contrast, which would make the assessment of active bleeding more difficult.[9] Details of the technique are provided in the section Male Urethral Imaging Protocols on page 19.

Secondary Survey

GU injuries are most commonly evaluated during the secondary survey based on mechanism of injury, physical findings, and the presence of associated injuries. Diagnostic workup during this phase requires additional imaging studies and/or endoscopic procedures.

The following may indicate the presence of GU injury in patients with blunt trauma:

- Unilateral or bilateral flank pain, contusions, abrasions, ecchymosis, or lacerations may be associated with renal trauma.
- A mechanically unstable pelvis raises the index of suspicion for a bladder or urethral injury.[3]
- Lower abdominal contusions from a seatbelt ("seatbelt sign") may be associated with a bladder injury.
- Peritoneal signs, gross hematuria, and inability to void may indicate a bladder injury.
- Blood at the urethral meatus, perineal and/or penile hematoma or ecchymosis, a palpable full bladder, and inability to void suggest a urethral injury. **A digital rectal exam is no longer recommended** to evaluate for a "high-riding prostate" to rule out posterior urethral disruption.[10]
- Scrotal swelling, ecchymosis, localized pain or tenderness, or lower abdominal pain may be associated with testicular injury.

Polytrauma Patients and Interdisciplinary Care

Polytrauma patients require a multidisciplinary approach to their injuries involving surgical and other specialists. Addressing life-threatening injuries is the initial focus, including those involving the GU tract. The goal during initial management is to control bleeding and ensure adequate urinary drainage to minimize potential complications related to urinary extravasation. Much of this initial management depends on associated injuries, as well as availability of experts and resources.

Definitive urinary reconstruction can be delayed when management of other injuries takes priority. However, promptly perform urinary reconstruction in otherwise hemodynamically normal patients with no contraindications. Involvement of other specialties and long-term GU follow-up may be required throughout the continuum of care to address the following:

- Preoperative needs (e.g., placement of a nephrostomy tube)
- Postoperative complications (e.g., percutaneous drainage of urine leak or abscess)
- Long-term issues related to the injuries or the surgical procedure performed (e.g., urinary incontinence, sexual dysfunction)

Long-term medical management may also be required, such as in patients with hypertension following high-grade renal trauma. Coordination of care between all involved teams is of paramount importance to ensure that injury management is prioritized appropriately, leading to the best possible short- and long-term outcomes. To this end, patients with complex injuries who require urological reconstruction or other interventions may require transfer to higher-level trauma centers with the necessary resources.

Older Adult Considerations

While the diagnosis and management of geriatric urologic trauma patients is like that of younger adults, the outcomes tend to be worse. This is likely due to increasing comorbidities and decreasing physiologic reserve.[11,12] Delayed diagnosis of some acute and traumatic pathologies in the geriatric population may occur due to confounding

effects from increased rates of comorbidities.[13–16] It is thus essential that the same trauma algorithms be followed for geriatric patients and for younger adults. Once stabilized, geriatric patients may benefit from medical management incorporating geriatric consult teams.[11,12]

Trauma Center Level and Specialist Availability

Admission of polytrauma patients to high-level trauma centers is associated with improved outcomes, including survival.[17,18] In addition to resources for initial resuscitation, higher-level trauma centers are expected to secure around-the-clock availability of other expert practitioners, including urologists and interventional radiologists. These experts are prepared to undertake complex surgeries or other interventions more expeditiously, leading to improved outcomes.[19] The volume of patients with GU injuries seen at the center significantly impacts outcomes. For example, a significantly lower rate of nephrectomy for renal injuries occurs at trauma centers with higher patient volumes.[20]

Lower-level trauma centers may not have resources such as interventional radiology and urology expertise to maximize the success rate of nonoperative management (NOM) of renal and other injuries. Complex pelvic fractures combined with urethral or bladder injuries require coordination of care to prevent serious complications and ensure optimal short- and long-term functional and other outcomes.[5,21,22] This impact may be even greater in older adult and pediatric trauma patients.[23] Given the associated injuries and the complexity of reconstructive surgeries required for some GU injuries, admission or transfer of these patients to higher-level trauma centers is often justified when appropriate urologic, interventional radiologic, or orthopaedic services are not available.

Disparities in trauma system access, specifically in rural areas, may impact care available to certain patient populations. Rural patients are likely disproportionately affected by delays in diagnosis, inadequate specialist coverage, and longer transport times, which can impact receipt of timely and appropriate care. Patients in areas of higher social vulnerability may similarly face barriers to postdischarge follow-up for complications from injury such as urinary incontinence, erectile dysfunction, or other quality-of-life adverse effects. Finally, lower-resourced Level III and Level IV trauma centers may not have access to many of the recommended imaging and management protocols advocated for in this guideline. Acknowledging these disparities underscores the importance of regional system-level readiness and appropriate utilization of triage and transfer protocols to help minimize the impact that these access disparities might create.

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INDICATIONS FOR EMERGENT INTERVENTION

KEY POINTS

- High-grade renal injuries require emergent intervention if the patient is actively bleeding and hypotensive.
- Ureteral injuries are usually the result of penetrating trauma but can occur after significant blunt deceleration injuries. They are most often discovered at the time of laparotomy.
- Intraperitoneal bladder injuries require emergent surgical repair.
- Urethral injuries identified at the time of a RUG require emergent intervention to obtain effective bladder drainage (e.g., urinary catheter placement or suprapubic cystostomy).

Genitourinary Injury Discovered During Physical Exam

Except for the external genitalia, most GU organs are extraperitoneal structures in the abdomen and pelvis and cannot be evaluated by physical examination. When no obvious GU injury exists on physical exam, perform additional imaging only if the clinical index of suspicion is high.

Traumatic injuries to the external genitalia may be evident on physical exam performed during the secondary survey. They may not require additional imaging prior to emergent operative management. Perform ultrasound evaluation on patients with male anatomy who have blunt trauma to the external genitalia to identify injuries needing management.[1] Penetrating injuries to the penis and scrotum, for which there is a high clinical suspicion of injury, do not require additional imaging prior to surgical exploration and management.

Genitourinary Injury Discovered During Imaging

The majority of traumatic GU injuries will be identified during imaging. Imaging may include contrast studies of the urethra and bladder or CT scan of the abdomen and pelvis with intravenous (IV) contrast.[2] Ultrasound is commonly used to assess for testicular injury in blunt trauma. Some of these traumatic GU injuries will require emergent surgical intervention.

- **Renal injuries** are most often identified at the time of abdomen and pelvis CT scan with IV contrast. The majority of renal injuries (approximately 90%) are low grade (I–III) and can be managed nonoperatively.[3] However, some grade III injuries may be associated with significant bleeding, resulting in a higher potential for failure of NOM. Some cases of more severe injuries (grades IV and V) require emergent surgical intervention if the patient is actively bleeding and hypotensive. Significant urinary extravasation may require intervention utilizing a ureteral stent or nephrostomy tube. If the patient is hemodynamically stable, many grade IV and V injuries can be managed nonoperatively, potentially using adjunctive angiography with possible embolization, as required.
- **Bladder injuries** are identified during conventional cystography or CT cystography. Uncomplicated extraperitoneal bladder injuries are generally managed nonoperatively with urinary catheter drainage alone. Intraperitoneal and complicated extraperitoneal injuries identified during cystography require surgical repair.
- **Urethral injuries** identified at the time of RUG may not need emergent surgical intervention, but they do require emergent intervention to obtain effective bladder drainage. This intervention may include urinary catheter placement or suprapubic cystostomy.

Genitourinary Injury Discovered During Laparotomy

Trauma patients with abdominal injury and diffuse peritonitis or hypotension require an exploratory laparotomy. Traumatic GU injuries identified during laparotomy may present as free urine in the abdomen from an intraperitoneal bladder injury or as a retroperitoneal hematoma. Intraperitoneal bladder injuries can be easily identified and repaired during exploratory laparotomy. A retroperitoneal hematoma may be the first sign of a traumatic GU injury.

For a trauma laparotomy, the retroperitoneum is divided into three zones (I, II, III) to describe the location of a hematoma.[4]

- Zone I is a central hematoma, extending from the diaphragm to the pelvic brim, and includes the inferior vena cava, aorta, origins of the renal vascular structures, duodenum, and pancreas.
- Zone II is a lateral hematoma, from diaphragm to pelvic brim and contains the kidneys, renal vasculature, ureters, adrenal glands, as well as the ascending and descending colon.
- Zone III is a pelvic hematoma, below the pelvic brim and contains iliac arteries and veins, ureters, bladder, and rectum.

Retroperitoneal Hematoma

For blunt trauma, a retroperitoneal hematoma is explored selectively based on anatomic location and hemodynamic status of the patient. A retroperitoneal hematoma can often be left undisturbed unless it is expanding, pulsatile, has freely ruptured, or if the patient is hemodynamically unstable. Exceptions include patients presenting with penetrating trauma and concern for underlying ureteral or renal vascular injuries that require acute surgical repair. In most cases, a retroperitoneal hematoma after penetrating trauma needs to be explored. If not obtained preoperatively, perform a postoperative abdominal CT with IV contrast in patients who do not undergo a retroperitoneal exploration.

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BEST PRACTICES GUIDELINES

MANAGEMENT OF GENITOURINARY INJURIES

IMAGING

INTRODUCTION

KEY POINTS

- Initial CT imaging of urologic trauma is usually performed as part of the general torso evaluation.
- Contrast-enhanced imaging is required to adequately identify and characterize injuries.

Initial imaging for patients with urologic trauma is usually obtained as part of the overall torso imaging for trauma patients, which is not specifically designed for renal imaging. The torso imaging protocol must detect and evaluate injuries to the remainder of the body, such as the liver, spleen, pancreas, vascular system, and musculoskeletal system.

CT Imaging Phases

A brief review of the different CT imaging phases is provided to improve understanding of urologic imaging options in this section.

- The unenhanced (or nonenhanced) phase occurs when imaging is performed without IV contrast.
- Arterial phase imaging occurs approximately 20–40 seconds after the start of IV contrast injection, and it allows better differentiation of the arteries and veins. Partial enhancement of soft tissue structures occurs during this time and may be less homogeneous than enhancement during later phase imaging.
- Portal venous phase imaging occurs approximately 70 seconds after the start of IV contrast injection and provides brighter and more homogeneous enhancement of the organs, including the liver, spleen, and kidney. The arterial system, portal vein, and central venous system are opacified and may be fairly similar in enhancement (brightness/whiteness). This is the typical phase used for general evaluation of the abdomen and pelvis.
- Delayed-phase imaging typically occurs 3–10 minutes after the start of IV contrast injection, and it is used primarily to detect urinary extravasation. It is also useful in detecting active bleeding (vascular contrast extravasation).

RENAL AND URETERAL IMAGING PROTOCOLS

KEY POINTS

- While arterial phase imaging may help identify and characterize arterial urologic injuries (e.g., pseudoaneurysm (PSA) or arteriovenous fistula (AVF)), it requires additional radiation. Its use may be determined by the specific clinical situation and local institutional protocols.
- Portal venous phase imaging is optimal for the evaluation of parenchymal injuries.[1,2]
- Delayed-phase imaging may be needed to evaluate for contrast extravasation due to vascular injury, and it is required to identify injury to the renal collecting system or ureters.

Alternative imaging strategies for the initial evaluation for abdominal trauma, such as ultrasound, fluoroscopy, plain film radiography, or unenhanced CT, are **not** recommended. While magnetic resonance imaging (MRI) can potentially provide the same level of detailed evaluation as contrast-enhanced CT imaging, it is much costlier, slower, and often requires sedation to perform.

Arterial and Parenchymal Phase Imaging

Although the literature provides no agreement about the optimal protocol for evaluation of renal trauma,[3–7] initial trauma imaging protocols are generalized for torso trauma. The initial urologic trauma evaluation is usually part of that trauma imaging protocol. The exact technique may vary based on the trauma center's experience and resources, as well as the patient's injury mechanism and suspected injury severity.[2]

The portal venous phase is considered essential/optimal for evaluation of renal parenchymal injuries and active bleeding, as recommended by the American College of Radiology (ACR) Expert Panel on Major Trauma[1] and the *ACS Trauma Quality Improvement Program (TQIP) Best Practices Guidelines in Imaging.*[2] This phase is recommended by almost all protocols reported in the literature.[1,2,4,7,8]

The addition of arterial phase imaging to the portal venous phase imaging is less universally agreed upon. The 2018 *ACS TQIP Best Practices Guidelines in Imaging* recommends arterial phase imaging if vascular injuries are suspected, and the ACR Expert Panel on Major Trauma lists arterial phase imaging as optional.[1,2] In contrast, the American Association for the Surgery of Trauma (AAST) and European Association of Urology (EAU) recommend arterial phase imaging for all trauma imaging.[9,10] While the addition of arterial phase imaging improves detection and characterization of arterial injuries, it requires the patient to receive additional radiation, and its use may depend on specific patient parameters. If a patient is being imaged specifically to evaluate for an arterial injury due to clinical findings or prior imaging, arterial phase imaging needs to be included.

Delayed-Phase Imaging

Delayed-phase (excretory) imaging can improve the detection and characterization of urinary extravasation for both renal and ureteral injuries, as well as vascular injuries; however, it also requires additional radiation. The approach that results in the smallest radiation dose and the ability to image at the optimal time is one in which parenchymal phase images are reviewed while the patient is on the CT scanner table to determine if delayed images are indicated and, if so, which region to image.

This panel recommends that clinicians selectively obtain delayed imaging when concern for renal or ureteral injury exists, as manifested by a demonstrated renal injury, by mechanism concerning for renal/ureteral injury, or by unexpected fluid around the kidneys or ureters.[1,2,9,11] Radiation can be minimized by using a lower radiation dose protocol for delayed images and limiting imaging to the region of interest.

Reviewing images while the patient is still on the CT scanner table may not be practical in all environments. At such facilities, practitioners may obtain delayed images on all patients with concern for renal injury, as recommended by other guidelines.[12] While this approach simplifies imaging, it results in a higher radiation dose to all patients, some of whom may not meet criteria for delayed imaging. Other practitioners may send the patient back to CT after reviewing their study, if delayed images are determined to be needed at that time.

Delayed Imaging Timing

The traditional timing to obtain delayed images is variable (3–20 minutes after start of contrast injection).[2,11] Optimal timing for evaluation of collecting system injury, however, is reported to occur at 10 minutes after initiation of contrast injection.[13]

When review of a patient's study indicates the need for delayed imaging, the patient will typically return to the CT scanner considerably more than 10 minutes after start of injection. For patients who previously received IV contrast, CT without additional contrast may be an option to evaluate for urinary extravasation. However, there is variability and inconsistency related to how long the extravasated contrast will remain visible on follow-up imaging. Several sources suggest that extravasation can be visualized well beyond 10 minutes.

The *ACS TQIP Best Practices Guidelines in Imaging* states that images may be obtained up to an hour after IV contrast injection.[2] The European Society of Emergency Radiology (ESER) states that delayed imaging may be considered up to a few hours after the initial CT without further injection of contrast media.[14] This likely depends on the volume of the extravasated contrast, the accumulation of other fluid or hemorrhage over time, whether in the peritoneal or extraperitoneal compartment, and rate of resorption. Larger extravasations in the extraperitoneal compartment likely persist longer.

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BLADDER IMAGING PROTOCOLS

KEY POINTS

- The recommended practice to evaluate for bladder injury is to perform CT cystography or conventional cystography for patients meeting criteria for bladder evaluation.
- Perform cystography via retrograde filling of the bladder with contrast (minimum of 300 mL, or until patient tolerance is reached, or contrast stops flowing into the bladder).
- Do **not** passively fill the bladder with antegrade contrast by clamping of the urinary catheter and using delayed CT imaging. This is inadequate to evaluate for bladder injury.

Conventional cystography (using radiographs or fluoroscopy) and CT cystography (CTC) are both recommended imaging modalities to evaluate for bladder injury, and both techniques are reported to have similar sensitivity (90%–95%) and specificity (100%).[1,2] CTC is the preferred imaging modality to properly identify complicated bladder injuries (e.g., bony fragments protruding into the bladder, bladder neck injuries, concomitant abdominal injuries, vaginal/rectal injuries) when a separate CT that includes the pelvis was not already performed. However, a CTC may be easier and faster to obtain for the following reasons:

- Does not require the patient to be transferred to the fluoroscopy suite
- Does not require rotating a patient with pelvic fractures
- Can be performed by CT technologists (if a urinary bladder catheter is already in place) without the need to wait for an available radiologist

Imaging Guidance

If conventional cystography is performed, obtain anteroposterior, bilateral oblique, and post-drainage images. When persistent concern for bladder injury exists without evidence of injury on these images, a lateral view may be helpful. If CTC is performed, image the bladder only once, after full distension. Post-drainage or partial filling images are **not** routinely obtained for CTC, because they are unnecessary and result in additional radiation dose.

Contrast Administration

Perform conventional cystography using higher-density, water-soluble iodinated contrast with approximately 8–25 gm iodine/100 mL. Examples include diatrizoate meglumine (Cystografin®) and iothalamate meglumine (Cysto-Conray®). Perform CTC using water-soluble iodinated contrast with approximately 2–5 gm iodine/100 mL (i.e., add 50 mL of iohexol to 500 mL of normal saline). For either modality, fill the bladder with a minimum volume of 300 mL of contrast, until patient discomfort is reached during filling,[3] or until contrast stops flowing into the bladder. Passive filling of the bladder by clamping of the urinary catheter while the bladder is filled in an antegrade fashion by contrast excretion from the kidneys results in inadequate distention to assess for bladder injury.[1]

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MALE URETHRAL IMAGING PROTOCOLS

KEY POINT

- RUG is the preferred imaging technique to evaluate for male urethral injury.

Imaging the Male Urethra

Initial evaluation and diagnosis of a potential urethral injury begins with a RUG, considered the gold standard for identifying a partial or complete injury of the urethra.[1] If not readily available, urologic consultation for cystoscopy can be performed for urethral evaluation. However, for unstable patients, neither method may be technically feasible in the acute setting.[2] When it is not possible to obtain a timely RUG and bladder drainage is required, a single attempt to place an indwelling urinary catheter (16 Fr straight-tip catheter) by an experienced team member is justified. If any resistance or blood is encountered, urological consultation is necessary.

In patients who undergo a RUG, contrast extravasation confirms the presence of a urethral injury.[3] Contrast extending through the proximal urethra and into the bladder indicates an incomplete or partial injury, while a complete injury will have contrast extravasation at the level of the injury without any bladder filling.[4,5]

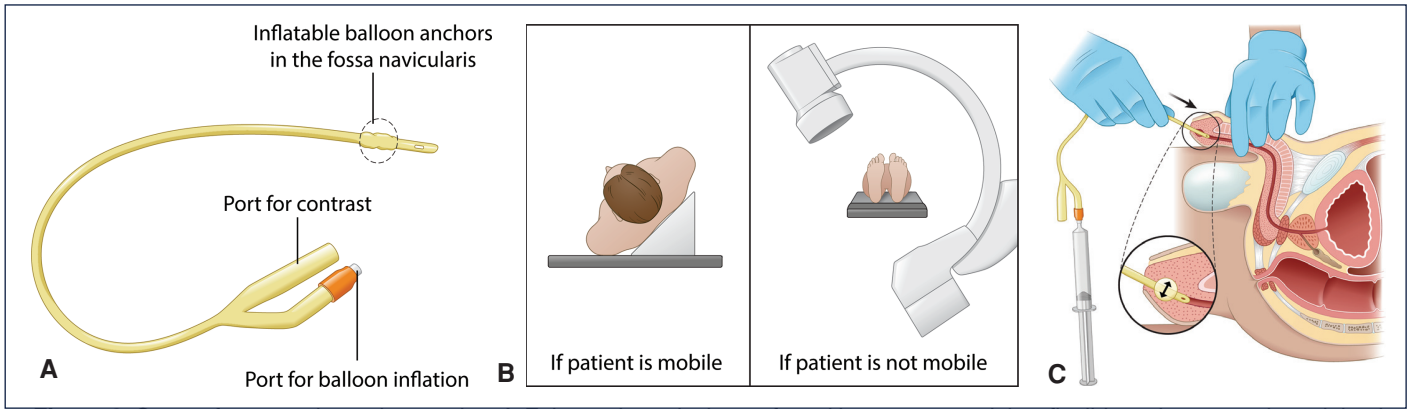
Performing a Retrograde Urethrogram

Performing a RUG begins with preparation of the contrast delivery method (see Figure 1A) and patient positioning. When clinically feasible, place the patient supine at 30° to 45° oblique angle (see Figure 1B), and flex the dependent leg.[5] When this is not feasible—because the patient is uncooperative, hemodynamically unstable, experiencing pain, or immobilized out of concern for a possible pelvic or spinal injury—anteroposterior and oblique views are acceptable alternatives.

Subsequent RUG procedure steps include the following:

- Place a 16 Fr Foley in the meatus for approximately 2 cm and inflate the balloon with 2–3 cc of air or saline to occlude contrast backflow. Alternatives to inflating the balloon include use of a gauze sponge applied around the penis after introducing the catheter, to act as a lasso. This allows traction on the penis to ensure that the urethra is "on stretch". Finally, a cone-tip adapter can be used for urethral occlusion at the meatus (see Figures 1A and 1C).[6]
- If the patient is mobile, position them obliquely so that the collimator of the fluoroscopy C-arm is perpendicular to the penile and bulbar urethra. The urethra is stretched by gently pulling the penis to elongate and allow visualization of the entire course of the urethra. Alternatively, if the patient is immobile (e.g., related to an unstable pelvic fracture, spinal precautions, etc.) and cannot position their pelvis obliquely, attempt to obtain films by rotating the C-arm to a 30° to 45° oblique position (see Figure 1B).

Figure 1. Preparation for Performing a Retrograde Urethrogram.



From: Lee MJ, Archer-Arroyo K, Levenson RB, Mazza M, Chong S. Imaging of traumatic injuries to the male lower genitourinary organs and impact on surgical management. *Contemp Diagn Radiol.* 2019;42(10):1–5. doi:10.1097/01.CDR.0000557796.34158.c4. Permission from Wolters Kluwer Health, Inc. conveyed through Copyright Clearance Center, Inc.

- Obtain a scout view before injecting contrast to avoid false positive findings (e.g., vascular contrast extravasation in a pelvic fracture patient who previously received a CT with IV contrast). Inject undiluted nonionic iodinated contrast (10–30 mL) per the urethral meatus with the penis placed in tension toward the lateral upper thigh after positioning.[6]
- Take fluoroscopic images as contrast is injected at 10 mL intervals. Plain film radiograph can be used to diagnose an injury; however, fluoroscopy is preferred depending on patient condition.[7] Plain film radiograph will not provide real-time information during instillation of contrast. Stop injecting contrast once extravasation is visualized.
- Pelvic plain film radiograph may be useful to assess for widening of the pubic symphysis and inferior rami fracture which are associated with pelvic fracture urethral injury (PFUI).
- Any extravasation of contrast or urethral occlusion with no advancement of contrast through the urethra requires urological consultation to assess for urethral injury.

When a patient already had a successful Foley catheter placement during acute trauma resuscitation and a suspicion for urethral injury exists, do **not** remove the Foley catheter. Rather, perform a pericatheter RUG by injecting 10–30 mL full-strength contrast via a syringe connected to an 18 gauge angiocatheter or a 4–8 Fr straight catheter inserted a few centimeters into the urethra alongside the Foley catheter.[8] If the existing Foley catheter is found to **not** be within the bladder during a pericatheter RUG, consult urology for further management and possible cystoscopic replacement or suprapubic tube (SPT) placement.

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BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

RENAL INJURY

RENAL TRAUMA IMAGING AND STAGING

KEY POINTS

- Contrast-enhanced abdominal/pelvic CT is the gold standard for patients who are hemodynamically stable or were stabilized after blunt or penetrating trauma.
- When concerned about a collecting system injury, delayed-phase imaging is necessary for evaluation and staging.
- The renal injury scale, updated by AAST in 2018, provides a tool for grading renal trauma.
- Perform follow-up imaging (within 48 to 72 hours) only for patients with ongoing blood loss, urine extravasation on initial imaging, penetrating high-grade ballistic injury, or who are symptomatic with suspicion for a complication related to the renal injury.
- Delayed follow-up imaging (weeks or months post trauma) is recommended only to monitor known complications or when the patient presents with either gross hematuria or symptoms related to complications from renal trauma.

Renal Injury Imaging

The majority of patients with abdominal injuries undergo CT imaging. When concern for renal trauma arises, contrast-enhanced abdominal/pelvic CT is the gold standard for the patient who is hemodynamically stable or was stabilized after blunt or penetrating trauma.[1] Degree of hematuria can be used to reduce imaging burden. For individuals with only microhematuria or no hematuria and no hypotension, imaging of the GU system can be omitted.

Injury staging is essential to guide further management. Certain imaging findings can predict the need for bleeding interventions, including contained vascular injury, vascular contrast extravasation, presence of pararenal hematoma, and hematoma rim distance.[2,3] For patients with significant renal injuries on contrast imaging, delayed-phase imaging is necessary for appropriate evaluation and injury grading when a mechanism of injury is concerning for significant renal or ureteral injury, or when the patient has unexpected fluid around the kidneys or ureters. See Imaging Section on page 15 for more detailed information about specific imaging protocols and recommendations.

If imaging has not been obtained, perform CT imaging for suspected renal injury in patients with any of the following:[4]

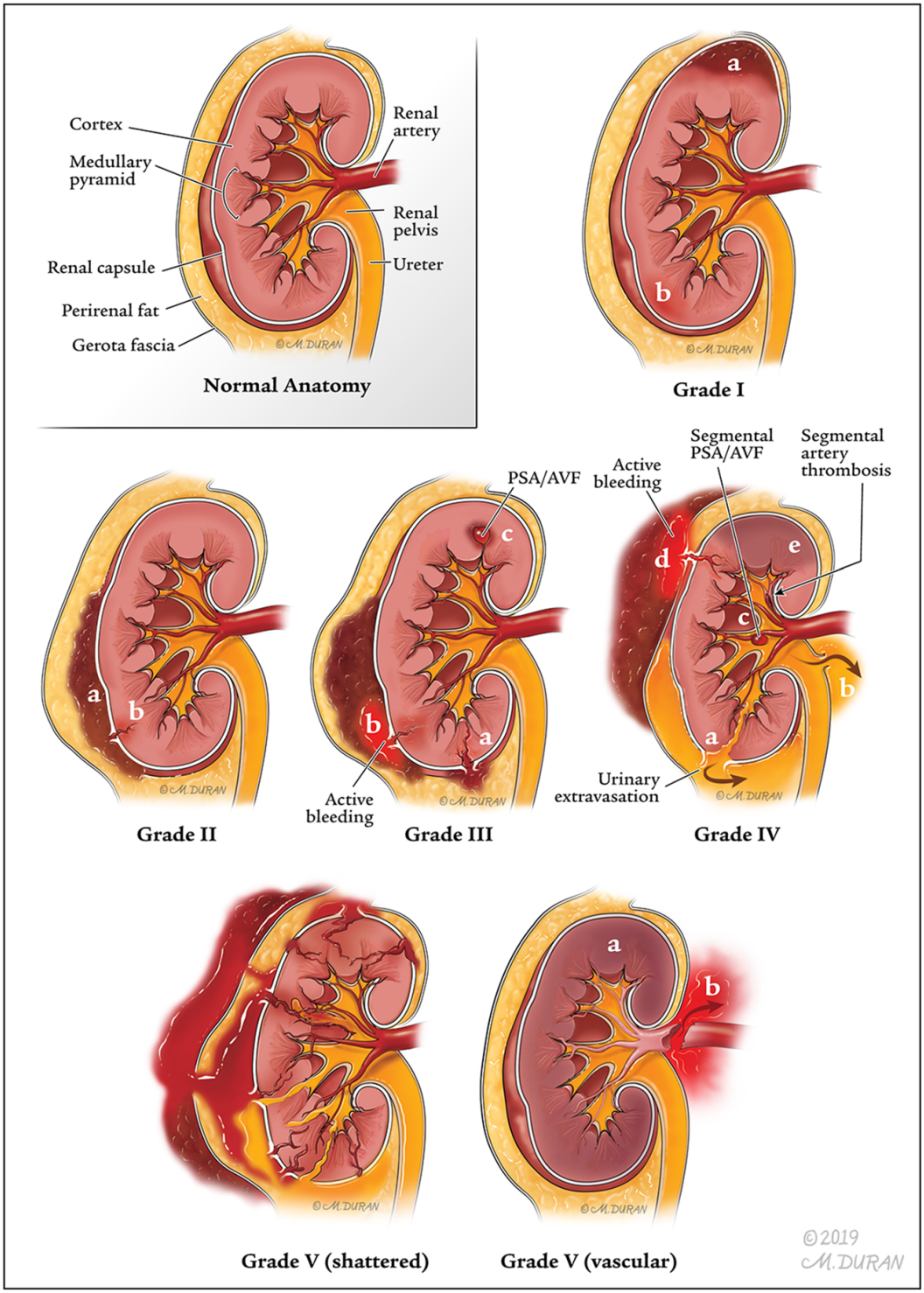
- Gross hematuria
- Microhematuria and hypotension without indications for emergent operative interventions
- A significant injury mechanism (fall from height, blow to flank, rapid deceleration, etc.) [5,6]
- Penetrating injuries to the abdomen or flank [6]
- Clinical findings suggestive of renal trauma, including flank ecchymosis on physical exam and rib fractures seen on initial trauma radiograph studies

See Figure 2 for CT imaging associated renal injury staging. Plain film radiograph or ultrasound is **not** recommended as a diagnostic tool for initial evaluation and diagnosis of trauma patients with a suspected kidney injury.

Staging

The AAST renal injury scale, introduced in 1989, was updated in 2018.[7-9] The scale defines levels of organ injury severity that can be used to guide management decisions and predict patient outcomes. See Table 1 for the renal injury scale, which addresses both blunt and penetrating trauma. In addition to the AAST grading scale, the need for bleeding intervention can be predicted by certain patient and injury characteristics, including trauma mechanism, hypotension/shock, concomitant injuries, vascular contrast extravasation, pararenal hematoma, and hematoma rim distance.[10]

Figure 2. AAST Renal Injury Grading on CT Scan



From: Chien LC, Vakil M, Nguyen J, et al. The American Association for the Surgery of Trauma Organ Injury Scale 2018 update for computed tomography-based grading of renal trauma: A primer for the emergency radiologist. *Emerg Radiol.* 2020;27(1):63–73. doi:10.1007/s10140-019-01721-z. Permission from Springer Nature BV conveyed through Copyright Clearance Center, Inc.

Table 1. AAST Renal Injury Scale for Blunt and Penetrating Renal Injury

Grade	Description of injury
I	• Subcapsular hematoma • Parenchymal contusion
II	• Perirenal hematoma • Parenchymal laceration ≤1 cm
III	• Parenchymal laceration >1 cm • Active bleeding • PSA/AVF arising from the kidney and contained by Gerota's fascia
IV	• Parenchymal laceration into collecting system with urine extravasation • Renal pelvis laceration, ureteropelvic junction (UPJ) disruption • Segmental renal vein or artery PSA or AVF • Active bleeding extending beyond Gerota's fascia • Segmental or complete kidney infarction
V	• Shattered kidney • Devascularized kidney • Active bleeding due to main renal artery or vein laceration or avulsion of hilum

From: Kozar RA, Crandall M, Shanmuganathan K, et al. Organ injury scaling 2018 update: Spleen, liver, and kidney. *J Trauma Acute Care Surg*. 2018 Dec;85(6):1119–1122. doi:10.1097/TA.0000000000002058. Permission from Wolters Kluwer Health, Inc. conveyed through Copyright Clearance Center, Inc.

Follow-Up Imaging

Perform follow-up imaging, within 48 to 72 hours of the initial scan, and use a contrast-enhanced abdominal/pelvic CT, with delayed-phase imaging for the following patients:[10–12]

- Grade III–V injuries with ongoing blood loss or urine extravasation on initial imaging
- A penetrating, destructive firearm injury (grade III or above)
- Renal trauma patients with potential symptoms of renal injury complications (e.g., fever, ongoing blood loss, worsening flank pain, etc.)

For patients who are suspected to have a persistent urine leak but no evidence of ongoing blood loss, consider initiating the CT scan with a low-dose, noncontrast scan to identify potential retained contrast from prior imaging. Follow this with contrast administration and **only** the delayed-phase images. It is recommended that follow-up imaging—weeks to months after injury—be performed only in patients who develop gross hematuria or clinical signs of complications from the renal trauma (these should be contrast-enhanced studies).

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NONOPERATIVE MANAGEMENT OF RENAL INJURY

KEY POINTS

- All hemodynamically stable or stabilized patients with renal injuries (blunt or penetrating) are candidates for nonoperative management (NOM).
- Imaging findings, including vascular contrast extravasation, presence of pararenal hematoma, and hematoma rim distance, can predict the need for bleeding interventions.

All patients with renal injuries, independent of mechanism (blunt or penetrating) or AAST grade (I through V), are candidates for NOM when the following conditions exist:

- Patient has normal hemodynamics, either on presentation or after the initial resuscitation
- No other indications for operative exploration exist, such as peritonitis or visceral injuries that require operative management[1-6]

Persistent hemorrhagic shock directly related to a high-grade renal injury is the **only contraindication to NOM**. When angioembolization is readily available, it may maximize the success rates of NOM in select patients with ongoing hemorrhage, as well as those who develop PSA.[1,3,4]

Liberal surgical exploration and opening of Gerota's fascia results in a high rate of nephrectomy.[7-9] With appropriate implementation of NOM principles, surgery may be avoided, significantly decreasing the nephrectomy rate even in high-grade injuries.[2-4]

Nonoperative Management Principles

NOM of renal injuries may consist of close hemodynamic monitoring, bed rest, intensive care unit (ICU) admission, and blood transfusion.[4] It requires an appropriate clinical setting that allows for serial clinical and laboratory assessments to detect early signs of hemorrhagic shock and other complications.[6] Availability of a multidisciplinary team is required, including urology specialists and interventional radiologists.

While no standardized period of observation is recommended, a minimum of 48 to 72 hours may be appropriate for higher-grade renal injuries, especially when repeat imaging does not demonstrate need for intervention and the patient remains asymptomatic.[10] The setting for observation (ICU versus stepdown or ward) will largely depend on associated injuries and facility resources available to closely monitor the patient for early signs of bleeding.

Blunt Renal Injury

The overall nephrectomy rate for blunt renal injuries is less than 10%, but this rate increases in a stepwise fashion for higher-injury grades.[1-3] The vast majority of nephrectomies occur within 24 hours of admission, almost exclusively for patients who have high-grade renal injuries and who fail NOM (with or without angioembolization).[1,3] NOM may be appropriate in many cases, as described below.

Injury Found on Initial Imaging

NOM is considered the standard of care in hemodynamically stable patients with grades I, II, and III renal injuries found on imaging.[4-6] These injuries represent the majority of all blunt renal trauma, and NOM is successful in almost all cases. Grade III injuries may be associated with significant bleeding if the injury traverses the entire renal cortex and medulla, resulting in a higher potential for failure of NOM. Approximately 7%–10% of renal injuries are grade IV, and NOM may be successful in over 94% of cases. Even for grade V injuries, angioembolization can be successful in up to 85% of cases.[11] AAST grade IV injuries with segmental renal infarction represent a subset of grade IV injuries that warrant special mention. These injuries are associated with a significantly low risk of bleeding requiring intervention, and they have been proposed for downgrade to grade III injuries.[12-14] Intervention for revascularization is generally not warranted.

Injury to the renal pelvis or proximal ureter may still be treated initially with NOM. However, these injuries may require expeditious drainage of urinary leak via ureteral stenting, percutaneous nephrostomy, and/or surgical intervention within the same admission. Aside from hemodynamic instability, complete avulsion of the ureteropelvic junction (UPJ) is the only absolute contraindication to NOM; however, management of the patient's other life-threatening injuries may take priority before urologic surgical repair.[6]

Injury Found on Exploratory Laparotomy for Blunt Injury

Renal injuries may be found or suspected intraoperatively when a Zone II retroperitoneal hematoma is noted. When the indication for the exploratory laparotomy is hemorrhagic shock attributed to injuries other than the kidney, determine if the Zone II retroperitoneal hematoma is expanding. When this hematoma is **not** expanding after blunt injury, exploration of Zone II is contraindicated, because it is associated with a significantly higher rate of nephrectomy than may otherwise be necessary. When a Zone II hematoma is not explored surgically, the characteristics and severity of the renal injury must be assessed by a postoperative CT scan of the abdomen and pelvis, with IV contrast and delayed-phase imaging.

Penetrating Renal Injury

NOM of penetrating renal injuries is less successful compared to blunt renal injuries, especially in cases of gunshot wounds and high-grade injuries.[15,16] However, indications and contraindications for NOM are similar to those in blunt renal injuries.

Injury Found on Initial Imaging

For grade I, II, and III penetrating injuries, NOM is the standard of care in hemodynamically stable patients, and it is successful in almost 100% of cases. NOM may be successful in over 70% of grade IV–V injuries, especially in cases of isolated injury.[3] As with blunt renal injuries, complete avulsion of the UPJ is a contraindication to NOM; however, management of the patient's other life-threatening injuries may take priority before urologic surgical repair.[6]

Injury Found on Exploratory Laparotomy for Penetrating Injury

Consider exploration of Zone II hematomas associated with penetrating injury found on exploratory laparotomy to rule out the presence of injury to the renal pelvis, proximal ureter, and renal vessels. The surgical decision may be made regardless of whether the hematomas are expanding and independent of hemodynamic status. However, as with blunt injury, selective use of renal exploration is justified, with the caveat that in unexplored patients without prior imaging, postoperative imaging will be obtained to assess the nature and severity of the renal injury.[6] Exploration is not indicated for a small, nonexpanding Zone II hematoma lateral to the colon in a patient who is hemodynamically stable and for whom clinical suspicion is low for an injury to the renal pelvis, ureter, and major vascular structures.[5]

Special Considerations

Successful NOM of high-grade (IV and V) renal injuries may be associated with the development of renovascular hypertension. This complication remains largely understudied, because it is believed to be rare. Increased risk is associated with some injury characteristics, mainly injury to the renal artery and possibly large, devitalized fragments or compression of the renal parenchyma by a circumferential hematoma (called a *Page kidney* or *Page phenomenon*).[5,17–20] The underlying pathophysiology is presumed to be related to activation of the renin-angiotensin system, leading to refractory hypertension. A majority of patients with refractory hypertension will eventually require a delayed nephrectomy after their index trauma admission and usually have good clinical outcomes.[16] Although new onset hypertension after renal trauma is rare, patients with high-grade renal injuries managed non-operatively need routine follow-up with a primary care physician to be evaluated for new onset hypertension and the potential need for outpatient referral to urology or nephrology for further management.

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SURGICAL INTERVENTION FOR RENAL TRAUMA

KEY POINTS

- The presence of a Zone II retroperitoneal hematoma is the primary indication of an underlying renal injury during exploratory laparotomy.
- A nonexpanding Zone II retroperitoneal hematoma, resulting from blunt trauma and found during exploratory laparotomy for other injuries, should not be disturbed. CT imaging is performed to monitor the renal injury.
- Explore Zone II hematomas after blunt trauma if the hematoma is ruptured, pulsatile, expanding, or in a patient with ongoing hemodynamic instability.
- Zone II retroperitoneal hematomas associated with penetrating injury may be explored, because of an increased likelihood for clinically significant injury to the kidney or ureter.

Operative Indications

Trauma patients presenting with hypotension, who are not responsive to resuscitation, or who have diffuse peritonitis are taken directly to the operating room (OR) for exploratory laparotomy prior to CT imaging.[1,2] In these cases, traumatic renal injuries will often be identified by a Zone II retroperitoneal hematoma.[3]

- Do **not** disturb nonexpanding Zone II retroperitoneal hematomas resulting from blunt trauma, and take patients to CT imaging after laparotomy if hemodynamically stable.
- Explore Zone II hematomas after blunt trauma if the hematoma is ruptured, pulsatile, expanding, or in a patient with ongoing hemodynamic instability.
- After penetrating trauma, Zone II retroperitoneal hematomas may be explored because of the increased likelihood for clinically significant injury to the kidney or ureter that requires repair.

Surgical intervention is required in patients who undergo imaging prior to exploration and are found to have hilar avulsions or extensive injuries of the renal pelvis or proximal ureter. Patients with complex injuries to the collecting system, however, can often undergo nonemergent surgical intervention. Conservative or endourologic (minimally invasive) techniques can often be used as first-line options. Retroperitoneal exploration can generally be avoided in hemodynamically stable patients with renal parenchymal injuries without hilar involvement or other previously stated indications for exploration.

Preoperative Preparation

Manage all trauma patients taken to the OR for exploratory laparotomy in the same way, regardless of the underlying injury. Resuscitate patients using balanced resuscitation (e.g., permissive hypotension, limited crystalloid fluid use, and blood product transfusions). Activate the massive transfusion protocol when appropriate. Send blood for type- and crossmatching so type-specific blood can be used when needed. In the OR, place the patient in the supine position with arms abducted. Preparation for exploration includes preoperative antibiotics, wide skin preparation with antiseptic solution, and draping (chin to knees, table to table).

Exploratory Laparotomy

Use a vertical midline incision from xyphoid to pubis. To expedite entry into the abdomen, open the skin, subcutaneous tissue, and linea alba sharply. Once retraction is optimized, explore areas most likely to be injured based on mechanism (e.g., the liver or spleen in blunt trauma, or the ballistic tract in penetrating trauma). The remainder of the abdomen is then explored in its entirety. The primary indication of an underlying renal injury is the presence of a Zone II retroperitoneal hematoma.

> **Caution:** Prior to exploring an injured kidney (especially without preoperative CT imaging), palpate the contralateral kidney. If the contralateral kidney is present and feels normal to palpation, exploration of the injured side can proceed. If the contralateral kidney is absent or abnormal (polycystic, atrophic), give more consideration to renal salvage of the injured kidney. A single-shot, on-table IV pyelogram (2 mg/kg IV contrast followed by imaging at 10 minutes) can also be considered in this setting, primarily to confirm a functioning contralateral kidney. Do **not** use imaging to exclude injury or to identify urinary extravasation alone, as it lacks sufficient sensitivity in this setting.[1]

Renal Exposure

Once it is determined that a renal injury requires surgical management, begin by opening the hematoma and expose the kidney using a medial or lateral approach.[4] Either approach is acceptable, and the choice is most likely determined by a surgeon's training and experience.

Medial Approach

The medial approach involves opening the retroperitoneum in the midline to isolate and control the renal artery and vein prior to entering Gerota's fascia. This approach takes time but provides definitive vascular control prior to opening a hematoma. This can minimize bleeding after loss of tamponade from opening the hematoma. However, the medial approach may be difficult or impossible when a large central retroperitoneal hematoma significantly distorts the anatomy of the renal hilum.

Lateral Approach

The lateral approach involves mobilizing the colon and opening the hematoma and Gerota's fascia. The kidney is rapidly, bluntly mobilized into the operative field, and the renal hilum may be manually compressed and subsequently clamped to control bleeding. Thoroughly inspect and determine the type and severity of the injury after kidney mobilization. Take particular care to identify injuries to the parenchyma, collecting system, and vasculature. The type of injury found drives decision-making about subsequent operative management.

Management of Renal Injury

Management of renal injury is driven by the grade of injury and hemodynamic stability of the patient.

Grade I–III Injuries

Low-grade injuries (AAST grades I–III) are managed with local measures and rarely require a nephrectomy.[4–6] Grade I–III injuries involve only the renal parenchyma, and bleeding from these injuries can be controlled with cautery, topical hemostatic agents, or an absorbable suture for primary control of individual vessels in the parenchyma. If the parenchyma cannot be easily approximated, a partial nephrectomy can be considered.

Grade IV–V Injuries

For patients with AAST grade IV–V injuries, hemodynamic stability determines the plan of care. If the patient remains hemodynamically stable, grade IV injuries may be repairable, depending on the type of injury encountered. Perform a nephrectomy for patients who are hemodynamically unstable or require ongoing resuscitation with blood and pressors, making no attempt at renal salvage. Similarly, if a grade V injury (shattered or avulsed kidney) is encountered during exploration, perform a nephrectomy.

Manage the parenchymal components of grade IV injuries as described above for low-grade injuries, using cautery, topical hemostatic agents, and/or suture ligation of individual vessels to control bleeding. Injuries to the collecting system are repaired using running absorbable sutures to obtain a watertight closure. Renal parenchymal defects may be reapproximated with bolstered capsular sutures. Gerota's fascia can also be used to buttress a repair of the collecting system. Consider a partial nephrectomy if a grade IV injury involves the collecting system of the superior or inferior pole of the kidney. A collecting system repair or partial nephrectomy can be buttressed with an omental pedicle flap for coverage when other local tissue is not available. Leave a closed-suction drain in place after any repair of the collecting system.

Grade IV injuries involving the renal artery and vein have several management options. Segmental vein and artery injuries can be ligated without significant impact. Perform a primary repair of a main renal vein injury, as long as it does not narrow the lumen more than 50%. A more significant narrowing of the main renal vein on the left side can be tolerated due to collateral venous drainage. If venous outflow is compromised on the right side, a nephrectomy is likely indicated. Options to manage a main renal artery injury include primary repair, primary end-to-end anastomosis, saphenous vein interposition, or a hybrid approach using an endovascular stent. Little evidence exists to guide operative management of renal artery injuries, and the reported outcomes are poor. Individualize patient care for the clinical situation and the experience of the operating surgeon. Nephrectomy is commonly the outcome in cases of major renal hilar injuries encountered during exploration.

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RENAL ANGIOGRAPHY AND EMBOLIZATION IN TRAUMA PATIENTS

KEY POINTS

- Consider NOM of high-grade renal trauma, including angiography with possible embolization, in hemodynamically stable patients and/or those who responded to resuscitative measures.
- Indications for angiography and possible embolization include active extravasation of intravascular contrast from the kidney on CT scan, renal PSA, renal AVF, persistent gross hematuria, or large and/or expanding perirenal hematomas.
- When possible, sub-selective arterial embolization is preferred to preserve renal function.
- Patients with hemodynamic instability not responding to initial resuscitation or patients with associated injuries requiring operative repair may need surgical intervention.

As a supplement to NOM, renal artery angiography with embolization (RAE) is an appropriate therapeutic strategy for many patients with radiographic or clinical signs of hemorrhage after renal trauma. A recent analysis compared surgery (n = 215) to RAE (n = 266) among patients from the National Trauma Data Bank (NTDB) who were matched based on grade of renal injury, mechanism of injury, and hemodynamic stability.[1] Clinical success, defined as not requiring additional therapy to control hemorrhage, was higher for patients receiving RAE than for surgery in both grade IV and grade V injuries. Further, if patients were selected for operative management rather than RAE, they were more likely to end up with a total nephrectomy.[1] Additionally, a single-center prospective study of trauma patients concluded that, with appropriate use of RAE, surgery can be avoided in most patients with higher-grade (defined as grade III and higher) renal injuries.[2]

Patient selection for management—either observation, RAE, or surgery for renal injuries—is not easily delineated by the grade of injury. A systematic review and meta-analysis by the Eastern Association for the Surgery of Trauma (EAST) found that for a hemodynamically stable adult with clinical or radiographic signs of renal hemorrhage, insufficient evidence existed to determine whether RAE or observation was superior in decreasing mortality, nephrectomy, delayed hemorrhage necessitating intervention, or the need for long-term renal replacement therapy.[3]

Other studies reported both clinical and radiographic characteristics that can help guide patient selection in these cases. For example, patients more likely to benefit from RAE (rather than observation alone) included hemodynamically stable patients or those who responded to initial resuscitative efforts with the following characteristics: active extravasation on arterial phase CT, renal PSA, renal AVF, persistent hematuria, or large and/or expanding perirenal hematomas.[4–9] A nomogram predicting risk of bleeding control interventions after high-grade renal trauma has been validated.[10] This multi-institutional study reported that mechanism of injury, shock, pararenal hematoma, hematoma rim distance >3.5 cm, and active contrast extravasation were predictive of the patient undergoing an intervention for bleeding, including angioembolization, renorrhaphy, or nephrectomy.[10] The nomogram is a useful tool for bleeding risk stratification and shows that every centimeter increase in hematoma rim distance from 1.5 cm up to ≥4 cm is associated with a 66% increase in the odds of requiring bleeding interventions.

The failure rate for angioembolization in patients with active renal hemorrhage was reported to be 27%–29%, and these patients frequently required laparotomy for treatment of ongoing bleeding.[6,11] However, repeat angioembolization for ongoing bleeding is recommended to avoid open exploration, and it has a success rate of 97%.[6,11]

Grade IV renal injuries need to undergo angiographic intervention or surgical exploration when the patient has hemodynamic instability. Grade V injuries with complete hilar avulsion most likely require emergent exploration, with a high likelihood of nephrectomy. However, grade V injuries that demonstrate a completely shattered kidney can be managed conservatively with close monitoring and angioembolization, if required. If the patient remains unstable or has ongoing blood loss, renal exploration is indicated. Availability of a hybrid room (an operating suite with a mix of interventional radiology and surgical equipment) may allow for rapid surgical exploration combined with angioembolization for patients with hemorrhagic shock.

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SPECIAL POPULATIONS

KEY POINTS

- On presentation, expeditiously determine the anticoagulation status and thromboembolic risk of geriatric renal trauma patients.
- CT imaging with IV contrast is appropriate for geriatric renal trauma patients, regardless of age.
- A best practice for geriatric renal trauma patients with low-grade injuries is the early use of thromboembolism chemoprophylaxis.
- Ultrasonography is neither sensitive nor specific enough for the initial investigation of renal injuries in children.
- In pediatric patients, decisions for CT imaging should be based on the presence of hematuria and associated injuries rather than on hypotension, which is a late sign of shock in children.
- NOM is recommended for all grades of renal injury in pediatric patients based on hemodynamic stability.

Older Adult Considerations

Given the common use of anticoagulation agents in the older adult population, give special consideration to the geriatric patient's anticoagulation status on presentation with renal trauma.[1] Consider anticoagulation reversal for patients who are hemodynamically unstable or who have significant acute blood loss anemia. See the *ACS TQP Best Practices Guidelines: Geriatric Trauma Management* for more information.[1]

Unrecognized traumatic injuries in older adults portend worse outcomes.[2] Given the importance of renal functional outcomes for older adult patients and their comparably low risk of complications from radiation exposure, appropriate use of CT imaging is acceptable for geriatric renal trauma patients. Do not withhold contrast-enhanced imaging based on age alone; associations between age and contrast-induced nephropathy are inconclusive.[3–5]

In patients over 65 years old, age is an independent risk factor for venous thromboembolism.[6] For stable patients, the decision to restart anticoagulation is based on the risk of renal bleeding weighed against the individual's risk of thromboembolic complications. Due to the very low rate of renal-related complications, consider chemoprophylaxis in geriatric renal trauma patients with low-grade injuries unless contraindicated by associated injuries.[7,8] These patients do **not** require bed rest.[9] A best practice is to withhold chemoprophylaxis for geriatric patients with high-grade injuries until clinical stability is determined.

Pediatric Considerations

Renal injuries are more common in children due to their underdeveloped and cartilaginous ribs, which provide less protection for the kidneys.[10] CT imaging decisions for renal injury detection in children are based on the presence of hematuria and associated injuries. Differing from recommendations for adults, hypotension and mechanism of injury may not serve as appropriate indicators of cross-sectional CT imaging, because children display hypotension as a late sign of shock. Use of ultrasonography was investigated, but it is neither sensitive nor specific enough for initial investigation of renal injuries in the trauma center.[11] For children with a high suspicion of renal injury, cross-sectional imaging with CT with delayed phases is recommended. However, ultrasound can be helpful to monitor for the development of a perinephric fluid collection, particularly in children who did not receive delayed contrast images on the initial CT.

NOM is recommended for all grades of renal injury based on hemodynamic stability. A 2019 guideline jointly developed by EAST and the Pediatric Trauma Society (PTS) strongly recommends NOM in hemodynamically stable pediatric patients.[12] In stable patients with AAST grade III, IV, and V renal injuries, consider the use of angioembolization for ongoing or delayed bleeding. A recent multi-institutional retrospective study reported a majority of pediatric patients had NOM management, although bleeding control was more frequently done with operative intervention.[13]

Base the hospital observation of children with renal injuries on their clinical status rather than grade of injury. Bedrest is **not** recommended.[14] Routine follow-up imaging is **not** recommended, regardless of grade of injury.[15] It is recommended that follow-up imaging after injury be performed only in patients who develop gross hematuria or clinical signs of complications from the renal trauma. Perform a routine blood pressure check after discharge.

When the pediatric patient has a solitary kidney, consider revascularization of the kidney in cases of arterial thrombotic injury, acknowledging that this is not a standard therapy. Other congenital abnormalities can be identified during trauma workup and may need special consideration. For example, a horseshoe kidney, which has multiple segmental aortic and renal branches, is generally very difficult to revascularize without significant risk of complete renal loss due to thrombosis.

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BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

BLADDER INJURY

OVERVIEW

KEY POINTS

- Extraperitoneal bladder injuries are commonly associated with pelvic fractures and often result in urinary extravasation contained within the extraperitoneal space.
- Intraperitoneal bladder injuries commonly occur near the dome of the bladder and result in urine leaking into the peritoneal cavity.
- Cystography is the gold standard for diagnosis and staging of bladder injuries.

Mechanism of Injury

Bladder injuries are classified and managed based upon the location of the urinary extravasation and on the size and complexity of the injury. Of extraperitoneal bladder injuries, 60%–90% occur in conjunction with pelvic fractures and involve shearing of the bladder wall near the base caused by distortion of the pelvic ring or by a contrecoup injury at the opposite side of the bladder.[1-3] The highest risk of bladder injury occurs with displaced fractures of the pelvic ring and pubic rami, as well as diastasis of the pubic symphysis.[4]

Intraperitoneal bladder injuries occur most often when external forces on the lower abdomen cause an abrupt rise in pressure within the bladder (intravesical pressure). These injuries typically occur at the weakest part of the bladder, the dome, which is located adjacent to the peritoneal reflection. These injuries are associated with urinary ascites, where urine bathes the intraperitoneal space and puts patients at risk of infection, peritonitis, and ileus.[4]

Penetrating bladder injuries can involve all parts of the bladder and are frequently discovered during exploratory laparotomy for associated bowel and vascular injuries.

Assessment

CT or conventional cystography is recommended for patients at risk for bladder injury, including those with the following:

- Gross hematuria with pelvic fracture or other mechanism when bladder injury is of concern
- Penetrating injury with trajectory toward the bladder and any degree of hematuria
- Clinical indicators raising suspicion of bladder rupture, including inability to void, low urine output, abdominal distention, and elevated creatinine due to peritoneal absorption of urine
- Radiologic indicators raising suspicion of bladder rupture, such as low-density perivesical or peritoneal free fluid on imaging

The prevalence of bladder rupture varies according to mechanism of injury and degree of hematuria.[5-7] Gross hematuria is the primary indicator for bladder imaging in blunt trauma.[8] Urinalysis can be useful in reducing need for cystography in selected scenarios. For patients with microhematuria and pelvic fracture without high-risk features, cystography is generally **not** indicated due to the low incidence of bladder rupture. In contrast, patients with pelvic fracture with high-risk features (disruption of obturator ring with >1 cm displacement, or diastasis of the pubic symphysis >1 cm) and any degree of hematuria need to undergo imaging.[8] Conventional cystography (using radiographs or fluoroscopy) and CTC are imaging modalities recommended to evaluate for bladder injury, and both techniques are reported to have similar sensitivity (90%–95%) and specificity (100%) for blunt trauma.[9,10] Cystography can be considered in stable patients with penetrating trauma and a suspected bladder injury, although the sensitivity and specificity have not been established. Passive filling by clamping of the urinary catheter with antegrade contrast filling of the bladder on delayed CT imaging is **not** adequate to evaluate for bladder injury. See Bladder Imaging Protocols on page 18 for full details and techniques of cystography.

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ORTHOPAEDIC CONSIDERATIONS

KEY POINTS

- Combined bladder and pelvic injuries require close interdisciplinary communication for optimal management.
- Suprapubic cystostomy placement for a bladder injury may be thought to preclude internal fixation of anterior pelvic fractures, but no high-quality data support worse outcomes or higher infection rates with the presence of SPTs.

Pelvic ring injuries are commonly associated with injuries to the lower GU system.[1] A thorough evaluation of the pelvis with radiographs and/or CT is required to determine overall pelvic stability and need for operative intervention or for sequential examination of the pelvis under anesthesia in the OR.[2] Young-Burgess classification is the most widely used classification system of pelvic ring fractures, and it is based on the predominant force vectors during trauma: lateral compression, anterior-posterior compression (APC), vertical shear, and combination injuries (see Table 2). Most APC II and APC III injuries are optimally treated with anterior internal fixation, often in conjunction with posterior fixation.[3]

Table 2. Young-Burgess Classification: APC Injuries

Classification	Injury Description
APC I	Symphysis widening <2.5 cm
APC II	Symphysis widening >2.5 cm Anterior sacroiliac joint diastasis Disruption of sacrospinous and sacrotuberous ligaments
APC III	Disruption of anterior and posterior sacroiliac ligaments Disruption of sacrospinous and sacrotuberous ligaments

From: Alton TB, Gee AO. Classifications in brief: Young and Burgess classification of pelvic ring injuries. *Clin Orthop Relat Res.* 2014 Aug;472(8):2338–2342. PMID:24867452. PMCID:PMC4079881. doi:10.1007/s11999-014-3693-8. Permission from Wolters Kluwer Health, Inc. conveyed through Copyright Clearance Center, Inc.

Pelvic ring injuries with concomitant bladder injuries represent a clinical scenario with significant associated morbidity.[3] Their treatment requires multidisciplinary care and communication between urology, orthopaedics, intensivists, and trauma surgeons.[3] In settings where bladder disruption occurs and anterior internal fixation is necessary for pelvic ring stabilization, communication between services is critical.[3] No current evidence reports that utilization of SPTs in the presence of internal fixation leads to higher infection rates; however, no adequate studies address this question.[3] For most orthopaedic trauma surgeons, the use of a definitive SPT would be a contraindication to anterior internal fixation, and alternative methods would be utilized (e.g., definitive external fixation, which has its own complications and sequalae).

The timing of surgical correction of bladder injuries and concomitant pelvic ring fractures is an important discussion between consultants. If open repair of a bladder injury and anterior internal fixation of the pelvic ring injury are indicated, consider performing the surgeries in the same setting. Because most of these bladder injuries are extraperitoneal, NOM can be initiated until a combined surgery is scheduled. In the case of symphyseal diastasis, consider repairing the bladder first, because reduction of symphyseal diastasis can make this repair more difficult or impossible. However, without adequate data addressing these issues, surgeon preference and hospital protocols dictate management of these injuries, further stressing the critical nature of interdisciplinary communication.

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MANAGEMENT OF BLADDER INJURY

KEY POINTS

- Manage most uncomplicated extraperitoneal injuries nonoperatively with at least 7 days of large-bore (at least 18 Fr) urethral catheter drainage.
- Surgically repair intraperitoneal and complicated extraperitoneal bladder injuries with a two-layer closure.
- Urethral catheter drainage alone is sufficient after most bladder repairs.
- Give special consideration to repairing injuries in patients who have complex bladder anatomy, such as neobladders, continent reservoirs, or bladder augmentation.
- Leave closed-suction drains in the pelvis following repair of bladder injuries.
- Obtain cystography at a minimum of 7 days post repair to demonstrate healing.

The management strategy for bladder trauma depends on injury mechanism, injury severity, intraperitoneal versus extraperitoneal injury location, and concomitant injuries requiring surgical intervention. Bladder injuries discovered during exploratory laparotomy need to be repaired, regardless of location. In the setting of blunt trauma, extraperitoneal injuries are most common (63%), followed by intraperitoneal (32%) and combined intraperitoneal and extraperitoneal injuries (<5%).[1,2] Features of complex extraperitoneal bladder injuries include:

- Concomitant urethral or bladder neck injuries
- Concomitant vaginal or rectal injuries
- Significant intravesical clot burden that compromises catheter function
- Intraluminal foreign bodies (bone fragments, bullets, etc.)
- Need for anterior pelvic internal fixation

Nonoperative Management of Bladder Injury

NOM using adequate drainage with a large-bore urethral catheter (at least 18 Fr) can be considered for most uncomplicated extraperitoneal bladder injuries resulting from blunt trauma. No high-level published evidence supports the use of antibiotic prophylaxis for the duration of catheterization; however, it may be considered in the presence of orthopaedic anterior pelvic hardware (see Orthopaedic Considerations section on page 38). Duration of catheterization in uncomplicated extraperitoneal injuries is recommended to be at least 7 days, with some studies recommending 2–3 weeks of bladder drainage.[3,4] Imaging (conventional cystogram or CTC) is recommended to confirm healing prior to catheter removal.

Operative Management of Bladder Injury

Intraperitoneal bladder injuries require surgical repair. Because of the large size of a dome rupture and the potential negative effects of urinary ascites, including infection and peritonitis, repair is delayed only to ensure patient hemodynamic stability and completion of other urgent evaluation.[5] A lower abdominal midline incision provides excellent exposure.

Intraperitoneal injuries are often readily visible along the peritoneal surface at the bladder dome. However, when pelvic fracture is present, it is imperative to open the intraperitoneal injury widely enough to confirm that no concomitant extraperitoneal injuries require repair. A transvesical approach via a wide anterior cystotomy is the recommended technique for repairing extraperitoneal injuries, because it gives adequate exposure to the entire bladder lumen, including the bladder neck.[6] If the extraperitoneal rupture is easily identified anteriorly, it can be used to perform the exploration, being widened as necessary. With this approach, the ureteral orifices can also be inspected, and injury can be ruled out with direct catheterization or direct visualization of clear urine efflux.

Standard practice is to repair the bladder in two layers (mucosal and seromuscular) using absorbable 2-0 or 3-0 sutures.[3] Place a closed-suction drain. A recommended practice is to perform urethral catheter drainage alone after bladder repair; however, SPT placement may be

considered for patients who expect to have prolonged need for catheterization (e.g., spinal cord injury, complicated repairs, presence of significant hematuria, and those with associated urethral injuries). Post-repair cystography is the recommended practice for most operatively repaired injuries; it is typically performed a minimum of 7 days post repair, but it can be extended to 3–4 weeks for complex injuries.[7]

Operative repair is also a recommended practice for patients with complicated extraperitoneal bladder injuries described above. Surgical reconstruction is recommended, because these concomitant injuries harbor significant risks of the following:[2,8,9]

- Fistula formation with vaginal or rectal injuries
- Infection
- Incontinence (bladder neck injury)
- Failure to successfully manage nonoperatively

Penetrating injuries present similar levels of complexity and thus generally undergo operative repair. Surgical repair of extraperitoneal bladder injuries may also be considered in patients who are undergoing laparotomy for other indications.

Give special consideration to patients who have complex bladder anatomy such as neobladders, continent reservoirs, or bladder augmentation. Most of these injuries require surgical intervention, given the unpredictable nature of the healing process and the high risk of complications. Consider making a specialized, tertiary referral.

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SPECIAL POPULATIONS

KEY POINTS

- Anticholinergics are associated with a risk of aggravation of dementia symptoms in older adults, so use them with caution in this population.
- Initiate or restart alpha-adrenergic blockers at least 3 days before an attempted trial of void for geriatric patients.
- Treat pediatric bladder injuries in the same manner as adult injuries.
- Recognize that pediatric patients have smaller bladder volumes when performing diagnostic imaging.

Older Adult Considerations

Given the higher prevalence of chronic urinary retention in older adults and the association between blunt trauma with a distended bladder and intraperitoneal injury, geriatric patients are at higher risk for bladder rupture following lower-force traumas compared to younger patients.[1–3] Mechanisms of injury include falls from standing or lower heights, as well as low-speed motor vehicle collisions with associated seatbelt injuries or airbag deployment. Maintain a high index of suspicion for geriatric patients with abdominal exam findings out of proportion to their external injuries. Follow standard guidelines for evaluation, and consider urinalysis and cystography for unexplained signs or symptoms.

It is necessary to determine baseline voiding status before catheter removal in geriatric trauma patients. Identify patients with chronic catheterization, and transition them back to their baseline bladder management. A best practice is to restart alpha-adrenergic blockers at least 24–72 hours before catheter removal for patients who take these medications chronically. Ensure urologic follow-up for geriatric patients who fail a voiding trial.[4] Monitor geriatric patients for cognitive side effects when placed on anticholinergic medications, either for bladder spasms or to aid in the healing of a bladder injury.[5] The recommended practice before long-term continuation of these medications is to discuss the risks of dementia specific to this cohort with the patient and family.

Pediatric Considerations

Bladder injury is the second most common GU injury in children.[6] The bladder is an intra-abdominal organ in infants and slowly descends into the pelvis, reaching adult positioning around puberty. The bladder is significantly less protected in young children because of a more exposed position above the pelvic ring, with less abdominal muscle and adipose tissue.

Treatment of bladder injuries in children mirrors the adult treatment, with a few exceptions.[6,7] For diagnostic imaging, consider that anticipated bladder volume is lower in children. Bladder volume can be calculated as follows:

- For children <2 years old: (7 × weight in kg) + 2 = mL capacity[8]
- For those ≥2 years old: (age in years + 2) × 30 = mL capacity[9]

Have an increased suspicion for bladder injuries in children who have undergone bladder substitution or augmentation for congenital anomalies. It is imperative to understand the child's anatomy before operative intervention, and these children may benefit from transfer to a pediatric trauma center for treatment.

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BEST PRACTICES GUIDELINES
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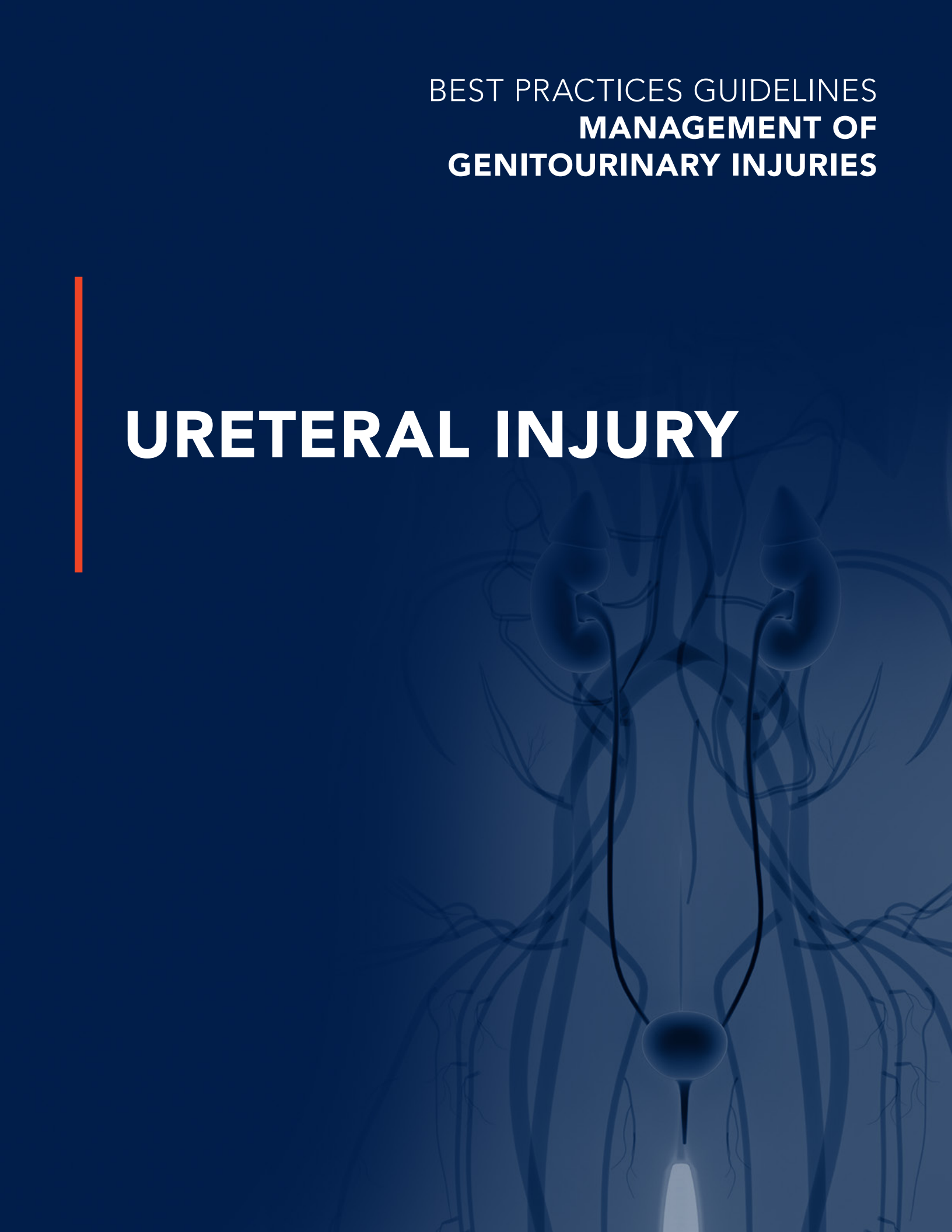
URETERAL INJURY



ASSESSMENT AND DIAGNOSIS

KEY POINTS

- Ureteral injuries are relatively rare compared to other GU injuries, with penetrating trauma causing the large majority of ureteral injuries in adults.
- Maintain a high index of suspicion in patients with any abdominal or pelvic trauma involving ballistic trajectory in proximity to the ureter, as well as in patients with sudden deceleration injuries.
- Hematuria is absent in up to 55% of ureteral injuries.[1]
- IV contrast-enhanced abdominal/pelvic CT with a delayed-phase is recommended for evaluation of suspected ureteral injury.
- Retrograde pyelography (RPG) performed by a urologist is the most accurate imaging test to evaluate the location and extent of ureteral injury with equivocal CT findings.

Ureteral injuries account for less than 1% of all urologic injuries, because the ureter is well protected in the retroperitoneum by its small size, mobility, and adjacent visceral and musculoskeletal structures. Most ureteral injuries are iatrogenic. Penetrating trauma accounts for the large majority of ureteral injuries in adults caused by external trauma (in particular, ballistic trajectory in proximity to ureter).[2,3] Blunt injury mechanisms (e.g., sudden deceleration) cause 5%–40% of ureteral injuries.[2-4] Blunt trauma can result in UPJ injuries, especially in children, due to a more mobile spine.[5]

Prompt diagnosis is essential, because unrecognized injuries can result in significant complications including ileus, urinomas, abscesses, and ureteral stricture. Each of these complications may require procedural intervention with possible loss of the affected renal unit. Suspect and rule out ureteral injury in complex, multisystem abdominal or pelvic trauma patients, including ballistic trauma to the abdomen. Hematuria is absent in up to 55% of ureteral injuries.[1] Concomitant injuries associated with ureteral trauma in patients with penetrating trauma include bowel (46%) and vascular injuries (14%).[6] Bony pelvic injuries (2.4%) are a concomitant injury in blunt trauma.[6]

Imaging and Staging of Ureteral Injury

In a stable patient with a suspected ureteral injury who is not undergoing exploratory laparotomy, obtain an IV contrast-enhanced abdominal/pelvic CT with a delayed-phase to evaluate for ureteral injury. The facility's imaging protocols may include a standard delayed-phase versus obtaining it based on clinical suspicion. Each facility's protocol needs to be designed based on the resources and logistical considerations at the facility.

In addition to the mechanism and trajectory of the injury, CT findings that raise the index of suspicion for ureteral injury include periureteral fluid and ipsilateral delayed nephrogram, as well as hydronephrosis. Delayed-phase CT findings diagnostic of ureteral injury include contrast extravasation, while lack of opacification of the ureter distal to the area of suspected injury is suggestive.[7,8] When CT imaging is inconclusive and ureteral injury is suspected, adjunctive imaging techniques can aid in the diagnosis of ureteral injuries. Cystoscopy with a RPG may be performed in equivocal cases; however, fluoroscopic examination of the ureter is often logistically challenging in a trauma setting and requires the presence of a urologist. Thus, direct inspection of the ureter remains the gold standard for suspected injuries. Intraoperative single-shot IV pyelography cannot reliably exclude ureteral injuries, so do **not** use it solely for this purpose.[9]

As previously discussed, most Zone II retroperitoneal hematomas from penetrating trauma need to be explored. However, exploration may be avoided in cases where only a small, nonexpanding hematoma exists lateral to the colon, in a patient who is hemodynamically stable, and when clinical suspicion is low for an injury to the renal pelvis, ureter, and major vascular structures.[10] These require follow-up imaging of the kidneys and ureters, as discussed in the section Renal Trauma Imaging and Staging on page 22.

Up to 12.5% of intraoperative ureteral injuries are missed at the time of the initial operation, but identifying ureteral injury at the time of laparotomy avoids delays in diagnosis and potential resultant complications.[1] The severity of ureteral injuries is graded from I to V (least to most severe) according to the classification system developed by the AAST Organ Injury Scaling Committee (see Table 3).[11]

Table 3. AAST Organ Injury Scale for the Ureter

Grade*	Type	Description
I	Hematoma	Contusion or hematoma without devascularization
II	Laceration	Less than 50% transection
III	Laceration	Greater than 50% transection
IV	Laceration	Complete transection with less than 2 cm devascularization
V	Laceration	Avulsion with greater than 2 cm devascularization

*For bilateral injuries, advance one grade (up to grade III)

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ENDOSCOPIC MANAGEMENT OF URETERAL INJURY

KEY POINTS

- Minor traumatic ureteral contusions can routinely be managed with the placement of a ureteral stent alone.
- Severe ureteral contusions with evidence of diminished viability need to undergo surgical repair rather than endoscopic management.

Ureteral contusions can often be treated with ureteral stent placement.[1] Exercise caution, because underappreciated microvascular injury from ballistic mechanisms can result in delayed ureteral necrosis with urinary extravasation in the first 5–7 days after injury and/or stricture in the following weeks to months.[2] It is recommended to avoid endoscopic management when a contusion is severe or spans a long segment.

When an incomplete ureteral transection is diagnosed in a delayed fashion, perform RUG imaging and attempt placement of a ureteral stent.[3,4] Place a percutaneous nephrostomy tube when stent placement is unsuccessful, or if urine leakage is persistent following stent placement.

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SURGICAL MANAGEMENT

KEY POINTS

- A best practice is to directly inspect the ureter at the time of laparotomy in patients with a suspected ureteral injury and with no, or equivocal, preoperative imaging.
- In cases of a ureteral injury in an unstable patient, surgeons need to employ a damage control approach that involves external urinary drainage.
- Principles of surgical repair of ureteral injury include choosing a repair based on injury location; debridement of devitalized tissue; avoidance of over-mobilization; spatulation of ureteral ends; tension-free, watertight anastomosis; and appropriate drainage.
- Use retrograde ureteral stenting or placement of a percutaneous nephrostomy tube for ureteral injuries that present in a delayed fashion, if the patient has no subsequent laparotomy planned.

The treatment choices for ureteral trauma are based on injury location and mechanism, timing of presentation, hemodynamic status, associated injuries, and overall prognosis. Weigh all these factors to make treatment decisions that provide the most favorable outcomes and minimize patient morbidity.

If no preoperative ureteral imaging was performed, employ additional methods to detect ureteral injury during the intraoperative evaluation. Always perform direct inspection of the ureter during emergency laparotomy if a ureteral injury is suspected. Because some ureteral injuries can be missed by intraoperative inspection alone, employ additional techniques for intraoperative assessment of the ureter. These adjunctive procedures include the following:

- Cystoscopic visualization of ureteral efflux
- IV injection of methylene blue or fluorescein
- Direct injection of methylene blue or fluorescein into the renal pelvis to assess for dye leakage along the course of the ureter
- Retrograde passage of a ureteral catheter via cystoscopy or a cystotomy

Several important principles are necessary for successful ureteral repair:

- All devitalized tissue must be debrided.
- Sufficient ureteral mobilization must permit a tension-free anastomosis; however, balance this with preserving the periureteral adventitia and vasculature.
- The ureteral ends need to be spatulated.
- Perform a watertight, tension-free, mucosa-to-mucosa anastomosis using absorbable sutures, and place a retroperitoneal drain.
- A double-J ureteral stent is recommended for repair of both adult and pediatric ureteral injuries.

Ureteral Injury Distal to the Iliac Vessels

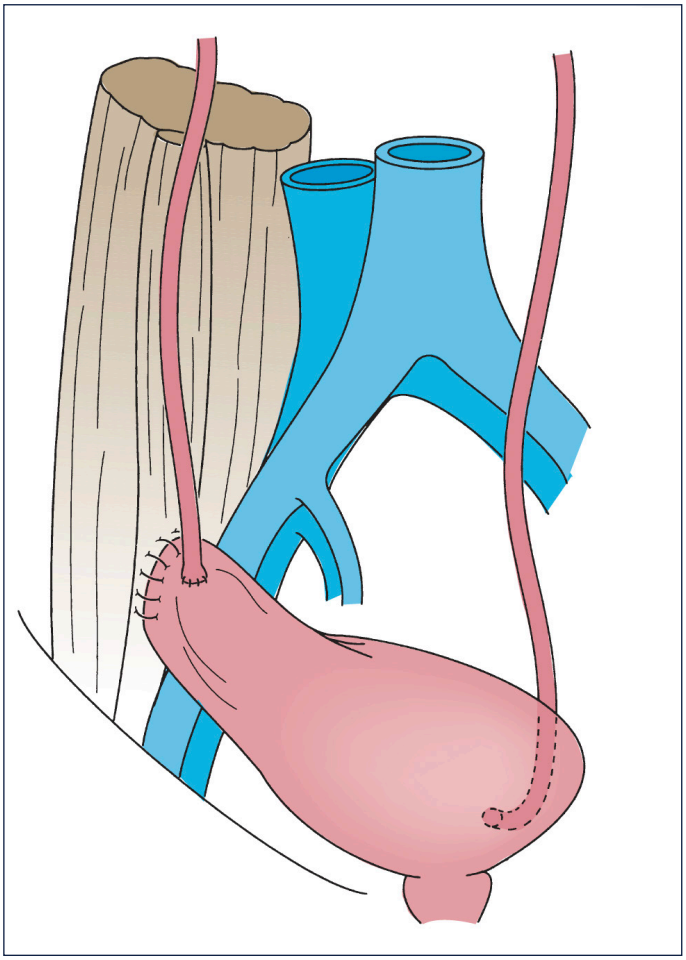
The recommended practice for repair of ureteral injuries distal to the iliac vessels is ureteral reimplantation into the bladder, whenever possible. Primary repair over a double-J ureteral stent is also acceptable if reimplantation is not possible. These injuries may disrupt the blood supply to the distal ureter. Ureteral reimplantation (ureteroneocystostomy) is the preferred surgical management when any question exists about the distal segment viability. Additional maneuvers, including a psoas hitch or Boari flap, can be employed to ensure a tension-free repair.

The principles of distal ureteral repair include debridement and spatulation of the ureter followed by reimplanting the stented ureter directly into the bladder using either a refluxing or a nonrefluxing technique. The choice of refluxing versus nonrefluxing ureteral reimplantation remains controversial and depends on surgeon preference. However, in the trauma setting, refluxing anastomoses are more common.[1] Ureteral reimplantation can be performed using intravesical or extravesical techniques. Both approaches are reported to have low complication rates and excellent success rates (91%–98%).[2,3]

The psoas hitch procedure is a mainstay in the treatment of lower ureteral injuries when a tension-free reimplantation of the ureter into the bladder cannot be performed due to damage or loss of significant ureteral length. Mobilize the bladder from its pelvic attachments in the Space of Retzius. The contralateral superior vesical pedicle may be divided to obtain

additional length. The bladder dome is pulled cephalad and sutured to the ipsilateral psoas tendon, allowing the ureter to be reimplanted medially (see Figure 3).[4] The success rate using this technique is reported to be as high as 97%.[5]

Figure 3. Psoas Hitch Reconstruction for Injury to the Lower or Middle Third of the Ureter



Note the fixation of bladder dome to right psoas tendon and medial reimplantation of right ureter.

From: Wessells H. Genitourinary trauma. In: *Mulholland & Greenfield's Surgery: Scientific Principles & Practice.* 6th ed. Mulholland MW, Lillemoe KD, Doherty GM, Upchurch Jr. GR, Alam HB, Pawlik, TM, eds. Lippincott Williams & Wilkins; 2021. Used with permission.

When the distance from an extensive mid- to lower ureteral injury is too long to be bridged with a psoas hitch alone, a Boari flap can provide additional length by cephalad rotation and tubularization of a bladder flap.[6–8] However, the Boari flap technique is a highly technical reconstructive procedure generally performed by urologists and rarely used in the acute trauma surgical setting. For such complex situations, a damage control approach is recommended.

Injury Proximal to the Iliac Vessels

Manage ureteral injuries located proximal to the iliac vessels with spatulated primary repair (ureteroureterostomy) over a ureteral stent. Carefully consider the blast effect from ballistic injuries, and ensure appropriate debridement of devitalized tissues. In the case of an incomplete ureteral transection discovered during laparotomy, primary repair is the best practice the majority of the time. The ureteral injury is converted from a longitudinal laceration into a transverse repair over a double-J ureteral stent to avoid narrowing of the ureteral lumen (Heineke-Mikulicz procedure). Certain clinical situations (e.g., high-velocity gunshot wounds) may require that an incomplete transection be divided and debrided, followed by primary repair over a double-J ureteral stent. Manage a ureteral avulsion from the renal pelvis by ureteropyelostomy, in which the proximal ureter is anastomosed directly into the renal pelvis.

Damage Control Strategy for an Unstable Patient

In the stable patient, a ureteral injury found at the time of laparotomy needs to be repaired. However, immediate repair may not be possible in the unstable, complex polytrauma patient, and a damage control strategy must be employed. In this scenario, or when injury complexity exceeds the capabilities of the trauma team, definitive treatment is deferred, the patient is resuscitated, and temporary urinary drainage/diversion may be performed. Options for drainage include the following:

- Exteriorizing the ureter via cutaneous ureterostomy
- Ureteral ligation with placement of a percutaneous nephrostomy tube
- Placement of a ureteral catheter secured to the proximal end of the injured ureter and externalized to a drainage device (intubated ureterostomy)

Common options for externalized catheters include ureteral stents, feeding tubes, or pediatric urethral catheters. In situations when even these maneuvers are not possible because of patient instability, urine can be allowed to temporarily drain into the abdomen and suctioned via a temporary abdominal closure device.

Delayed or Deferred Management

Delayed ureteral reconstruction can be performed during a repeat exploration following resuscitation in a more controlled setting, or it may require referral to a tertiary center that can offer advanced urinary reconstructive solutions.[6] Surgical techniques depend on the location and extent of ureteral injury, as previously discussed.

Delayed diagnosis of ureteral injuries, which occurs in up to 12.5% of cases, is associated with significant morbidity.[9] Complications include formation of fistulas, strictures, urinomas, abscesses, renal failure, and sepsis. For patients with no subsequent laparotomy planned, obtain endoscopic urinary drainage. Prioritize ureteral stenting. Use a percutaneous nephrostomy tube when stenting is not possible or to augment drainage in patients with persistent leakage.

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SPECIAL POPULATIONS

KEY POINTS

- Consider the risks and the benefits of complex ureteral reconstruction in older adults when the benefits of minimally invasive treatments may outweigh the benefits of complex but definitive repair.
- When a ureteral injury is suspected in pediatric patients, contrast-enhanced abdominal/pelvic CT with a delayed-phase is the main diagnostic tool to diagnose ureteral injury.
- Use double-J ureteral stents during the repair of pediatric ureteral injuries.

Older Adult Considerations

Older adult trauma patients are the fastest-growing segment of patients admitted to trauma centers and more commonly have blunt rather than penetrating mechanisms of injury.[1] Given the known benefits of ureteral repair when feasible and the significant risk of morbidity for untreated injuries, consider immediate repair of ureteral injuries in older adults during laparotomy.[2] However, for injuries diagnosed preoperatively, consider endoscopic management with a ureteral stent in the acute setting to temporize injuries until a thorough discussion of the risks, benefits, and alternatives of ureteral reconstruction can be discussed with the patient and/or caregivers.[3] Place a percutaneous nephrostomy tube if stenting is not possible. For patients with incomplete ureteral injuries or for injuries recognized in a delayed fashion, consider minimally invasive treatments, which may be more appropriate than complex surgical repairs.[3-6]

Pediatric Considerations

Isolated ureteral injury due to trauma is rare in children, with an incidence of less than 1% in pediatric abdominal trauma.[6] Penetrating ureteral trauma is more common than blunt trauma in the pediatric population. Ureteral injuries can include contusion, laceration, and avulsion. Because of their hyperextensible vertebral column, decreased perirenal fat, weaker abdominal musculature and less ossified thoracic cage, children are more likely to sustain high-energy deceleration injuries resulting in UPJ avulsion.[7]

When a ureteral injury is suspected, contrast-enhanced abdominal/pelvic CT with a delayed-phase is the main diagnostic tool, but RPG is the most sensitive imaging modality. Please refer to the *ACS TQIP Best Practices Guidelines in Imaging* regarding pediatric radiation dose and specific imaging considerations.[8]

The principles of management for ureteral injuries in children are the same as adults.

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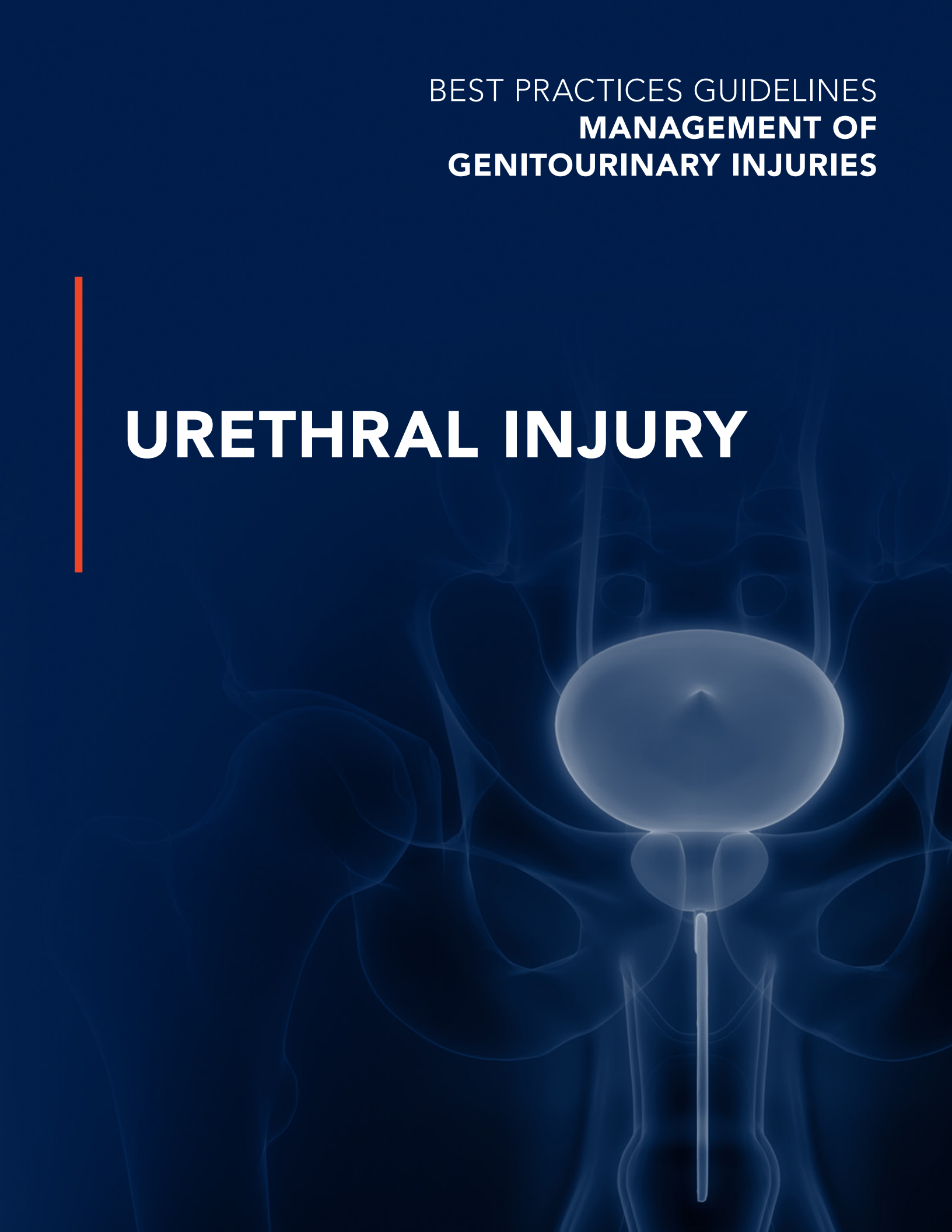
BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

URETHRAL INJURY



MALE AND FEMALE URETHRAL TRAUMA

KEY POINTS

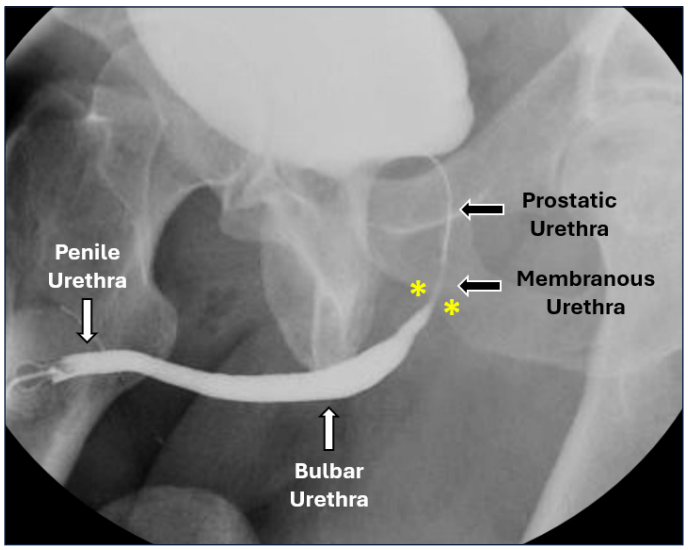
- Diagnosis of urethral injury is made by physical examination (blood at meatus, perineal butterfly hematoma, inability to void, etc.) or imaging after pelvic or genital trauma.
- Anterior urethral injuries in patients with male anatomy commonly occur due to blunt straddle trauma, while posterior urethral injuries commonly occur following pelvic fracture.
- A RUG is the preferred imaging for diagnosis of male urethral injury, and it will guide initial management.
- A high-riding prostate has low sensitivity and specificity for the presence of a urethral injury, so a rectal examination is **not** recommended for urethral injury diagnosis.
- Female urethral injuries are rare and occur in conjunction with pelvic fracture. A speculum exam should be performed to evaluate for associated injuries.
- Cystoscopy is recommended for evaluation of suspected female urethral injury.

An injury to the urethra is a relatively rare traumatic event, mainly affecting male patients. Typically, urethral injuries occur secondary to blunt trauma.[1] In a patient with male anatomy, urethral injuries are best categorized as anterior (bulbar urethra and distal) or posterior (membranous urethra and proximal).[2] See Figure 4.

The majority of anterior urethral injuries are due to blunt force, with straddle injuries being the most common.[3] For urethral injury associated with penile fracture, see Urethral Injury Special Scenarios on page 54.

Posterior urethral injuries occur most commonly following pelvic fracture, occurring in up to 5% of patients with male anatomy with anterior pelvic ring fractures.[4] A large retrospective study of pelvic fractures from a Level I trauma center reported that each millimeter of symphysis pubis diastasis or inferomedial pubic bone fracture displacement was associated with an estimated 10% relative increased risk of urethral injury.[4] As with bladder injuries, concomitant urethral injury and pelvic fracture require close multidisciplinary care and communication between urology, orthopaedics, intensivists, and trauma surgeons.[5,6]

Figure 4. Division of the Anterior Urethra from the Posterior Urethra



A RUG demonstrating the entire normal male urethra. The posterior urethra is proximal to yellow asterisks and includes the membranous urethra and prostatic urethra. The anterior urethra is distal and includes the bulbar and penile urethra.

Adapted with permission from Wolters Kluwer Health, Inc.: Lee MJ, Archer-Arroyo K, Levenson RB, Mazza M, Chong S. Imaging of traumatic injuries to the male lower genitourinary organs and impact on surgical management. *Contemp Diagn Radiol.* 2019;42(10):1–5. doi:10.1097/01.CDR.0000557796.34158.c4.

The clinical presentation of urethral injury will vary based on mechanism; however, a high level of suspicion is necessary for patients presenting with the following signs:[7]

- Blood at the urethral meatus
- Suprapubic fullness
- Perineal laceration
- Scrotal/butterfly perineal hematoma (see Figure 5)
- Difficulty passing a Foley catheter

Figure 5. Perineal, Scrotal, and Penile Butterfly Hematoma

Blood can track along Colle's fascial planes and involve the entire genitalia.

While these signs and symptoms are associated with a urethral injury, their absence does not exclude one. When a urethral injury is suspected, perform a rectal exam (and vaginal exam, for female anatomy), because 5% of urethral injuries are concomitant with a rectal or vaginal injury.[8] A high-riding prostate has both low sensitivity and low specificity for the presence of a urethral injury, so a rectal examination for its presence or absence is **not** recommended for urethral injury diagnosis. A RUG is the preferred imaging modality for diagnosis of a male urethral injury. See the Male Urethral Imaging Protocols in the Imaging section on page 19 for guidance on appropriate performance of a RUG.

If a patient with female anatomy is suspected to have urethral injury, **a RUG is not recommended** due to poor feasibility. Rather, cystourethroscopy and vaginoscopy are warranted.[9,10] In addition, a complete speculum examination is essential in patients with a vagina and suspected PFUI to identify associated vaginal or rectal injury.[11] Be suspicious for urethral injury when blood is found at the urethral meatus or in the introitus/vaginal canal. Promptly seek urologic consultation or transfer the patient to a center with appropriate expertise.[10,11]

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INITIAL MANAGEMENT OF URETHRAL INJURY

KEY POINTS

- Initial management of urethral injury begins with establishing prompt urinary drainage by either urethral catheter placement or SPT.
- If a partial urethral injury is seen on a RUG, a single attempt at Foley catheter placement can be performed.
- If a complete urethral injury is seen on a RUG, prompt urologic consultation is recommended.

Establishing Urinary Drainage

The initial management of a confirmed urethral injury begins with establishing prompt urinary drainage, using either a urethral catheter or SPT. The clinical scenario dictates which bladder drainage method is optimal. For example, an unstable patient with a complete urethral injury secondary to pelvic fracture needs to undergo SPT placement instead of urethral catheter placement.

Insert a SPT either by image-guided percutaneous placement or open cystotomy, because the bladder may be displaced by a pelvic hematoma or be poorly filled due to a concomitant bladder injury.[1] Use a 14 Fr or larger catheter to ensure the bladder is appropriately draining and irrigation of the tube is feasible. A true Foley catheter is preferred over various pigtail catheters, because these smaller catheters will likely need to be exchanged or upsized due to difficulties with drainage and clogging. Coordination with orthopaedics is necessary if pelvic hardware is to be placed.[2]

If a RUG confirms a partial or incomplete urethral injury (i.e., contrast is visualized proximal to the site of contrast extravasation), a single, gentle attempt at Foley catheter placement can be performed by experienced hospital personnel.[3] Alternatively, flexible cystourethroscopy or fluoroscopy can aid in catheter placement following an incomplete urethral injury.

Penetrating anterior urethral injuries confirmed by physical examination and RUG or cystourethroscopy require prompt surgical exploration and repair.[4,5] If the patient is clinically unstable, deferring repair is recommended as long as no ongoing bleeding is noted; bladder drainage with an SPT is necessary.[6] Typical surgical repair consists of isolating the injury, debriding any devitalized tissue, and performing a primary spatulated end-to-end repair.[7] A Foley catheter is always placed following urethral reconstruction, regardless of whether an SPT is in place. For larger urethral defects, temporizing exteriorization of the urethra may be required.

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URETHRAL INJURY SPECIAL SCENARIOS

KEY POINTS

- Urethral injury associated with penile fracture warrants prompt urologic consultation and surgical repair.
- Female urethral injury warrants urologic and gynecologic consultation.
- Cystourethroscopy is the preferred method to evaluate a suspected female urethral injury.
- Consider a vaginal and rectal exam if a female urethral injury is confirmed.
- Straddle urethral injury may cause urinary extravasation and warrants prompt urinary drainage with urethral catheterization or SPT placement.

In cases of penile fracture, concern for urethral injury is suspected in cases when gross hematuria, blood at the urethral meatus, inability to urinate, or difficulty passing a Foley catheter are present.[1] Approximately 15% of penile fractures have an associated urethral injury, so evaluate patients with cystourethroscopy or RUG if clinical signs or symptoms are present.[2]

In cases of suspected female urethral injury, cystourethroscopy is the preferred evaluation method. Urologic and/or gynecologic consultation is recommended after the appropriate diagnostic testing mentioned above. While the management of female urethral injury is not well established because of its rarity, management options include urethral catheterization versus immediate primary repair, either vaginally, transabdominally, or by a combined approach.[3] Consider a vaginal and rectal exam if a female urethral injury is confirmed. Consider urinary diversion with urethral catheter or SPT and delayed reconstruction when surgical expertise is not available.

A straddle urethral injury occurs when blunt trauma directly impacts the perineum and causes a crush injury of the bulbar urethra against the pubic symphysis. This mechanistic force coupled with the vulnerability of the bulbar urethra in the perineum may cause a partial or complete urethral injury.[4] Patients with a straddle injury need to undergo RUG to confirm the presence or absence of contrast extravasation. If injury is confirmed, urethral catheterization or SPT insertion is necessary for urinary diversion. Avoid immediate surgical intervention following a urethral crush injury due to the undefined borders of injury.[5] The rate of stricture formation following a straddle urethral injury with urinary extravasation is very high, and follow-up with a urologist is required for long-term care and delayed surgical reconstruction a few months after injury.[4]

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PELVIC FRACTURE URETHRAL INJURY

KEY POINTS

- Initially manage complete pelvic fracture urethral injury (PFUI) with SPT.
- Do **not** attempt open urethral realignment.
- Primary endoscopic realignment (PER) of the urethra may be attempted by a urologist; however, associated urethral obstruction rates are comparable to SPT.
- Any attempt at PER is performed within a few days of injury when the patient is hemodynamically stable.
- Duration of SPT or urethral catheter will be determined at an outpatient urology follow-up visit.

Initial Management

PFUI is secondary to a disruption in the pelvic ring, which causes a distraction of the membranous urethra away from the bulbar urethra.[1] PFUI is most often associated with fractures of the sacroiliac joint, fractures of the anterior arch with displacement, and/or diastasis of the pubic symphysis.[2] A complete PFUI is managed initially with SPT, while incomplete injuries may be managed with SPT or urethral catheterization. Insertion of an SPT is also widely accepted as the preferred bladder drainage modality in patients who are clinically unstable.[3] If a urologist chooses to perform PER in a delayed fashion once the patient's clinical condition permits, initially place an SPT for bladder drainage.[4] There is no evidence of higher infection rates when SPT is utilized in the presence of anterior pelvic fractures with internal fixation, although the available data are limited and institutional preferences may vary.[5]

No strong evidence exists to indicate that PER significantly impacts stenosis rates or complexity of future urethral reconstruction following complete PFUI. For a partial urethral injury, however, successful PER does permit a Foley catheter across the area of injury and may lower the stenosis rate in this subset of PFUI patients.[6,7] Following SPT or successful PER, urology consultation is necessary to delineate duration of catheterization and/or timing of urethral reconstruction. Open urethral realignment has **no** role in management of PFUI, because it is associated with substantially increased complications.[4]

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MANAGEMENT OF PELVIC FRACTURE URETHRAL INJURY SEQUELAE

KEY POINTS

- Most complete urethral injuries associated with PFUI will result in a stenotic/obliterative distraction defect.
- Urologic follow-up is warranted to assess for stenosis formation, erectile dysfunction, and urinary incontinence.

Patients with complete urethral injury secondary to PFUI or straddle injury have a high likelihood of delayed urethral obstruction, with urethral stenosis rates well over 90%.[1] Obstruction will generally manifest within the first year following injury. Furthermore, severe urethral injury—regardless of the mechanism—is often associated with erectile dysfunction and urinary incontinence, with reported rates of 20%–35% and 15%–20%, respectively.[2] Rates of erectile dysfunction and incontinence vary based on injury location and severity, as well as management strategy undertaken following trauma. Patients with PFUI or straddle injury need to have a urologic follow-up appointment scheduled at the time of hospital discharge to coordinate management of these potential long-term sequelae.

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SPECIAL POPULATIONS

KEY POINTS

- Management of pediatric and older adult urethral trauma mirrors that of adults.
- Geriatric urethral trauma may be complicated by prior urologic history.

Older Adult Considerations

Geriatric patients are more likely to have preexisting lower urinary tract pathology, including urethral stricture disease and/or prostatic enlargement. They may also have urologic implants such as artificial urinary sphincters. Geriatric patients with suspected urethral injury need to undergo a focused history and physical exam to identify the extent of any previous urethral conditions or surgeries, as well as the presence of urologic prosthetics.

Pediatric Considerations

Some logistical aspects of pediatric urethral trauma care diverge from adult urethral trauma secondary to pediatric patients' willingness or ability to tolerate awake catheter placement, SPT placement, RUG, and cystourethroscopy. However, the basic principles of diagnosis and management are the same and need to follow the adult algorithm.[1,2,3]

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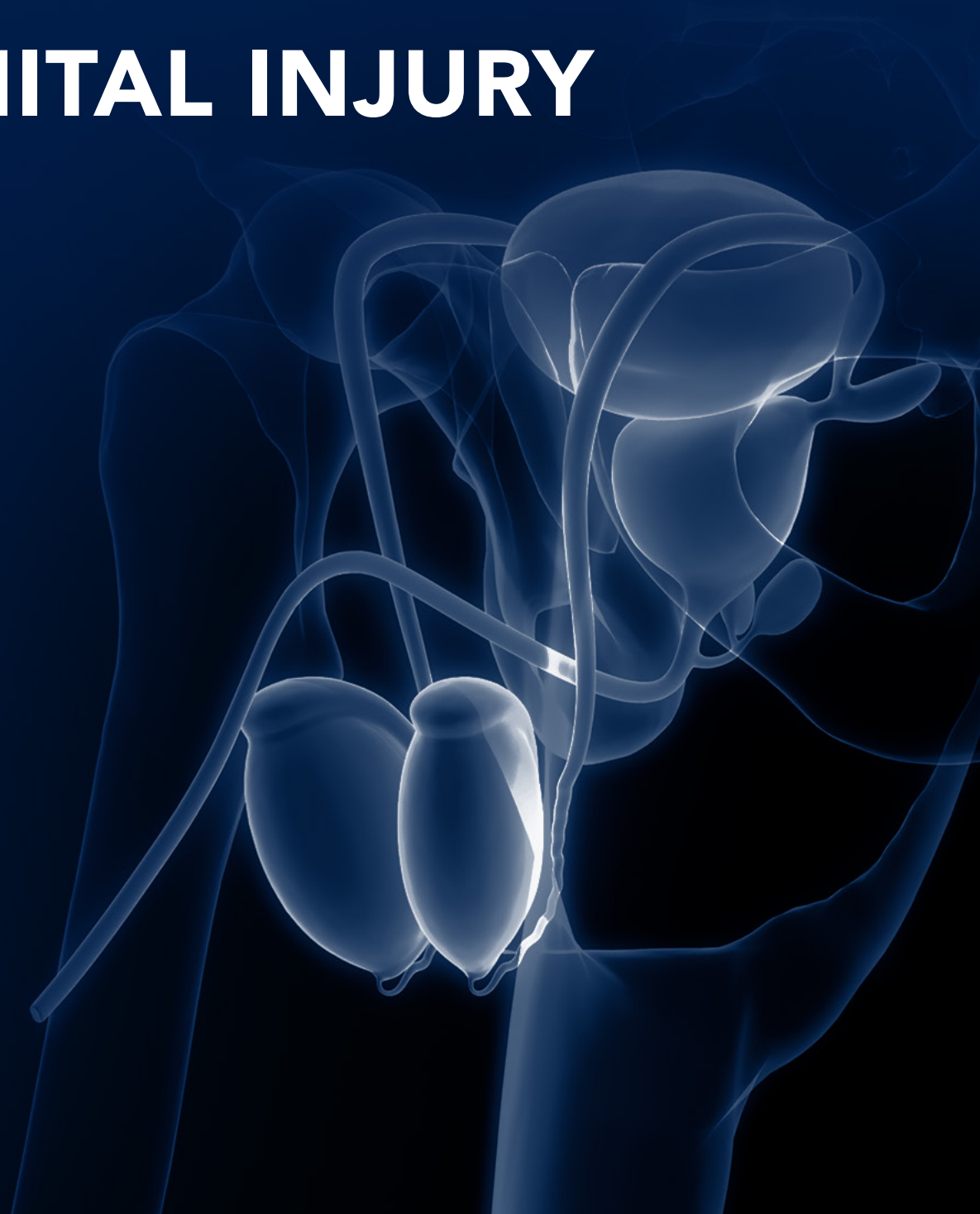
BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

GENITAL INJURY



MALE GENITAL TRAUMA

KEY POINTS

- Evaluate for penile fracture when patients present with penile pain and ecchymosis following sexual trauma associated with rapid detumescence of an erection.
- Perform a RUG or cystoscopy on patients with blunt or penetrating penile injury with blood at the urethral meatus, gross hematuria, or inability to void.
- Perform urgent surgical exploration and repair of penile fracture within a few days of the injury.
- Penile penetrating injury, commonly due to ballistic trauma, must be managed with urgent surgical exploration, debridement, and tissue repair.
- Penile amputation injuries are best managed urgently at a specialty center with both a urologist and microvascular surgeon.
- Refer patients performing self-amputation for psychiatric evaluation.
- Patients presenting with blunt scrotal trauma must undergo scrotal ultrasound evaluation.
- Manage testicular rupture with operative exploration and repair of the viable testicle.
- Penetrating scrotal injuries require urgent surgical exploration and debridement because of the high risk of testicular or vascular structure involvement.

Male genital injuries include trauma to the penis, anterior urethra, scrotum, and testicles. The most common injuries include testicular rupture, penile fracture, and penetrating penile injury.[1]

Penile Fracture

Penile fracture involves a tear of the tunica albuginea, the fibrous tissue layer surrounding the erectile bodies, leading to rupture of one or both of the corpora cavernosa. These injuries typically occur when the erect penis bends excessively during sexual activity or is forcibly bent. This trauma classically is accompanied by a popping sound and leads to rapid detumescence, pain, ecchymosis, and swelling. Penile fractures typically occur distal to the penile suspensory ligament on the ventral or lateral penile surface, where the tunica albuginea is thinnest.[2] Penile fractures may be unilateral or bilateral and involve urethral injury in an estimated 15% of cases.[3]

Assessment and Diagnosis

Evaluate patients for penile fracture when presenting with penile ecchymosis, edema, and pain following penile sexual trauma associated with rapid erection detumescence.[1,2,3] The diagnosis of penile fracture may be made by history and physical examination alone.[1,2,5]

For patients presenting with indeterminate history and physical exam, penile ultrasound or MRI may be used to evaluate for penile fracture.[1,2] Both imaging options have excellent sensitivity, so consider them in equivocal or more complex cases.[6] The imaging selected is based on the clinician's index of suspicion, access, and the facility's imaging capabilities.[1] Perform a RUG or cystoscopy when penile fracture injury is present with any of the following findings: concomitant blood at the meatus, gross hematuria, and difficulty with urination (e.g., weak urinary stream or acute urinary retention).[1,2]

Management

Perform surgical exploration within 7 days of injury for patients presenting with signs and symptoms of penile fracture or positive imaging findings.[7] Earlier intervention, near the time of presentation, may improve long-term patient outcomes, including reduced pain, faster convalescence, and lower risk of penile curvature.[1] For patients presenting with penile fracture to a lower-level trauma center, consider early transfer to a trauma center with urology expertise once the patient is stabilized.

Surgical repair is performed through a circumcising or ventral midline penile incision, based on the suspected location of injury. The penile skin is then mobilized to allow for exposure of the bilateral corpora cavernosa and the suspected tunica albuginea disruption.[1] Key surgical management principles include the following:

- An artificial erection (injection of saline with or without dye directly into the corporal body) may facilitate identification of the corporal injury.

- The tunica albuginea disruption is closed using absorbable suture.
- When a concomitant urethral injury is identified at the time of tunica albuginea repair, perform urethroplasty over a urethral catheter using a tension-free, watertight closure with absorbable suture.

Penile Penetrating Injury

Penile penetrating injuries are usually secondary to gunshot injury and are often associated with injuries to the abdomen, pelvis, and extremities.[2,4]

Assessment and Diagnosis

After patient stabilization, penetrating penile injury may be diagnosed by history and physical examination, including assessment of entry and exit wounds. Additional imaging with ultrasound or MRI may be considered for surgical planning, however, this is not required prior to operative exploration. The urethra may be involved in up to 50% of penile ballistic injuries.[8] If urethral injury is suspected with signs of a weak urinary stream, gross hematuria, or acute urinary retention, a best practice is to perform a RUG or cystoscopy.[1] See guidance for performing a RUG in the section Male Urethral Imaging Protocols on page 19.

Management

Immediate surgical exploration of penetrating penile injuries with irrigation, conservative debridement of nonviable tissue, removal of any foreign bodies, and repair of involved structures is recommended. When the corporal bodies are involved, perform repair in a similar fashion to penile fracture injury repair. If urethral involvement is identified, perform urethral debridement and repair over a urethral catheter using a tension-free, watertight closure at the time of surgical exploration. For patients presenting to a lower-level trauma center, consider early patient transfer to a center with urology expertise for penile injury management once the patient is stabilized.

Penile Amputation

Penile amputation, either partial or complete, is uncommon and most frequently due to self-injury. Genital self-mutilation is frequently associated with psychosis.[1,2] The diagnosis of penile amputation is made based on history and physical examination.

Management

Perform timely penile reconstruction including, at a minimum, anastomosis of the corporal bodies and the urethra. For optimal results, penile amputation requires urgent microsurgical replantation by a urologist and a microvascular surgeon. Transfer the patient urgently to a specialty facility if a urologist and/or a microvascular surgeon are not available. Transport the amputated penis in a two-bag system, with the penis wrapped in saline-soaked gauze in one bag and that bag placed in a second bag on ice.[1]

Microsurgical dorsal penile neurovascular repair, including arterial, venous, and nerve anastomosis, helps preserve penile skin and improve functional results. If a microvascular surgeon is unavailable and/or transfer is not possible, a urologist or a surgeon with prior experience with penile repair performs an anastomosis of macroscopic structures (corpora cavernosa, urethra, and skin) using small absorbable sutures. The urethra is repaired over a catheter. Obtain a mental health evaluation because of the strong association between mental health comorbidity, psychosis, and self-penile amputation.[9–11]

Blunt Scrotal Trauma

Blunt mechanisms cause up to 75% of testicular injuries.[1] Typically only one testis is involved.[2] Blunt trauma may also result in testicular torsion, hematocele, dislocation, or intratesticular hematoma.

Assessment and Diagnosis

The degree of scrotal pain and swelling does not always correlate with the severity of testicular injury. Obtain scrotal ultrasound to evaluate for testicular rupture (parenchymal laceration with capsular disruption) in patients presenting with a history of blunt scrotal trauma, pain, ecchymosis, and significant scrotal swelling.[1,2] Ultrasound findings used to identify testicular rupture include parenchymal heterogeneity, loss of contour, and a disruption or defect in the tunica albuginea of the testis. While interruption of the tunica albuginea is the most specific sign of testicular rupture, it may not always be detected. If the scrotal ultrasound is inconclusive, consider an MRI. However, do not delay surgical exploration if testicular rupture

is suspected. Up to 10% of testis tumors are found incidentally at the time of scrotal trauma evaluation and should be detected on ultrasound.[2,12]

Management

Patients diagnosed with minor blunt scrotal trauma, consisting of contained hematoma or hematocele *without testicular rupture*, can be managed conservatively with scrotal ice, elevation, and analgesics.[1,2] When an isolated, expanding scrotal hematoma without testicular rupture develops, it is explored and drained to prevent scrotal pressure necrosis and impairment of testicular perfusion.[2]

Patients diagnosed with testicular rupture need to undergo urgent surgical exploration, testicular debridement, and repair.[1,2] Early testicular repair within 3 days is associated with increased testicular salvage, faster recovery, and improved preservation of reproductive capability.[2] Testicular repair involves debridement of nonviable exposed seminiferous tubules and closure of the tunica albuginea with absorbable sutures. Surgeons performing testicular repair need to make every effort to salvage the affected testicles. As such, in the case of a complex injury to a solitary testicle, a tunica vaginalis flap harvested from the ipsilateral scrotum can be utilized to close a larger tunica albuginea defect and avoid excessive debridement.

Because intraparenchymal hematoma contained within an intact capsule can lead to testicular ischemia, use scrotal ultrasound with duplex Doppler to follow intratesticular hematoma until resolution of the hematoma. This will evaluate for compromised testicular viability or a potential testicular tumor necessitating surgical intervention.[12]

Penetrating Scrotal Trauma

Penetrating scrotal trauma is associated with unilateral testicular injury in 50% of cases and bilateral injury in 30% of cases. Such injuries may also involve the spermatic cord, with vascular or vas deferens injury in up to 9% of cases.[1] The diagnosis can be made by history and physical examination.[1,2]

Management

Patients diagnosed with penetrating scrotal trauma may have concomitant unilateral or bilateral testicular, spermatic cord vessel, or vas deferens involvement. Urgent surgical exploration, debridement, and repair are needed.[1] Based on the evaluation of the trajectory of the trauma and symptoms, bilateral testicular exploration is performed. When a testicle is found to be injured, attempt testicular repair and salvage to the extent possible. Testicular repair, similar to blunt injuries, involves debridement of nonviable exposed seminiferous tubules and closure of the tunica albuginea with absorbable sutures. Augmented repairs with tunica vaginalis flaps can be performed if there is insufficient viable tunica albuginea for primary closure. Should the vas deferens be involved in the injury, perform ligation and debridement, and then consider performing repair in a delayed fashion.[2] Perform orchiectomy for nonviable destroyed testicles.

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FEMALE GENITAL TRAUMA

KEY POINTS

- If sexual abuse is suspected in a patient with female genital trauma, strongly consider performing an examination under anesthesia.
- Involve a sexual assault nurse examiner (SANE) early in the evaluation of such patients.
- Hemodynamically stable patients presenting with simple contusions may be managed with ice and analgesics.
- Large labial/perineal hematomas (>5 cm) require incision and drainage.
- Complex vaginal and cervical lacerations are best managed urgently at a center with specialty expertise.

Female genital trauma may involve the vulva, labia majora, labia minora, clitoris, perineum, vagina, anus, and internal pelvic organs. The most common form of unintentional genital injury is straddle injury due to bicycle-related trauma.[1] Penetrating injuries most frequently occur when a victim falls onto their perineum and strikes a sharp object, or with a piercing bone fragment secondary to pelvic fracture.[1] Sexual assault victims presenting to health care facilities—often adolescents and young adults—may have genital trauma. Vaginal trauma may be associated with a high risk for bleeding, as well as a concomitant injury to the lower urinary tract and other internal organs (e.g., the uterus and bowel).

Assessment and Diagnosis

Ensure the presence of a chaperone when performing the female genital exam. Use a vaginal speculum to perform a thorough examination. When physical or sexual abuse is suspected, minimize potential trauma associated with the examination, and consider the inclusion of sexual assault experts (e.g., SANE or sexual assault response team [SART]). Strongly consider an examination under anesthesia.

Vaginal trauma may be associated with damage to the lower urinary tract and other internal organs such as the uterus and bowel. Therefore, consider cross-sectional imaging with CT if the patient presents with associated pelvic injury, demonstrates hemodynamic instability, or other internal organ damage is suspected. Perform urethral and bladder evaluation with cystography and/or cystourethroscopy if concomitant lower urinary tract injury is suspected.

Management

Manage the patient with supportive care and urgent surgical exploration as indicated. If female genital trauma is confirmed, obtain a gynecology consult for management and treatment. If physical or sexual abuse is suspected or confirmed, obtain multidisciplinary mental health and social support evaluations. The sexual assault workup may also include collection of forensic specimens, testing for sexually transmitted infections, emergency contraception, and consideration of human immunodeficiency virus (HIV) prophylaxis.[2] For patients with complex injuries presenting to a lower-level trauma center, consider transfer to a facility with expertise for gynecological injury management once the patient is stabilized.

Labial and Vaginal Lacerations

Patients diagnosed with superficial labial or vaginal lacerations without significant bleeding can be managed with local wound care. Patients with deep labial or vaginal lacerations—or any injuries with significant bleeding—need to undergo surgical debridement and repair with absorbable sutures using local or general anesthesia. The wounds are thoroughly irrigated, and deeper wounds are explored for foreign bodies or debris. Ligate sources of active bleeding. Close deep wounds in multiple layers when gross contamination or infection is not present.

Proximal Vaginal Canal and Cervix

For trauma involving the cervix and uterus, obtain subspecialty care following resuscitation and placement of vaginal packing for bleeding control. Manage injuries extending beyond the vagina and cervix with exploratory laparoscopy or laparotomy to rule out intraperitoneal organ or anorectal injuries. Perform a urologic evaluation when vaginal trauma is associated with gross hematuria or concern exists for urethral or bladder involvement.[1]

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GENITAL BITES

KEY POINTS

- Manage genital animal bites with irrigation, debridement, absorbable suture skin closure, and prophylactic antibiotic course.
- Manage genital human bites with irrigation, debridement, and prophylactic antibiotic course. **Do not close the skin.**

The diagnosis of genital bite is made based on history and physical examination.

Animal Bite

Manage a genital animal bite with copious irrigation, debridement of involved tissue, closure with absorbable suture, and prophylactic antibiotics.[1] Tetanus and rabies prophylaxis are administered. Notify the local health department as indicated. Given the risk of polymicrobial infection, provide patients with an empiric course of an antibiotic with beta-lactamase inhibitor (e.g., amoxicillin–clavulanic acid).[2]

Human Bite

Manage a genital human bite with copious irrigation, debridement, and antibiotics. Given the high risk of wound contamination and infection, do **not** perform primary skin closure.[1] Provide the patient with an empiric antibiotic course with amoxicillin-clavulanic acid or moxifloxacin.[2]

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PEDIATRIC GENITAL TRAUMA

KEY POINTS

- Clinicians must assess whether pediatric genital trauma is the result of abuse.
- Examination under anesthesia is strongly considered when abuse is suspected.

The most common cause of pediatric genital injury is unintentional trauma. Common etiologies include straddle injury and, for male anatomy, zipper and toilet seat injuries.[1] In all cases of pediatric genital injury, clinicians must assess whether the genital trauma is the result of abuse.[2]

While evaluation and management of genital injuries is similar to the adult population, performing the examination under anesthesia is strongly encouraged, particularly when abuse or intentional injury is suspected.[2]

Management

Children presenting with penile swelling and erythema, with or without urinary complaints, need to be evaluated for tourniquet/strangulation injury with a thread, hair, or rubber band. Perform expedited removal of the item to prevent penile ischemia and necrosis.

For penile zipper injuries, administer local versus general anesthesia depending on the severity of penile involvement and patient toleration. Following penile anesthetic block, maneuvers to release the zipper include the following: lubrication of the zipper with mineral oil, incising the cloth between zipper teeth, a metal cutting tool to release the median bar, or a screwdriver to release the metal zipper shield.[3]

Penile toilet seat crush injuries are typically minor and can be managed with supportive care. More severe injuries, with findings concerning for testicular rupture or urethral injury, are often associated with significant edema, ecchymosis, or gross hematuria. These injuries may require evaluation with imaging, but management is the same as described for adult genital injuries.[4]

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BEST PRACTICES GUIDELINES
MANAGEMENT OF GENITOURINARY INJURIES

IMPLEMENTATION AND INTEGRATION OF THE BEST PRACTICES GUIDELINES

GAP ANALYSIS AND EDUCATION PLAN

KEY POINTS

- A multidisciplinary workgroup, with a defined leader and reporting structure, is charged with developing a gap analysis document, which compares current practice to the BPG document.
- An educational plan is developed to help prioritize areas for implementation of the best practices guideline document.

Implementing a trauma center GU BPG begins with the trauma medical director (TMD), trauma program manager (TPM), and trauma liaisons as leaders and change agents. These individuals are responsible for the oversight, management, and continuous commitment to improving care within the trauma center and the trauma system, regardless of the trauma center's level of designation. These trauma center leaders define the leadership structure, culture, and implementation processes for the BPG that foster stakeholder engagement.

Gap Analysis

This workgroup is charged with creating a gap analysis to compare current practices to those recommended in the BPG (see Table 4). The workgroup, in conjunction with the trauma center's operations committee, establishes the priorities for implementation. Progress reports on the status of the document can be provided at the trauma operations committee meeting. The final gap analysis is submitted to the trauma operations committee and the TMD for approval. The operations committee has responsibility for disseminating and communicating the injury management guideline updates to individuals who participate in trauma care.

Table 4. Recommendations for Gap Analysis

Management Guidelines	Met	Not Met	Priority	Comments
GU trauma injury protocols include imaging and management considerations for patients of all ages.				
As low as reasonably achievable (ALARA) principles are applied to all patients, ensuring imaging from external facilities is available to minimize radiation exposure.[1]				
Radiologists utilize the appropriate AAST organ injury scaling table when grading GU trauma injuries.				
Radiology discrepancy report tracking is implemented when a change occurs.[2]				
Predefined transfer criteria for GU trauma are readily available.				
Protocols for GU penetrating trauma include radiographic or surgical evaluation of adjacent structures in the abdominal or retroperitoneal cavity.				
Renal trauma injury imaging protocols include indications for delayed-phase imaging for evaluation of collecting system injury.				
Renal trauma protocols include evidence-based guidelines for the management of hemorrhagic shock: - NOM, such as angioembolization - Operative intervention - Complications[3]				
Imaging protocols include RPG to evaluate for ureteral injury (when indicated).				
GU injury management protocols include a pathway for stable patients who can tolerate an endoscopic approach for retrograde ureteral stenting and/or percutaneous nephrostomy.				
GU trauma management protocols include a pathway for unstable patients who need to undergo a damage control laparotomy.				
Protocols for concomitant operative injury management include close interdisciplinary communication between specialty surgical services.				
Radiographic evaluation for bladder injuries includes: - CTC - Conventional cystography				
Bladder injury imaging protocols include indications for cystography.				
GU trauma management protocols include nonoperative and operative management guidelines of bladder injuries.				
Special considerations for management of bladder injuries include patients who may have complex bladder anatomy, such as neobladders, continent reservoirs, or bladder augmentation.				
Protocols for the evaluation of a suspected urethral injury in patients with male anatomy may include a RUG.				
GU trauma injury protocols include a genital exam and/or a RUG for the evaluation of male genital trauma injuries.				
GU injury protocols include a pelvic exam, cystoscopy, and/or vaginoscopy for the evaluation of female genital trauma.				
Pelvic exams include patient chaperone and SANE protocol documentation.				
Trauma-informed care is available to all patients.				

Education Plan

The next priority is the development of a BPG education plan that defines injury management needs. This education plan outlines the expectations for injury assessment and management, as well as the specific tasks associated with assessment, documentation, intervention, and reassessment (see Table 5).

Reference

1. American College of Surgeons Trauma Quality Programs. *ACS TQIP Best Practices Guidelines in Imaging*. Chicago, IL; 2018. https://www.facs.org/media/oxdjw5zj/imaging_guidelines.pdf. Accessed September 8, 2024.
2. American College of Surgeons. *Resources for Optimal Care of the Injured Patient (2022 Standards, Revised December 2022)*. Chicago, IL; 2022. https://www.facs.org/quality-programs/trauma/quality/verification-review-and-consultation-program/standards/. Accessed September 8, 2024.
3. American College of Surgeons. *National Trauma Standard Data Dictionary: 2024 Admissions*. Chicago, IL; 2023. https://www.facs.org/for-medical-professionals/news-publications/news-and-articles/acs-brief/august-13-2024-issue/download-free-2025-trauma-data-dictionary/. Accessed September 8, 2024.

Table 5. Education Plan for Management of Genitourinary Injuries

Education Plan Components	Priority for Education	Targeted Staff
Epidemiology and injury patterns for GU trauma injuries in patients of all ages		
High-risk mechanisms for GU trauma based on patient age		
Special imaging and management considerations of GU trauma within the pediatric and older adult patient populations		
The role of the ALARA principle for pediatric patients		
Potential complications from renal trauma injuries		
Transport and transfer criteria for GU trauma		
Delayed-phase imaging rationale for the evaluation of renal collecting system and ureteral injuries		
Role of NOM (such as angioembolization) versus operative management of renal trauma injuries		
Patient education: Percutaneous nephrostomy tube maintenance and potential complications		
Return-to-activity and imaging protocols for follow-up of pediatric and adult renal trauma		
Considerations for a RUG		
Rationale for RPG to evaluate a ureteral injury		
Ureteral stent function and potential complications		
Protocols for concomitant bladder injuries and pelvic fractures		
Nonoperative and operative management guidelines for bladder injuries		
Laparotomy indications for the management of GU trauma		
Cystography indications		
Management of bladder injuries for patients with bladder congenital anomalies or bladder modifications		
Patient education: RUG imaging		
Patient education: Foley and suprapubic catheter maintenance and potential complications		
The role of a pelvic speculum exam and cystoscopy for the evaluation of GU trauma in patients with female anatomy and pelvic fracture		
Protocols for chaperone and SANE liaison involvement for the evaluation of GU trauma for patients		
Local trauma resources for patients in the community		
Protocols for management of genital injuries		
Local mental health consultation resources availability		

INTEGRATION INTO TRAUMA CENTER PERFORMANCE IMPROVEMENT

Please note: Information contained in the performance improvement section serves as guidance only for trauma centers based upon evidence and current best practices.

KEY POINTS

- All rural trauma centers need to have predefined GU trauma transfer criteria if urology surgical provider specialists are not available.
- Mental health and peer-to-peer support resources need to be available for patients when a sexual assault examination is completed for the evaluation of GU injuries.
- The interdisciplinary workgroup defines elements to monitor through the Trauma Performance Improvement and Patient Safety (PIPS) process.[1]
- The performance improvement (PI) elements are integrated into the current structure and processes of the Trauma PIPS plan.
- PI filters are based on the trauma center's resource availability.
- PI filter tracking is integrated into a trauma registry, or other computer program, to facilitate consistency in monitoring events and tracking patient outcomes.

Regional System Integration of Genitourinary Trauma Care

A regional system may choose to develop a regional collaborative to review and coordinate GU trauma care across the region. This collaborative initiative is interdisciplinary and may include rehabilitation services and psychosocial services. The urology collaborative defines its priorities and focus, which may require regional data related to GU injury and outcomes. Potential priorities for development of regional GU guidelines include a focus on the following:

- Integration of prehospital care, field triage, and destination, requiring trauma center data sharing related to GU injury outcomes with prehospital services.
- Make every effort to obtain imaging from referring facilities based on as low as reasonably achievable (ALARA) principles to reduce radiation exposure, especially for pediatric patients.[2]
- Consider a regional resource for referring hospital imaging review and remote consultation.
- Timely access to rehabilitation and/or specialty GU service requires the region to identify the various resources and availability of services they provide.
- Identify community or web-based psychological and peer-to-peer support for the patients with GU injuries.

Trauma Performance Improvement Program Integration

The interdisciplinary workgroup defines and recommends key elements for integration into the trauma PI processes. The workgroup's trauma PI recommendations are applicable to the trauma program's resource availability for the evaluation and management of GU trauma injuries. Each trauma center will define the PIPS elements it will review (see Table 6).

Table 6. Performance Improvement Filters

Performance Improvement Recommendations	Reviewed for Each Patient and Reported
ATLS® assessment principles are followed.	
Adherence to age- and injury-specific guidelines are tracked.	
Timely urology consultation for injury evaluation is documented.	
Trauma centers consider implementing an injury scoring system for urologic trauma, such as the AAST organ injury scale, to determine the severity of an injury.	
Time to imaging is tracked.	
The center documents the occurrence rate for instances when a discrepancy between the preliminary and final radiology interpretations changes the initial management plan.	
Hospital events/complications, such as the following, are documented:[3] - Unplanned surgical interventions, such as failure of NOM - Escalation of care to the ICU - Catheter-associated urinary tract infection (CAUTI) - Surgical site infections	
Catheter/stent/skin-care adjuncts are documented per protocol when tracking hospital events/ complications.	
Predefined transfer guidelines for GU trauma injuries are implemented.	
The rate of referring facility imaging capture is tracked (to reduce radiation exposure, especially for pediatric patients).	
Time to angioembolization from request is documented.	
Rate of delayed-phase imaging on initial evaluation for patients with collecting system injuries is documented.	
Use of large-bore (≥18 Fr) urethral catheter for ≥7 days for NOM of uncomplicated extraperitoneal bladder injuries is documented.	
Failures of NOM for GU trauma injuries are tracked and reviewed in the trauma PI program.	
Adherence to protocols for management of specific GU trauma injuries for stable and unstable patients is documented.	
Nephrectomy occurrence rate for renal trauma at initial presentation and following initial NOM is documented.	
Adherence to imaging protocol for patients at moderate to high risk for bladder injury (e.g., missing cystography) is documented.	
Adherence to two-layer closure for intraperitoneal bladder injuries is documented.	
Postsurgical cystogram is completed at ≥7 days after bladder repair.	
Documented rate of a missed RUG prior to indwelling catheter insertion when urethral injury suspected in hemodynamically stable patients.	
Appropriate use of ultrasound or MRI is documented for evaluation of scrotal and penile trauma.	
Time to surgical exploration of patients with penile fracture is ≤7 days.	
Chaperone use, or patient declination thereof, when performing genital examinations is documented.	
Consultation of experts for sexual assault examination, resources, and patient advocacy is documented.	
Psychological support and resources are provided to ensure access to trauma-informed care.	
Law enforcement reporting occurs for suspected physical abuse or neglect of child or adult patients.	

References:

1. American College of Surgeons. *Resources for Optimal Care of the Injured Patient (2022 Standards, Revised December 2022).* Chicago, IL; 2022. https://www.facs.org/quality-programs/trauma/quality/verification-review-and-consultation-program/standards/. Accessed March 19, 2025.
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ACRONYMS

A

AAST — American Association for the Surgery of Trauma
ACR — American College of Radiology
ACS — American College of Surgeons
ALARA — as low as reasonably achievable
APC — anterior-posterior compression
ATLS® — Advanced Trauma Life Support
AVF — arteriovenous fistula

B

BPG — Best Practices Guidelines

C

CAUTI — catheter associated urinary tract infection
CT — computed tomography
CTC — CT cystography

E

EAST — Eastern Association for the Surgery of Trauma
EAU — European Association of Urology
ESER — European Society of Emergency Radiology

F

FAST — focused assessment with sonography for trauma

G

GU — genitourinary

H

HIV — human immunodeficiency virus

I

ICU — intensive care unit
IV — intravenous

M

MRI — magnetic resonance imaging

N

NOM — nonoperative management
NTDB — national trauma databank

O

OR — operating room

P

PER — primary endoscopic realignment
PFUI — pelvic fracture urethral injury
PI — performance improvement
PIPS — Performance Improvement and Patient Safety
PSA — pseudoaneurysm
PTS — Pediatric Trauma Society

R

RAE — renal artery angiography with embolization
RPG — retrograde pyelography
RUG — retrograde urethrogram

S

SANE — sexual assault nurse examiner
SART — sexual assault response team
SPT — suprapubic tube

T

TMD — trauma medical director
TQIP — Trauma Quality Improvement Program
TQP — Trauma Quality Program
TPM — trauma program manager

U

UPJ — ureteropelvic junction

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