REVIEW

Contemporary evaluation and management of renal trauma

Jyoti D. Chouhan, DO,[1] Andrew G. Winer, MD,[1] Christina Johnson, BS,[2] Jeffrey P. Weiss, MD,[1] Llewellyn M. Hyacinthe, MD[1,3]

[1]Department of Urology, SUNY Downstate Medical Center, Brooklyn, New York, USA
[2]SUNY Downstate Medical Center, Brooklyn, New York, USA
[3]Kings County Hospital Center, Brooklyn, New York, USA

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Introduction: *Renal trauma occurs in approximately 1%-5% of all trauma cases. Improvements in imaging and management over the last two decades have caused a shift in the treatment of this clinical condition.*
Materials and methods: *A systematic search of PubMed was performed to identify relevant and contemporary articles that referred to the management and evaluation of renal trauma.*
Results: *Computed tomography remains a mainstay of radiological evaluation in hemodynamically stable patients. There is a growing body of literature showing that conservative, non-operative management of renal trauma is safe, even for Grade IV-V renal injuries. If surgical exploration is planned due to other injuries, a conservative approach to the kidney can often be utilized. Follow up imaging may be warranted in certain circumstances. Urinoma, delayed bleeding, and hypertension are complications that require follow up.*
Conclusion: *Appropriate imaging and conservative approaches are a mainstay of current renal trauma management.*

Key Words: trauma, renal, management, evaluation

Introduction

Injury to the genitourinary tract, although only occurring in approximately 10% of trauma cases, is an important topic. While any genitourinary organ can be subjected to iatrogenic trauma, this review will focus solely on renal trauma, which is the most common organ involved. The severity of renal trauma can range significantly; thus, the management options likewise can vary. In the last two decades, improvements in radiographic and management technique, as well as the development of a validated renal injury scoring system, have dramatically shifted the paradigm away from surgical intervention and towards more conservative approaches. In this review, we summarize the evidence and recommendations for the contemporary management of renal trauma including presentation, diagnosis, staging, management and complications.

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Address correspondence to Dr. Jeffrey P. Weiss, Department of Urology, SUNY Downstate Medical Center, 450 Clarkson Avenue, Brooklyn, NY 11203 USA

Presentation

Renal injuries occur in approximately 1%-5% of all traumas and up to 10% of all abdominal injuries with

a male predominance of 3:1.[1-7] Renal trauma can be classified as either blunt or penetrating depending on the mechanism by which the injury occurs. In general, blunt injuries are more common, accounting for up to 90%-95% of renal injuries.[8] However, in urban and military settings penetrating renal injuries have a much higher prevalence, seen in 20% of cases or more.[9,10]

Blunt trauma

Blunt injuries occur as a result of high-energy deceleration collisions such as motor vehicle accidents (MVAs), falls, assault and contact sports. Of the mechanisms identified, MVAs comprise the majority of blunt renal injuries.[11] In a recent 9 year review, MVAs accounted for 61% of blunt renal injuries while the next most common was falls (11%) followed by pedestrian injuries (9%) and sporting injuries (7%).[12] Parenchymal contusions or lacerations are the most common method of renal damage, however, renal vascular insults may develop in roughly 5% of blunt renal traumas in the form of avulsions or thrombosis.[4] Thrombosis is thought to occur either secondary to tearing of the intimal lining of the renal vasculature during deceleration injury or extrinsic compression against surrounding organs, both resulting in activation of the clotting cascade.[13]

Penetrating trauma

Penetrating injuries to the kidney typically consist of stab and gunshot wounds (GSW). These injuries tend to be more severe and multi-organ in nature given the direct tissue damage that occurs. Characteristics regarding the weapon used, including the type of gun and bullet, can add tremendous value to the initial assessment. For instance, Hutton reported that the greater the bullet velocity, the greater the tissue damage as a result of a larger temporary cavity.[14] Also, expanding bullets are designed to "mushroom" to approximately double their initial diameter as they penetrate through various tissue planes causing significantly more soft tissue damage. In addition, the ballistic properties of bullets when coming in contact with various media (air, fluid, soft tissue, bone) make the trajectory and subsequent damage highly unpredictable.[15] Therefore, any GSW to the chest or upper abdomen should be investigated for concomitant renal trauma.

Physical examination

Once the details regarding the mechanism of injury have been established, airway, breathing and circulation have been assessed and appropriate resuscitation has begun, a thorough physical examination primarily of the chest, back and abdomen should be completed. Keep in mind that vital signs must be monitored throughout the evaluation. Indicators that may identify renal injury from blunt trauma include: hematuria, flank or abdominal pain, flank ecchymoses, fractured ribs, and/or abdominal distension. Physical examination of a patient with penetrating trauma, particularly from GSW, can be misleading, however. As previously mentioned, the trajectory of a bullet often changes once inside the body and depending on the bullet, the internal destruction may be more severe than a small entrance wound may lead the examiner to believe.

Hematuria

Hematuria is among the most important findings in the initial evaluation of a patient with trauma to the urinary tract. Typically, a urine specimen should be obtained from the initial catheterized or clean catch specimen. A urinalysis demonstrating > 5 red blood cells per high-power field (RBCs/HPF), a positive urine dipstick, or gross hematuria should raise one's suspicion of renal trauma but is neither 100% sensitive nor specific. Santucci and McAninch demonstrated that the majority of cases of renal trauma do in fact present with hematuria, however, the degree of hematuria does not predict severity of the injury.[8] Additionally, Shariat et al found that hematuria was absent in 7% of Grade IV injuries in their series and Eastham et al reported that 9% of stab wound victims with renal injuries did not develop hematuria.[16,17]

Additional laboratory evaluation

In addition to continuous monitoring of the patient's vital signs and the appropriate urine studies, the physician should obtain several basic laboratory values as part of any trauma evaluation. Serial hematocrit levels should be ordered, if needed, to evaluate for persistent blood loss which may require blood products. A basic metabolic panel will be useful but the serum creatinine level will likely reflect the renal function prior to the trauma. Additional standard tests include coagulation profiles and a toxicology screen. These basic laboratory studies may prove to be critical in the subsequent management of the patient.

Classification of renal injury

In 1989, the American Association for the Surgery of Trauma's Organ Injury Scaling (AAST OIS) Committee

developed the first widely accepted severity scale for injures to the kidney. This was subsequently validated.[18-21] In 2009, a study was published to further classify renal injuries (AAST OIS Grade III or IV) causing persistent or life threatening bleeding that may be managed non-operatively.[22] The presence of a perirenal hematoma 3.5 cm or greater, intravascular contrast extravasation (ICE), and/or medial and lateral (complex) lacerations were found to increase the likelihood of intervention. Those with 2 or 3 risk factors were deemed Grade IVb or high risk and patients with Grade III injury but 2 or 3 risk factors were increased to Grade IVb. The authors concluded that Grade IVb injuries were more likely to benefit from intervention including angiographic embolization, renal repair or nephrectomy.

A subsequent analysis of 3,580 renal injuries from a single institution sought to revise Grade IV injuries to include all urinary collecting system injuries and segmental vascular injuries. It also revised Grade V injuries to include main renal artery and vein injuries (i.e., tear, avulsion, thrombosis). Despite reclassification, rates of nephrectomy remained unchanged.[23]

Indications for imaging renal trauma

The most recent genitourinary trauma guidelines indicate that clinicians should perform computed tomography (CT) with contrast (immediate and delayed images) in all stable blunt trauma patients presenting with gross hematuria or microscopic hematuria with a systolic blood pressure < 90 mm Hg.[24] Additionally, they recommend this imaging modality in stable patients with mechanisms of injury concerning for renal involvement. Such mechanisms include: rapid deceleration, rib fractures, penetrating abdominal injury, and/or significant flank ecchymosis. This allows for early detection and intervention of significant renal injuries.

Two studies in particular served as the basis for the above guidelines. The first study found that in 1,146 patients suspected of renal trauma, none of those who presented with microscopic hematuria without shock revealed significant renal injury.[25] Subsequently, McAninch et al analyzed 2,254 patients with hematuria and a history of blunt or penetrating renal injury and found that most renal trauma occurs via blunt mechanism (2,023/2254, 89.7%) but only three of those imaged were above a Grade I injury (3/584 imaged, 0.5%).[26] However, though penetrating renal trauma was a small proportion of patients (230/2254, 10.2%), a greater number of patients had significant renal injury (154/230, 67%).

Imaging modalities

Previously, intravenous urography (IVU) and renal arteriography were used as first line radiological methods in the hemodynamically stable patient.[11] Currently, the gold standard is a helical CT scan of the abdomen and pelvis with intravenous contrast and delayed images (10 minutes later).[24] Immediate imaging after contrast load allows for recognition of arterial extravasation; delayed images allow recognition of renal collecting system injuries. Furthermore, CT can assess pre-existing renal pathology as well as document the contralateral kidney and any associated organ injuries.

When an initial CT scan is not feasible due to hemodynamic instability, alternate imaging methods must be considered. Ultrasound can be utilized, often in the emergency department, because of its availability, rapid imaging, lack of radiation and non-invasive technique.[11] However, it is operator-dependent and lacks the detailed resolution of CT scan; this can result in a missed injury.[27] It may be an option in patients with documented allergy to intravenous contrast.

IVU can be considered as a second-line form of imaging in stable patients whose mechanism includes stab wound or blunt mechanism but not gunshot wounds.[11,28] Imaging must include nephrotomograms and visualization of the excretion of contrast into the renal pelvis and ureter.[11] If the renal contour is deformed, extravasation is seen or there is non-visualization of the pelvis and/or ureter, further evaluation should be considered with CT scan or angiography. IVU as a first-line study in patients with stab wounds near the kidney has been found to be 96% accurate for establishing the presence or absence of injury.[17]

In the operating room, one-shot IVU can be considered when the patient is undergoing exploratory laparotomy.[11] This can be used to visualize the extent of renal injury and confirm the function of the contralateral kidney. To perform IVU, a rapid bolus of contrast must be given with a plain abdominal x-ray obtained 10 minutes after injection. Visualization of injury may be impaired with extreme hypotension, massive fluid resuscitation, and/or organ edema.

As for renal arteriography, this should be an adjunct to CT scan.[11] Indications for this modality include suspected renal arterial thrombosis and segmental arterial lacerations or pseudoaneurysms where interventional radiological methods may be considered.[29] MRI is another method to image renal trauma, but no clear advantages have been found when

compared to CT.[30,31] However, like ultrasound, it may be considered in those with an allergy to intravenous contrast.

Management

Conservative management (non-operative or embolization)

Non-operative or expectant management of renal trauma has been supported in the literature for most blunt renal injuries, and, in some instances, penetrating injuries.[32] Accordingly, the most recent AUA urotrauma guidelines advocate that patients who are hemodynamically stable (i.e., vital signs not consistent with shock and stable serial hematocrit values over time) should be managed using non-invasive strategies.[24] For blunt parenchymal renal trauma, it is accepted that Grade I and many Grade II injuries be managed conservatively.[33] For Grade III and IV parenchymal injuries, most still favor a conservative approach unless hemodynamic instability is present. Management for Grade IV and V parenchymal injuries remains controversial, however. Over time, there has been a growing body of literature regarding the success of non-operative management in this population.

Grade IV and V renal injuries

Altman et al treated 6 of 13 patients with hemodynamically stable Grade V parenchymal injuries in a conservative fashion.[34] In the non-operative group, there were fewer intensive care unit days (4.3 versus 9.0), significantly lower transfusion requirements (2.7 versus 25.2 units), and fewer complications during hospitalization versus the operative group (4/6, 66.6% versus 7/7, 100%). While no deaths were reported in the non-operative group, there were three deaths and a patient requiring repeat exploratory laparotomy for gangrenous bowel in the operative group.

Buckley et al reviewed all Grade IV renal injuries at a single institution and compared outcomes of isolated Grade IV injuries to those with concomitant non-renal injuries.[35] Of the 153 total patients, 43 (28%) had isolated renal injuries. Nephrectomy rate was 15% (15/103) with an overall renal salvage rate of 84% (128/153). Blood transfusion requirements were significantly higher in those with isolated renal injuries requiring surgical intervention than those managed conservatively (8.5 units versus 2.6 units). However, average hospital stays were similar (11.8 versus 11.9).

The most recent study published by Van der Wilden et al in 2013 evaluated management strategies for 206 patients with Grade IV or V blunt renal injuries at Level I and Level II trauma centers in New England.[36] Of the 206 patients, 154 (74.8%) were managed non-operatively (25 received angiographic embolization). The kidney was preserved in 18/52 (34.6%) of the immediate operative patients, 135/142 (95.1%) of the successful non-operative management group, and 4 of 12 (33%) of the failed non-operative management group. Ten of the 12 failures were related to kidney injury. However, none of the 10 patients had complications due to conservative management. Persistent or recurrent hematuria was the most common complication in all patients (26/206 (12.6%)) followed by urinoma (21/206 (10.2%)).

Trauma from gunshot wound (GSW)

For penetrating renal trauma, there is a small amount of evidence that select patients may be managed conservatively. GSWs typically present with higher grade injury and thus necessitate higher rates of surgical exploration than blunt mechanisms.[37] Velmahos et al published a retrospective study of 52 consecutive patients with renal GSW.[38] Only renal injuries involving the hilum or signs of continued bleeding were surgically explored (32 of 52 patients). Of those that were explored, 17 required nephrectomy for Grade IV and V trauma. In total, only two patients had complications from their renal injury and the authors concluded that renal GSWs with stable hematomas did not require exploration.

Voelzke et al evaluated 201 patients (206 renal units) with renal GSW from a single institution.[37] Eighty-seven of the 210 patients (43.3%) presented in shock and 194 of 201 (96.5%) patients had concomitant injuries. Management included bed rest (51/201), exploration only (20/201), nephrectomy (30/201), or renal reconstruction (105/201). Only two patients managed conservatively had Grade IV trauma. The overall renal salvage rate was 85.4% (176/206 renal units), which the authors concluded was due to observation, partial nephrectomy or renorrhaphy. Surgically, getting early control of the main renal vessels, debriding surrounding parenchyma before reconstruction and an "aggressive attitude toward reconstruction" all contributed to the high renal salvage rate.

Trauma from renal stab wound

For renal stab wounds, Heyns et al published a prospective study of 54 patients with renal stab wounds and hematuria.[39] Patients were randomized to either surgery or non-operative management after it was established that there were no signs of severe blood loss, associated intra-abdominal injury or major abnormality on the excretory urogram. They

found that 78% of the patients randomized to the operative arm had minor injury without associated intra-abdominal lacerations and probably underwent an unnecessary operation. Pulmonary complications were higher in the operative group (33% versus 4%) and hospitalization was also longer for the operative group versus those observed (9 days versus 5 days).

Another study evaluated 95 patients with renal stab wounds.[40] Thirty-five patients (37%) were selected for surgical intervention as they presented with signs of severe blood loss, associated intra-abdominal injury or major abnormality on IVU. Sixty patients (63%) underwent non-operative management (bed rest, intravenous antibiotic for 24 hours and observation). Twelve of the 60 patients managed conservatively (20%) had renal complications consisting of secondary hemorrhage from an arteriovenous fistula (AVF) or pseudonaneurysm. Management of these complications included segmental artery embolization (n = 6), nephrectomy (n = 2), heminephrectomy (n = 1), open surgical ligation of the AVF (n = 1) and spontaneous resolution (n = 2). Mean duration of hospitalization was shorter in those who were observed (6.1 versus 9.9 days).

Bjurlin et al published a study in 2011 that evaluated both gunshot and renal stab wounds and the outcomes of non-operative management versus renorrhaphy and nephrectomy at a single institution (n = 97 patients with 98 renal injuries).[41] Of the penetrating injuries, 79 were GSWs (83%) and 16 were stab wounds (17%). Non-operative management was chosen for 40% of patients, renorrhaphy in 38% and nephrectomy in 22%. No patients with renal stab wounds required nephrectomy. Renal injuries that were managed conservatively had significantly lower incidence of transfusion (34% versus 95%), significantly shorter mean ICU stay (3 days versus 9 days), and significantly shorter mean hospital length of stay (7.9 days versus 18.1 days). Mortality rate was lower (0% versus 20%) compared with nephrectomy. There was no significant difference in these parameters between those managed conservatively and those managed with renorrhaphy.

Operative management

It is important to discuss management goals with the trauma team in addition to assessing the patient's hemodynamic status.[42] The guidelines state that immediate intervention with exploratory surgery or angioembolization must be performed in "hemodynamically unstable patients with no or transient response to resuscitation." The goals of this include control of bleeding, repair of the kidney when possible and establishment of perirenal drainage.[24] If a patient is undergoing exploratory laparotomy for associated intra-abdominal injuries, a conservative approach can often be taken for renal injuries as retroperitoneal bleeding from the kidney is usually contained within Gerota's fascia or the perirenal fascia.[42]

Absolute indications for renal exploration include persistent, life-threatening blood loss believed to be renal in origin and renal pedicle avulsion (as seen by a large, expanding, pulsatile hematoma).[11] Relative indications include a large laceration of the renal pelvis or avulsion of the ureteropelvic junction, co-existing bowel or pancreatic injuries, persistent urinary leakage, post-injury urinoma or perinephric abscess with failed percutaneous or endoscopic management, abnormal intraoperative one-shot IVU, devitalized parenchymal segment with associated urine leak, complete renal artery thrombosis of both kidneys or of a solitary kidney, renal vascular injuries after failed angiographic management, and renovascular hypertension. In general, inadequate preoperative staging with penetrating renal trauma and a retroperitoneal hematoma should be explored and repaired with intraoperative single-shot IVU utilized beforehand.

For urinary extravasation, concomitant major parenchymal laceration and > 20% nonviable parenchyma or co-existing bowel or pancreatic injuries may require operative repair.[11] Bowel or pancreatic injuries necessitate that the injured kidney be well drained. Separation of the urologic injury from the gastrointestinal injury by omentum or other tissue interposition isolates any urinary leak and minimizes inflammatory effects on adjacent organ repairs. However, another approach is to place external drainage and plan for complete management at a later time.[42] Urine leak is often sterile and does not pose as much of a risk as fecal contamination.

Penetrating bilateral renal injuries are rare. In a recent series, Schecter et al noted only six cases out of 3,529 (0.17%) at a single institution.[43] Preservation of renal parenchyma should be the main priority as at least 25% of parenchymal mass or 20% of total renal function is necessary to prevent dialysis. The authors stated that renal exploration is necessary in one or both kidneys if there is free hemorrhage into the peritoneal cavity, an expanding perirenal hematoma or exsanguination into the renal collecting system presenting as gross hematuria in the bladder.

Complications following renal trauma

Several complications may occur following the initial management of a patient with renal injury. In a study by Starnes et al, the overall incidence of kidney-related

complications excluding renal failure was 5.2%.[44] They found that those who underwent renorrhaphy were significantly more likely to develop local kidney-related complications than those that underwent nephrectomy, partial nephrectomy, and conservative management. Therefore, the authors caution that if renorrhaphy is performed, "this repair should be performed meticulously, with attention to precise suturing of any calyceal injury and good hemostasis."

Persistent urinary extravasation with urinoma formation is among the most common complications that develop following renal trauma, occurring in up to 7% of cases.[45] Clinical symptoms that may indicate the presence of a urinoma are worsening renal function, flank pain, decreased urine output, and fever and can be confirmed via CT scan.

The vast majority (75%-85%) of urinary extravasation will resolve spontaneously, however, those that persist may benefit from insertion of a ureteral stent or percutaneous drainage.[11,46] The most recent trauma guidelines advocate urinary drainage with complications such as enlarging urinoma, fever, increasing pain, ileus, infection or fistula.[24] If not drained, the perinephric fluid collection (urine or blood) may become secondarily infected resulting in abscess formation. Percutaneous drainage is often a successful first step, however, if the abscess becomes a complex multiloculated collection, open surgical evacuation may be necessary.[46]

The guidelines recommend performing a follow up CT scan after 48 hours in patients with AAST Grade IV-V renal injuries or clinical signs such as fever, progressive flank pain, ongoing anemia and/or abdominal distention.[24] Delayed hemorrhage typically occurs within the first few days after the initial injury, but it can present up to several weeks after renal trauma. It is usually associated with deeper penetrating injuries of the renal cortex and medulla.[11,39] Most often, delayed hemorrhage occurs secondary to arteriovenous fistulization (AVF) or pseudoaneurysm formation. Delayed bleeding can be seen in up to 25% of Grade III, IV or V renal injuries that are managed conservatively and can be treated successfully via angioembolization in the majority of cases.[11,39]

Another potential long term consequence of renal injuries is hypertension. Although the incidence is directly related to the severity of the injury, one large published series reported the mean rate of hypertension after renal trauma to be approximately 5%.[47] Once renovascular hypertension has developed, medical management may be attempted initially. For hypertension refractory to medical therapy, the current evidence for renal artery revascularization and decortication for Page kidney has been conflicting.[48,49] Ultimately, nephrectomy may be required to control severe refractory renovascular hypertension.

Conclusion

Renal injuries are a relatively common occurrence in the urotrauma setting and can range widely in severity depending on the mechanism of injury. Historical predilection for operative intervention in such cases has largely been replaced by conservative approaches in properly selected patients. Sequelae of a conservative approach have proven to be manageable with few long term debilitating side effects. Thus, while renal injuries can be potentially life endangering, early recognition and a coordinated team effort can prevent the need for nephrectomy in the vast majority of cases. □

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