Endovascular embolization in renal trauma: a narrative review

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Abstract: Approximately 1–3% of all trauma patients have a renal injury. Eighty percent of renal trauma is due to blunt injury, with the remainder due to penetrating trauma which is most often iatrogenic. Contrast enhanced computed tomography is used to triage patients and offers a quick and accurate assessment of any potential organ injury. If injury is present, The American Association for the Surgery of Trauma grading system can both grade renal injuries and be used to help guide management and intervention. Grades are assigned based on imaging and clinical features of renal trauma, and have prognostic and treatment implications for patients. The objective of this narrative review is to identify optimal management of patients with renal trauma, specifically which patients can be treated with endovascular interventions following renal trauma, which can be observed, and which would be best managed surgically. For hemodynamically stable patients with renal trauma, endovascular angiography and embolization is a non-invasive approach that can be used to control bleeding and potentially avoid surgery or nephrectomy in select cases. Future research is needed to determine if a specific antibiotic regimen is needed prior to or following embolization. Further research is needed to evaluate the effectiveness of endovascular management of high-grade renal trauma (grade V). Complications of renal embolization include short-term hypertension, long term hypertension in cases of significant ischemia, acute kidney injury, and infection.

Keywords: Renal trauma; renal artery embolization; shattered kidney; renal angiography

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Introduction

Approximately 1–3% of all trauma patients have renal injury (1,2). Eighty percent of renal trauma is due to blunt injury (1). Penetrating trauma is often iatrogenic (i.e., renal biopsy, partial nephrectomy, tumor ablation, and nephrostomy placement) but can be due to a gunshot wound or stabbing (3). After the spleen and liver, the kidney is the third most common intra-abdominal organ injured in the setting of trauma (4). While the majority of renal traumas can be managed conservatively, about 10% require embolization and 5% require nephrectomy (3). The purpose of this narrative review is to discuss the imaging findings of renal trauma, triage, treatment, and outcomes with a focus on endovascular interventions.

We present the following article in accordance with the Narrative Review reporting checklist (available at http://dx.doi.org/10.21037/atm-20-4310).

Methods

A literature search was conducted using PubMed (US National Library of Medicine, Bethesda, MD). No studies were excluded based on year of publication. Studies which investigated the imaging findings and management of renal

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trauma were included, with an emphasis on endovascular management. Search terms included: renal embolization, renal trauma, renal angiography, blunt abdominal trauma.

Imaging

Although hematuria is the most common sign of renal trauma, it may be absent, even in cases involving significant injury (5). Therefore imaging, specifically with contrast enhanced computed tomography (CT) is of paramount importance in the initial evaluation and triage of trauma patients with suspected renal injury and should be performed in all hemodynamically stable trauma patients. To accurately grade renal injuries, the CT protocol should include the full abdomen and pelvis with late-arterial or portal-venous phase (50–70 seconds after contrast injection). If renal injury is present on initial scans or there is clinical suspicion for injury to the collecting system, a urographic-phase CT (4–5 minutes after contrast injection) should be obtained to evaluate for urine leak (6-9).

Grading

The American Association for the Surgery of Trauma (AAST) CT grading system helps triage patients appropriately (10-12) (*Table 1*). The AAST Kidney Injury Scale ranges from mild (grade I) to severe (grade V). Grading is based primarily on the size of laceration(s) and the proximity to the renal hilum (11). Current AAST grading system does not account for active contrast extravasation from an injured blood vessel.

The World Society of Emergency Surgery (WSES) has

Table 1 Adaptation of the AAST renal injury grading system, with an emphasis on CT findings. Prior studies have reported that approximately 28–32% of renal injuries are grade I, 16–26% grade II, 19–22% grade III, 18–25% grade IV, and 4–9% grade V (2,12)

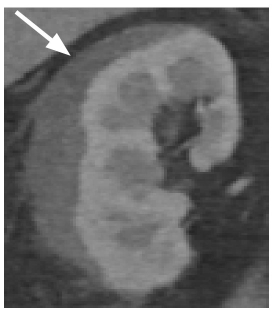
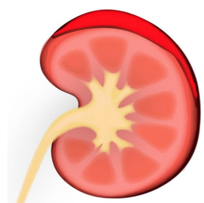
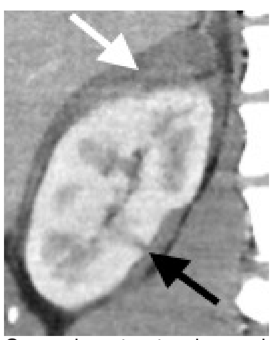
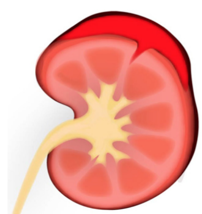
AAST renal injury grade	Grade description	CT findings	Schematic representation
I*	Subcapsular hematoma or contusion without laceration Microscopic or gross hematuria with normal imaging and urologic studies	 Coronal contrast-enhanced CT of the abdomen demonstrating a subcapsular hematoma surrounding the right kidney (white arrow) without laceration	 Perirenal hematoma without laceration
II*	Perirenal hematoma confined within the perirenal fascia Cortical laceration that is <1 cm in length No urinary extravasation	 Coronal contrast-enhanced CT demonstrating a 0.6-cm laceration (black arrow) and an adjacent hematoma confined to the retroperitoneum (white arrow)	 Laceration <1 cm with an adjacent hematoma confined by the perirenal fascia

Table 1 *(continued)*

Table 1 *(continued)*

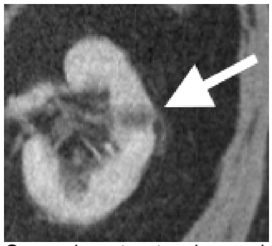
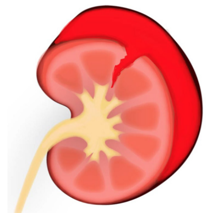
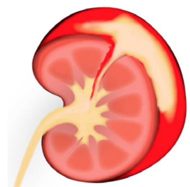
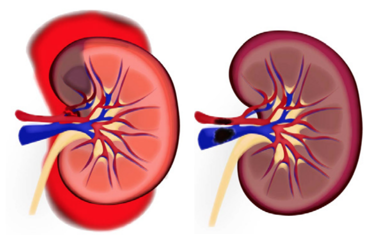
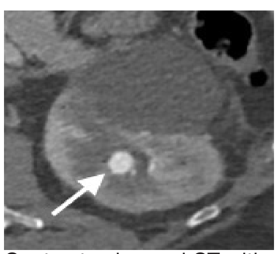
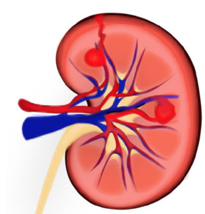
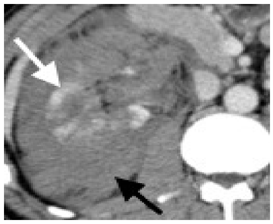
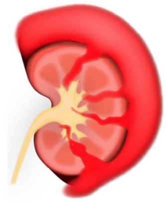
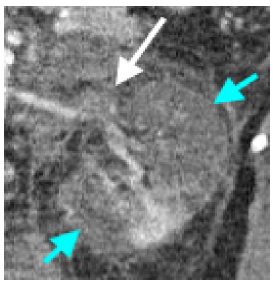
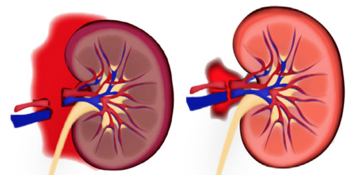
AAST renal injury grade	Grade description	CT findings	Schematic representation
III	Parenchymal laceration >1 cm without urinary extravasation Perirenal hematoma confined within the perirenal fascia	 Coronal contrast-enhanced CT demonstrating a 2.2-cm laceration and a small adjacent hematoma (white arrow)	 Laceration >1 cm with an adjacent hematoma which is confined by the perirenal fascia
IV	Parenchymal: parenchymal laceration that extends into the urinary collecting system and causes extravasation	 Axial urographic-phase CT with evidence of urine leaking outside of the collecting system (white arrow). Additionally, there is an adjacent hematoma extending beyond the perirenal fascia (blue arrow)	 Laceration which extends to the collecting system with a urine leak
	Vascular: segmental renal artery or vein injury with pseudoaneurysm, contained hemorrhage, vessel thrombosis, or partial vascular laceration; vessel thrombosis; evidence of renal vascular injury including infarct	 Coronal portal-venous phase CT demonstrating a renal laceration and segmental infarct (white arrow)	 Arterial injury that causes a segmental infarct with adjacent hematoma that extends beyond the perirenal fascia; Grade IV injury can also be a thrombus that causes renal infarct
	Hematoma: perirenal hematoma extending beyond the perirenal fascia	 Contrast enhanced CT with a focal segmental renal artery pseudoaneurysm (white arrow)	 Segmental renal artery pseudoaneurysm and/or AV fistula

Table 1 *(continued)*

Table 1 *(continued)*

AAST renal injury grade	Grade description	CT findings	Schematic representation
V	Parenchymal: shattered kidney	 Axial CT demonstrating a shattered kidney (white arrow) with an adjacent hematoma extending beyond the perirenal fascia (black arrow)	 Shattered kidney
	Vascular: main renal artery or vein with complete laceration or avulsion; devascularization of the kidney	 Contrast enhanced CT with injury to the renal vascular pedicle (white arrow) causing near complete infarct of the renal parenchyma (blue arrows)	 Vascular pedicle avulsion or a pseudoaneurysm (contained rupture) of the main renal artery or vein

*, advance by one grade for bilateral injuries up to grade III. CT, computed tomography; AAST, the American Association for the Surgery of Trauma.

Table 2 Adaptation of the WSES grading system. This system considers both the AAST grade and hemodynamic stability, with unstable patients with any grade of injury being classified as WSES grade IV

WSES grade	AAST	Hemodynamic stability
Minor (grade I)	I–II	Stable
Moderate (grade II)	III or segmental vascular injury	Stable
Severe		
Grade III	IV–V or parenchymal lesion with main vessel dissection/occlusion	Stable
Grade IV	I–V	Unstable

AAST, the American Association for the Surgery of Trauma; WSES, the World Society of Emergency Surgery.

an additional classification system which considers both the AAST classification and the patient's clinical status (*Table 2*).

Triage

The AAST renal injury grading can help triage patients for appropriate management. AAST grade I and II injuries are generally self-limited without long term sequela and can be observed (6,11). Patients are at risk for non-operative management failure when CT demonstrates active contrast extravasation from an injured blood vessel (6,13,14). Therefore, strong consideration should be given to endovascular embolization in patients whose imaging demonstrates vascular contrast extravasation even if the AAST grade is low. Hemodynamically stable patients with grade III and IV vascular injuries should be treated

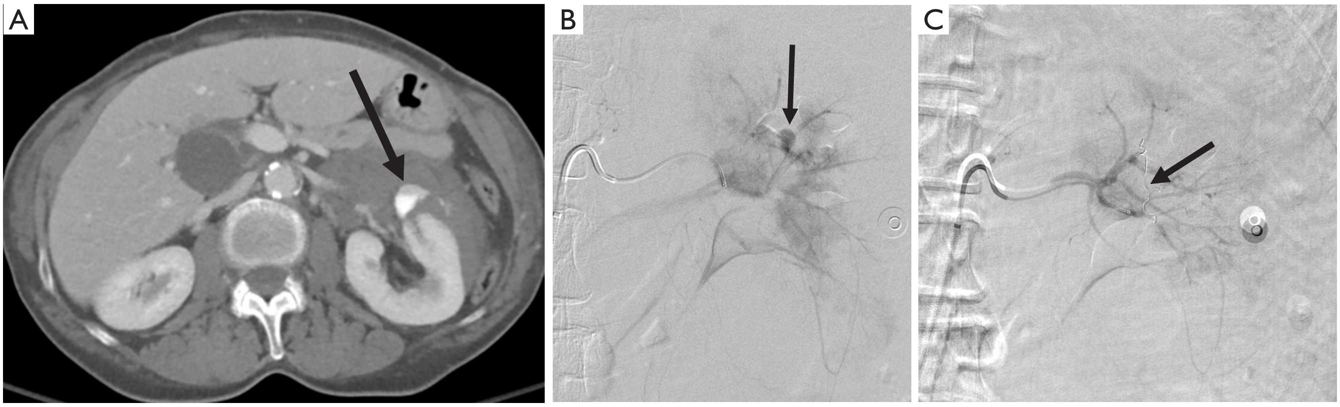


Figure 1 A 62-year-old female who was the driver of a pickup truck, which was struck by a train. Routine trauma CT was performed (A), and demonstrated a left kidney laceration with active extravasation of contrast (black arrow). The patient was taken to angiography (B), which demonstrated active extravasation (black arrow). Super-selective coil embolization (black arrow) was performed, which led to devascularization of the extravasating artery (C).

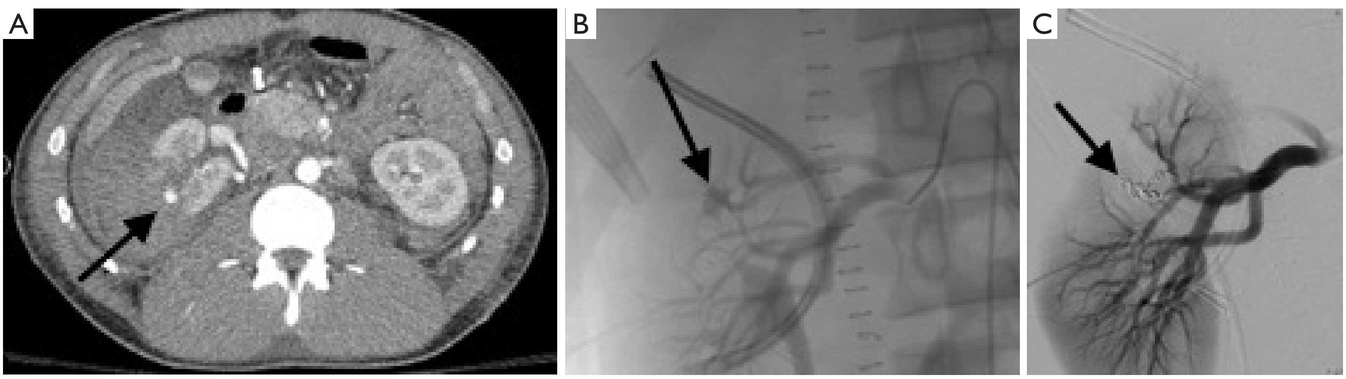


Figure 2 A 55-year-old male in a motor vehicle collision. Routine trauma scan demonstrated active extravasation of contrast from the right kidney (black arrow), consistent with renal artery injury (A). The patient was taken to angiography, which demonstrated active extravasation of contrast (black arrow) from an interlobar artery (B). Selective coil embolization was performed (black arrow) and final angiogram demonstrated cessation of contrast extravasation (C).

with selective embolization (*Figures 1,2*) (15-17). Vascular avulsion requires surgical treatment, including attempted revascularization if within the timeline for salvage of viable tissue (6,11). Patients can have preserved blood pressure despite significant blood loss when a perinephric hematoma causes Page kidney, wherein compression of segmental and subsegmental blood vessels leads to the activation of the renin-angiotensin system (*Figure 3*) (18).

Endovascular embolization technique

Aortogram, which can be done to evaluate the origin of renal arteries and the presence of accessory renal arteries, can be avoided if CT has been performed immediately prior. Transfemoral access is generally preferred. After placing a vascular sheath in the common femoral arteries, the renal artery is selected using a curved catheter, such as a Cobra-2, or a reverse-curve catheter, such as a SOS Omni Selective Catheter or Simmons (19). If a trans-radial approach is taken, a Judkins Right 5 (JR5) can be used (20). Selective angiography of the renal arteries is performed with an injection rate of 5–6 mL/s for 2–3 seconds (19). Microcatheter and microwires are then used to subselect the injured segmental or subsegmental artery; selective embolization is preferred, when possible, to preserve renal function as renal function can even be preserved

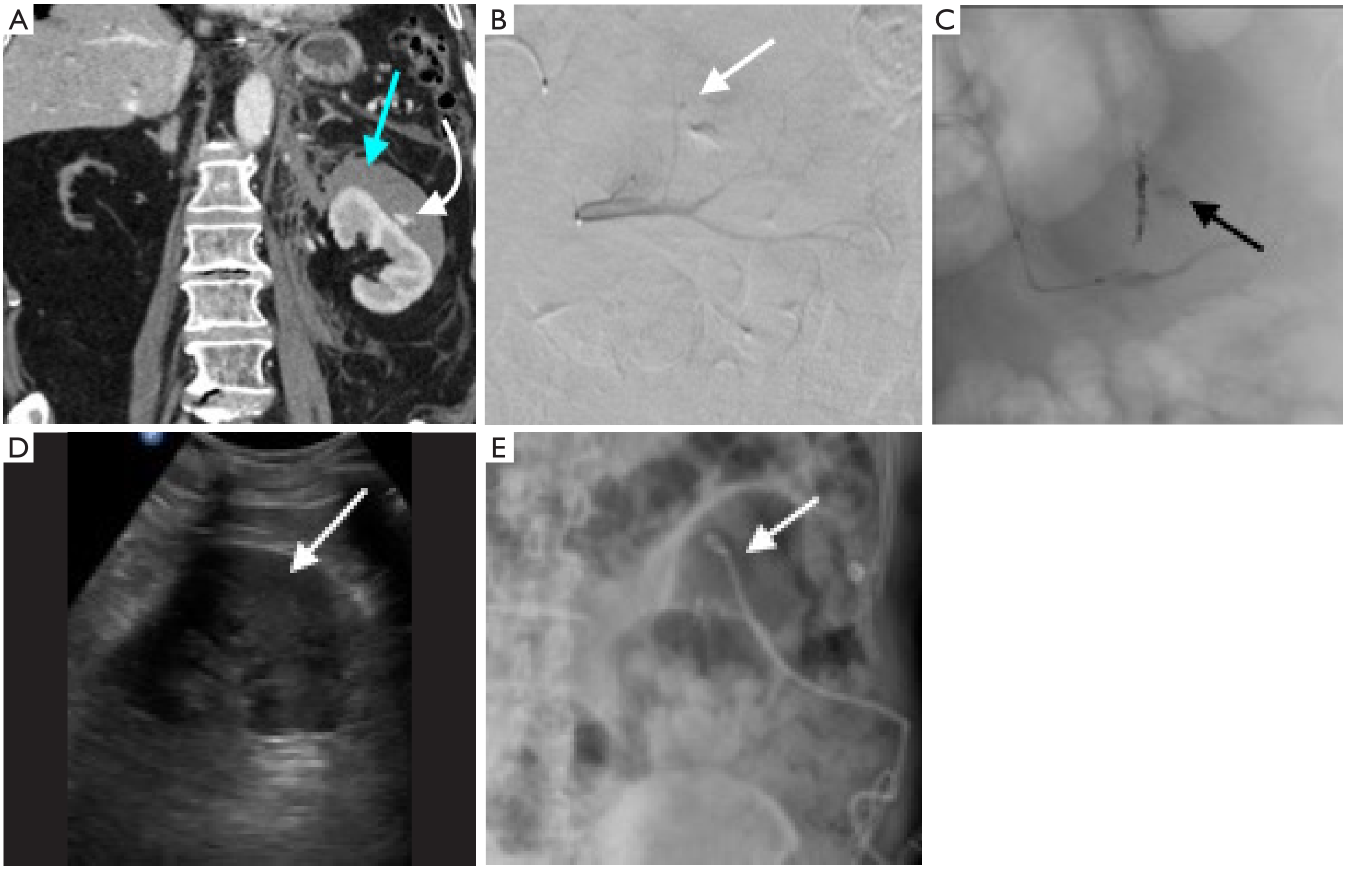


Figure 3 A 92-year-old male with a functionally solitary left kidney who presented to the emergency department after an unwitnessed ground-level fall. In the emergency department, his creatinine was 3.2 mg/dL, up from a baseline of 1.6 mg/dL, and his blood pressure was 212/122 mmHg. (A) CT scan of the abdomen and pelvis demonstrated a subcapsular hematoma compressing the kidney (blue arrow) with active extravasation of contrast (curved white arrow). (B) Selective angiography of the kidney demonstrated a focal pseudoaneurysm arising from an interlobar artery (white arrow). Super-selective coil embolization was performed. (C) Repeat angiography demonstrated pooling of contrast adjacent to the coiled pseudoaneurysm (black arrow) and complete devascularization of the affected interlobar artery. Given the clinical presentation of a Page kidney, attention was then turned to draining the subcapsular hematoma. (D) Ultrasound images demonstrated a subcapsular hematoma compressing the renal parenchyma (white arrow). An 8.2-French multipurpose drain was placed in the subcapsular hematoma. (E) Post-procedure abdominal radiograph demonstrates coils within the kidney and a well-positioned pigtail drain superior to the renal parenchyma (white arrow).

in patients with grade IV lacerations (4,6). In cases of a shattered kidney without renal hilum avulsion, a proximal embolization of the main renal artery can be used as a non-surgical alternative to nephrectomy (*Figure 4*) (6,21-24). In cases of complete vascular pedicle avulsion, embolization is contraindicated and the patient should be managed operatively (25,26). Embolization is most often performed with gelfoam and/or coils. Gelfoam and other particles should be avoided when there is an arterio-venous fistula present due to risk of pulmonary embolism (*Figure 5*). If no vascular injury can be identified at angiography (*Figure 6*) embolization should not be performed (6). Trauma to the main renal artery that requires revascularization, such as dissection or occlusion, can be treated with percutaneous procedures using stents (27). Ideal patients for this type of intervention are hemodynamically stable with an ischemic kidney time of under 3 hours (3,6,28,29).

Outcomes

When arterial injury is identified by angiography and technically successful embolization is performed, reported

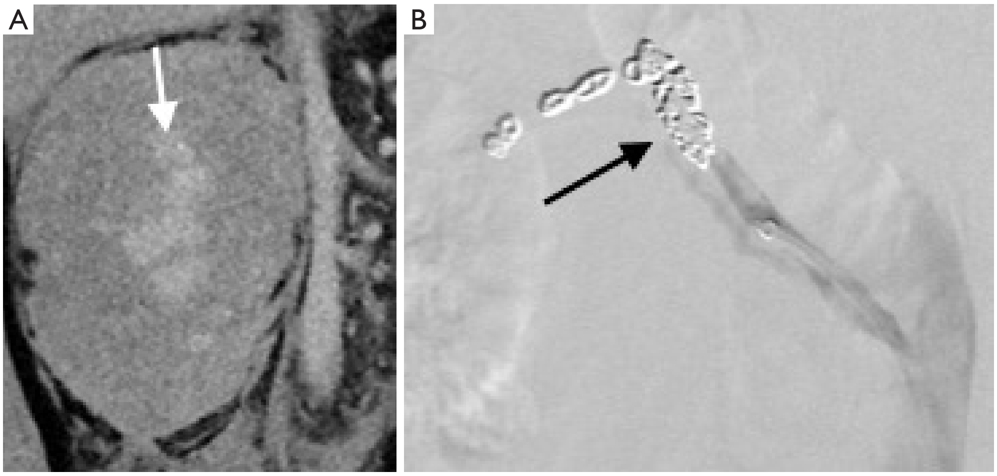


Figure 4 A 64-year-old male involved in a high-speed motor vehicle collision. Contrast-enhanced coronal CT (A) demonstrated a shattered kidney (white arrow) and a main renal artery vascular injury (not shown). The patient was taken to angiography (B) and the proximal main renal artery was embolized with coils (black arrow).

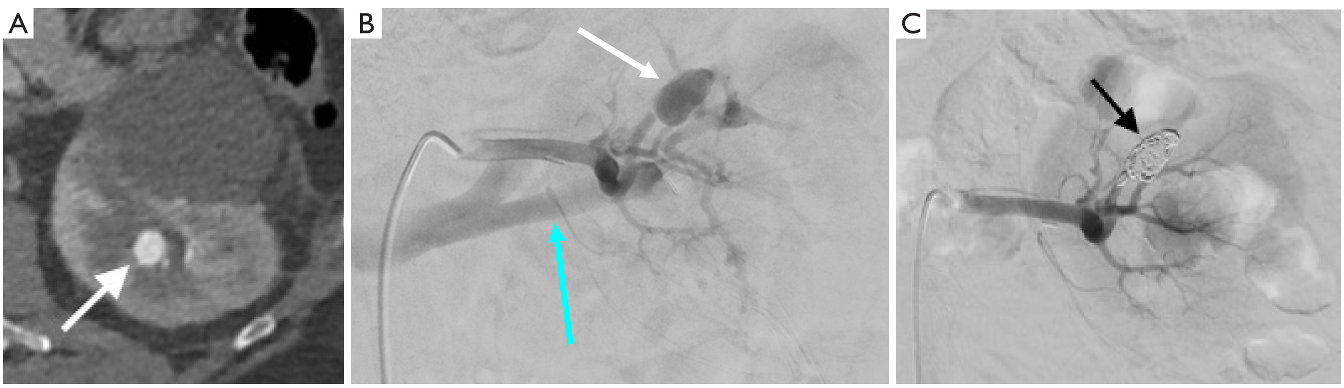


Figure 5 A 56-year-old male with a history of clear cell RCC who was 1 day post-partial nephrectomy who presented with gross hematuria. Contrast enhanced CT (A) demonstrated a pseudoaneurysm near the nephrectomy margin (white arrow). (B) Angiogram demonstrated combined pseudoaneurysm (white arrow) and arteriovenous fistula confirmed by early filling of the main renal vein (blue arrow). (C) The patient was treated with coils only (black arrow), as particle embolization is contraindicated in cases of arteriovenous fistula. RCC, renal cell carcinoma; CT, computed tomography.

success rates of non-operative management ranges from 63–100%, with the vast majority of clinical failure following embolization observed in AAST grade V renal injury (6,15,30-35). One study showed a low initial rate of embolization success (63%), but when repeat embolization was performed the clinical success rate increased to 95% (33). That study reported markedly different results when compared to others which showed between 94.4–100% initial clinical success rates of non-operative management for stable patients with AAST grade IV and V renal injuries when triaged to embolization (32,34-38).

Pediatric patients with blunt abdominal trauma and evidence of vascular injury on CT have a very high success rate when treated with angiography and embolization (reported up to 100%) and a low morbidity rate (39-41). Given these success rates, angiography and selective angioembolization is considered a first line treatment; hemodynamically borderline pediatric patients can be treated with embolization when appropriate surgical backup is available (6,39-41).

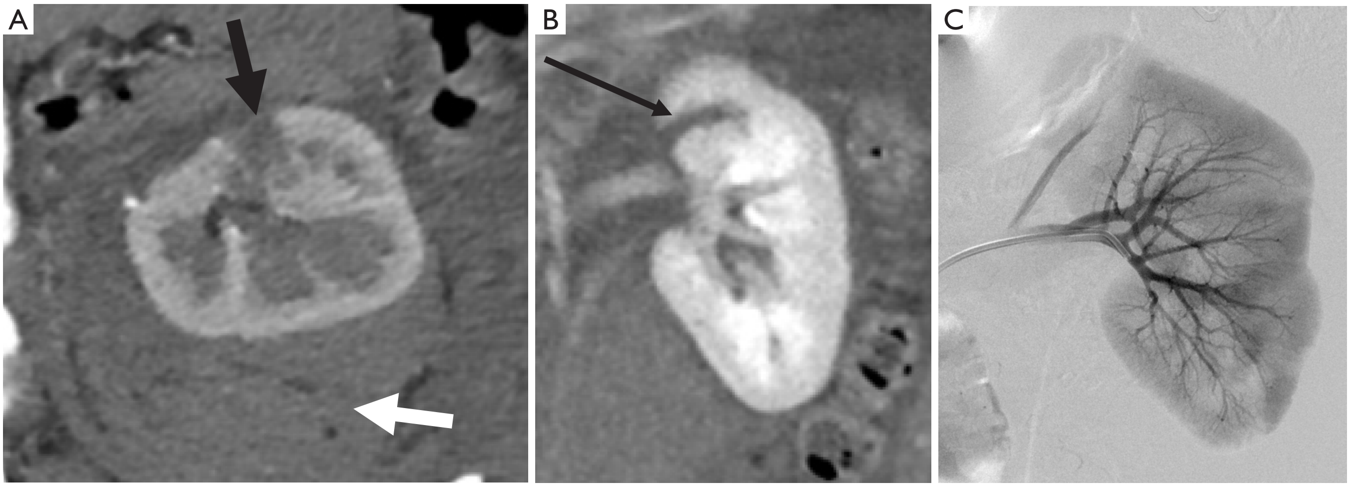


Figure 6 A 17-year-old male with left flank pain following a motor vehicle collision. Axial (A) and coronal (B) CT of the abdomen and pelvis with a left renal laceration measuring approximately 1.5 cm (black arrows), and an adjacent perinephric hematoma (white arrow), consistent with a AAST grade III renal injury (A,B). The patient was taken to angiography; however, no focal extravasation or vascular injury was appreciated (C) and no embolization was performed. Despite the CT findings, up to 32% of blunt renal trauma with evidence of extravasation on CT imaging are negative at the time of angiogram. CT, computed tomography; AAST, the American Association for the Surgery of Trauma.

Complications

Renal embolization can lead to short-term hypertension due to activation of the renin-angiotensin system, and may persist if embolization results in significant ischemia (42). Decrease in renal function can be caused by a variety of factors including contrast-induced nephropathy, especially in those with pre-existing renal insufficiency, older patients and those with diabetes, parenchymal tissue loss from the trauma, and non-selective embolization (43). While current Society of Interventional Radiology (SIR) guidelines do not include a recommendation for antibiotics prior to renal embolization, infection can occur if there is a large perinephric hematoma (*Figure 7*) or if non-selective embolization is performed (44). Cefazolin has been shown to reduce the risk of infection and should be considered in these scenarios (44,45).

Discussion and summary

Renal trauma is most commonly seen in the setting of blunt abdominal injury but can also be seen with penetrating injury, which is often iatrogenic in etiology. Hemodynamically stable patients with significant blunt or penetrating trauma should be evaluated with contrast-enhanced CT. If renal injury is suspected based on mechanism, hematuria or abnormality seen on initial images, a delayed excretory phase CT should be obtained to evaluate for urinary collecting system injury (7). Observation should be the treatment of choice for all hemodynamically stable or stabilized minor (AAST I–II) renal injury when no vascular contrast extravasation is seen. Hemodynamically stable patients with moderate (AAST III) and severe (AAST IV–V) injuries, when there is no other indication for surgery, should be managed with selective embolization, which is safe and highly effective (6). Hemodynamically unstable patients with high grade injury should undergo emergent nephrectomy (6). Embolization is typically performed with coils and/or gelfoam. Proximal or main renal artery injury can be treated with stent and/or stent graft in selected cases. Endovascular embolization has few large prospective trials, and thus this review is limited by the lack of current evidence. Smaller retrospective trials are promising, however larger prospective trials are needed to further refine indications and expected outcomes for the endovascular treatment of renal trauma. Further trials are also needed to investigate the best practices for antibiotic use in the setting of renal embolization.

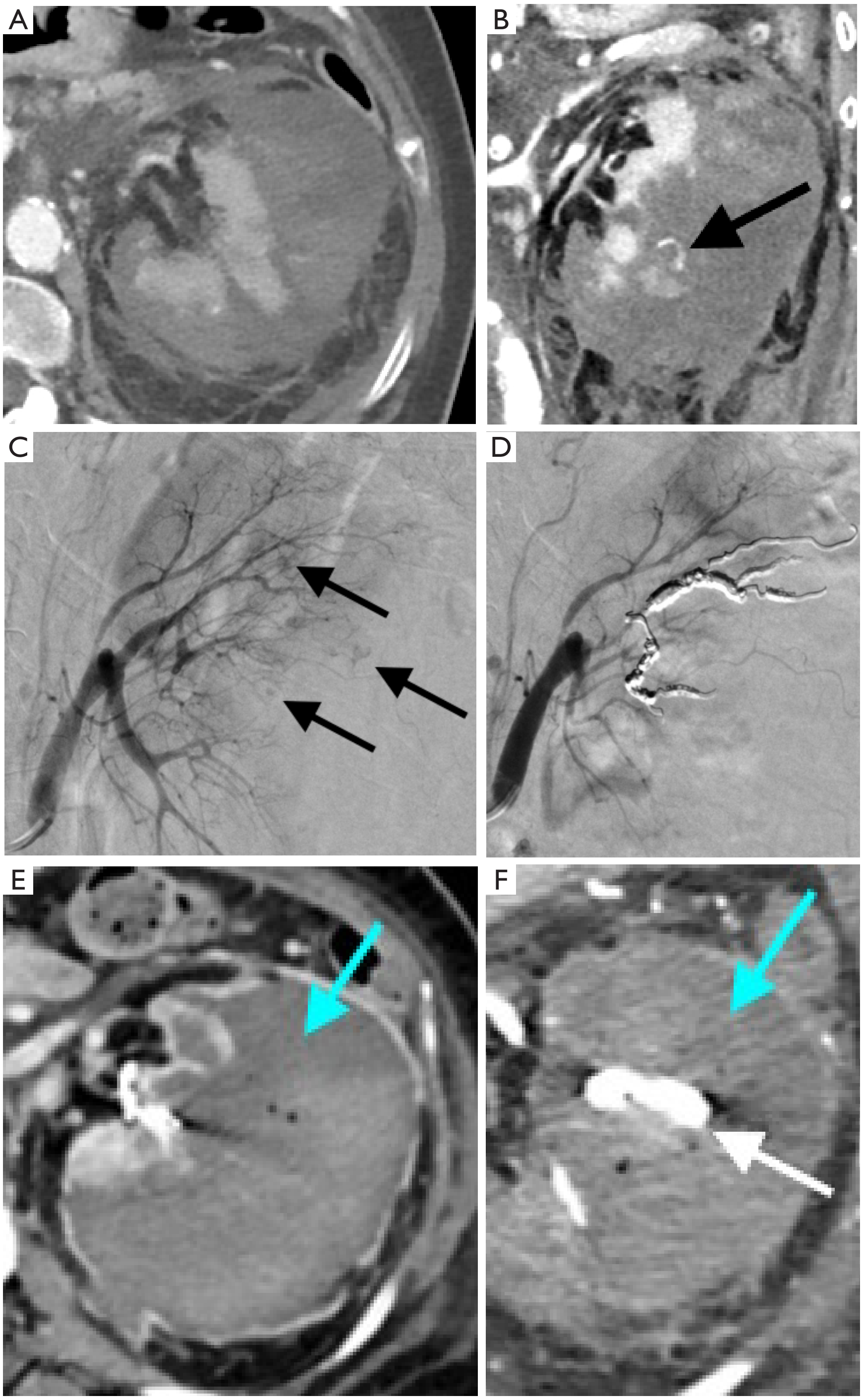


Figure 7 A 65-year-old female who presented following a high-speed motor vehicle collision. Contrast-enhanced CT scan demonstrated multiple deep lacerations extending to the renal collecting system with areas of active extravasation (black arrow) and a large hematoma, consistent with AAST grade IV injury (A, axial; B, coronal). Patient was deemed to be not a surgical candidate and therefore emergent embolization was performed. Angiography (C) demonstrated multifocal contrast extravasation (black arrows). Multiple selective coils were placed, and post-embolization angiography demonstrated resolution of contrast extravasation (D). Post-procedure course was complicated by an infected perinephric hematoma (blue arrows), which required drain placement (white arrow) (E,F). CT, computed tomography; AAST, the American Association for the Surgery of Trauma.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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