

Western Trauma Association Critical Decisions in Trauma: Management of renal trauma

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Renal injury may be discovered during computed tomography (CT) scan for evaluation of trauma or during operative exploration as a zone II retroperitoneal hematoma. Most injuries are lower grade and can be managed without operative or angiographic intervention. This algorithm presents a practical approach for the management of both blunt and penetrating renal injuries and is presented as two components, one for renal injury discovered at the time of CT scan (Fig. 1) and the other for management of zone II retroperitoneal hematoma identified during a laparotomy (Fig. 2).

HEMODYNAMIC INSTABILITY

Hemodynamic instability and grade of injury are the primary factors driving the management of renal injuries. A hemodynamically stable patient with a renal injury may be managed in a systematic fashion as outlined in the sections below. However, hemodynamic instability changes the approach to renal trauma completely. A patient who is hemodynamically unstable, after either blunt or penetrating trauma, warrants laparotomy. A hemodynamically unstable patient with a zone II retroperitoneal hematoma, after either blunt or penetrating trauma, needs exploration of the retroperitoneum. Persistent hemodynamic instability due to a high-grade renal injury is a contraindication to renal salvage, and the patient should undergo a nephrectomy rather than prolonged attempts to save an injured kidney.

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INJURY GRADING

The management of renal injuries is driven primarily by the hemodynamic status of the patient; however, the grade of renal injury also plays a significant role in treatment strategy. The most commonly applied renal injury grading system is the American Association for the Surgery of Trauma–Organ Injury Scale, shown in Table 1, that was originally published in 1989.¹ This grading system includes five grades of injury (I–V) and the most obvious distinction of low-grade versus high-grade injury is an injury beyond the extent of the renal cortex and extending into the urinary collecting system and renal vasculature. Grades I to Grade III include injuries confined to the capsule and/or renal parenchyma, while grade IV includes injury to collecting system and/or renal vascular injury and Grade V includes a completely shattered kidney or avulsion of the renal hilum with a devascularized kidney. The American Association for the Surgery of Trauma–Organ Injury Scale for renal injuries has been shown to correlate with interventions, complications, and mortality.^{2–4} Grade IV injuries have been subcategorized as low risk or high risk for intervention (angiographic or operative) with risk factors including size of perirenal hematoma, contrast extravasation, and location of the renal laceration.⁵

GRADES I-III INJURY DISCOVERED ON CT SCAN

Most renal injuries discovered during CT scan of the abdomen will be of lower grade. In a large, multicenter trial of renal injuries, 64% were Grade I, 25% were Grade II or III, 8% were Grade IV, and 3% were Grade V.⁶ Nearly 100% of low-grade (I–III) injuries discovered on CT scan can be managed without surgical or angiographic intervention. Once a patient is found to have a renal injury on the initial CT scan, they should routinely undergo delayed imaging in the same setting to better evaluate for contrast extravasation from either the vasculature or collecting system. In the infrequent occasion, where there is evidence of intravenous contrast extravasation on CT scan, the patient may be a candidate for angiography and embolization (see section F).

GRADE IV AND V INJURIES DISCOVERED ON CT SCAN

Grades IV and V renal injuries discovered on CT scan present a more complex set of decision making that may require intervention, but usually in a delayed fashion. In addition to a renal parenchymal injury, grade IV renal injuries include either an

RENAL INJURY FOUND ON CT SCAN

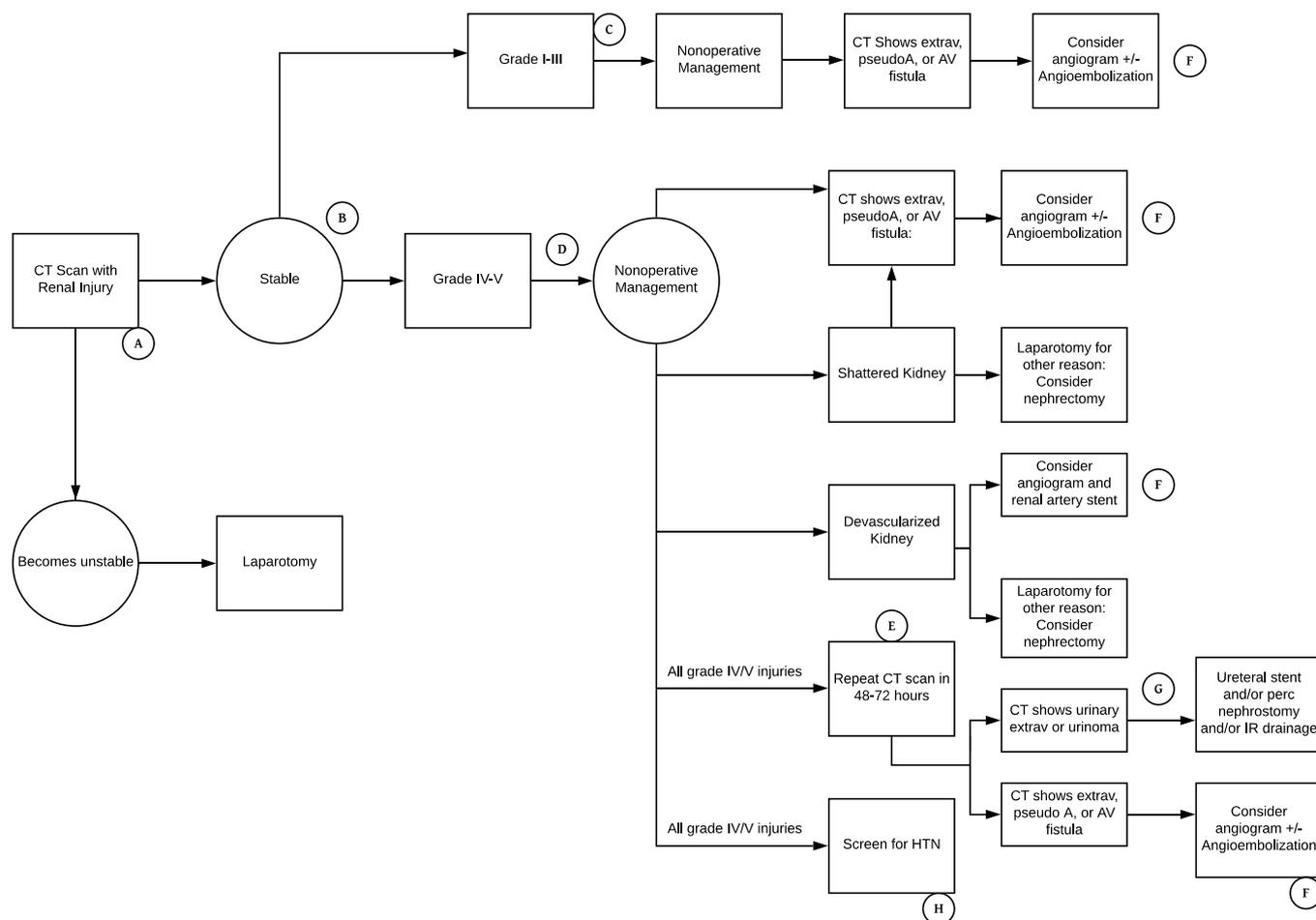


Figure 1. Algorithm for the management of renal injury discovered on CT scan.

associated collecting system or vascular injury. Grade V injuries include a completely shattered kidney, a renal hilum avulsion, or a devascularized kidney. It may be difficult to distinguish a Grade IV versus Grade V injuries on CT scan, but the management principles remain the same. Despite representing the highest grades of renal injury, Grades IV and V renal injuries can still be managed nonoperatively in the majority of cases. A patient known to have a completely devascularized kidney (after 72 hours) who has been managed nonoperatively but undergoes laparotomy for another reason may have the injured kidney removed to avoid the late sequela renovascular hypertension. Considerations, such as repeat CT scan, the role of angiography, management of urinary extravasation, and long-term screening for hypertension are discussed further in the following sections.

REPEAT CT SCAN

Patients with higher-grade (IV-V) renal injuries, who are managed nonoperatively (including patients who underwent angiographic intervention), should undergo a repeat CT scan (including delayed images) of the abdomen 48 hours to 72 hours after injury to evaluate the progression of the injury and the need

for potential intervention.^{6,7} These scans may reveal arterial, venous, or urinary extravasation that could require additional treatment. In addition, patients with clinical deterioration attributable to the renal injury (e.g., fever, worsening flank pain, ongoing blood loss, abdominal distention, new or worsening hematuria) should undergo a repeat CT scan.⁷

ANGIOGRAPHY

Angiography and angioembolization or stenting of the renal artery may be useful tools for hemodynamically stable patients with Grades IV and V renal injuries and are found to have associated contrast extravasation, pseudoaneurysm, or AV fistula seen on either initial or follow-up CT scan.⁸⁻¹⁰ Though used infrequently in the management of renal injuries, several studies have shown an improvement in the success rates of nonoperative management of renal injuries with the inclusion of angiography and angioembolization or stenting.^{10,11}

URINARY EXTRAVASATION

Urinary extravasation is the most common complication after renal trauma, and urinomas may occur in as many as 7%

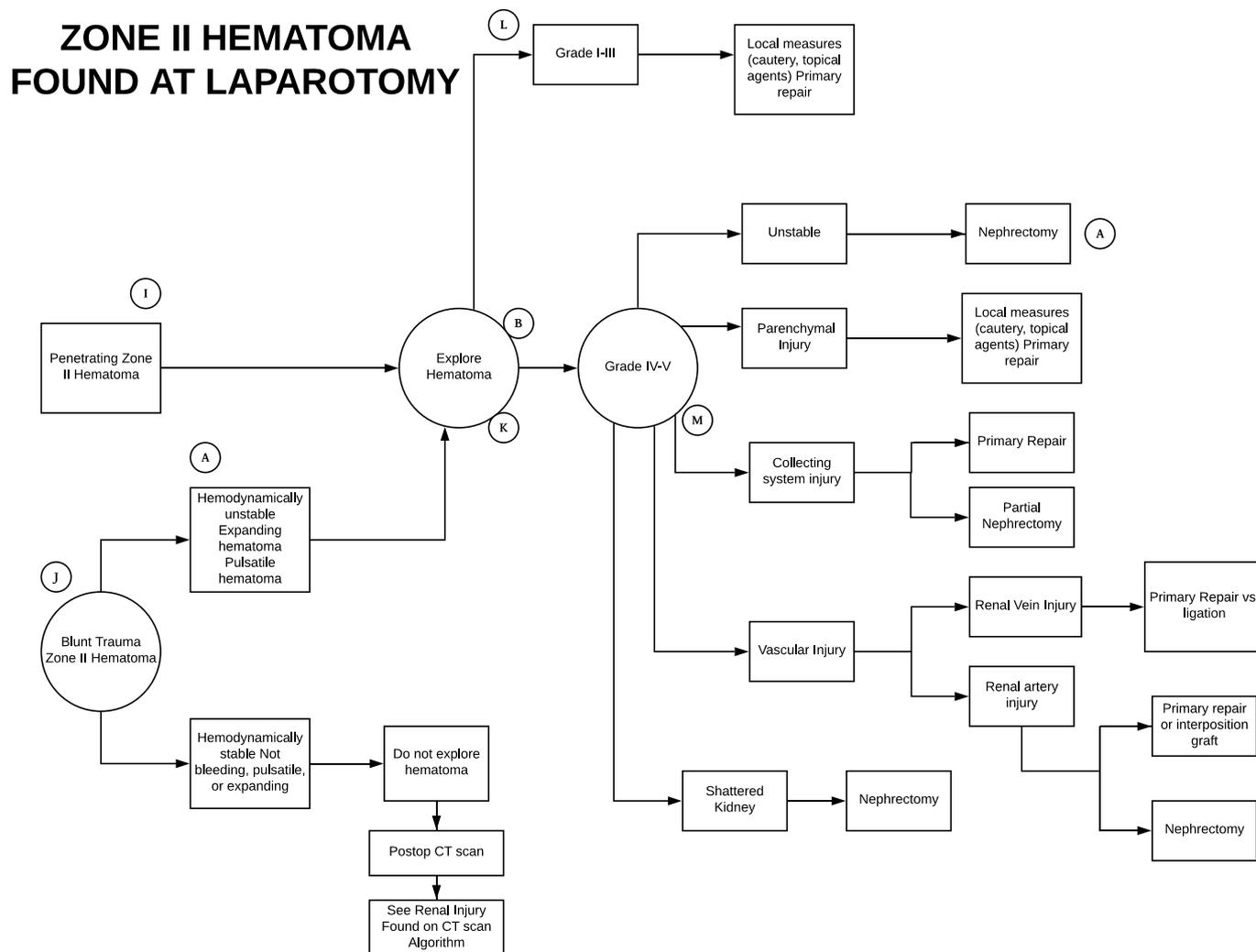


Figure 2. Algorithm for the management of zone II hematoma and renal injury discovered at laparotomy.

of the cases of renal injuries.^{9,12} Urinary extravasation puts the patient at risk for infection and persistent urine leak.⁹ Urinary leaks and urinomas may be observed or may be treated with a combination of minimally invasive techniques, including bladder catheterization, vesicoureteral stenting, and percutaneous drainage or nephrostomy.^{7,13}

HYPERTENSION

Arterial hypertension may occur after nonoperative management of high-grade renal injuries and has been reported to occur in 5% to 40% of the patients.^{14,15} The etiology of hypertension may be the result of injury to or compression of the renal artery leading to elevated renin release (Goldblatt kidney), direct compression of the renal parenchyma from a surrounding hematoma (Page kidney), or from an arteriovenous fistula formation.⁹ After discharge, all patients with high-grade (Grades IV and V) renal injuries should be screened for hypertension. Many cases of renovascular hypertension after trauma can be managed medically. However, some cases may require delayed surgical intervention (nephrectomy) for treatment of refractory hypertension.⁹

ZONE II HEMATOMA AFTER PENETRATING TRAUMA

In general, retroperitoneal hematomas after penetrating trauma should be explored to identify and treat underlying visceral and vascular injuries that cannot be appreciated with an intact retroperitoneum. Routine exploration for a penetrating injury to zone II of the retroperitoneum is an acceptable approach, because the underlying renal vasculature, collecting system, and ureter are at risk of injury from the penetrating mechanism. However, in a hemodynamically stable patient with a lateral zone II hematoma after penetrating injury, the hematoma may be left intact as the renal vasculature, collecting system, and ureter are all medial structures and should not be at risk of injury. If the zone II hematoma is not explored, the patient should undergo a postoperative CT scan to evaluate the extent of injury.

ZONE II HEMATOMA AFTER BLUNT TRAUMA

Most lower-grade renal injuries will not be readily apparent at laparotomy. Instead, the first indication that a renal injury exists will be the presence of a zone II (lateral) retroperitoneal

TABLE 1. American Association for the Surgery of Trauma Renal Organ Injury Scale¹

Grade	Description
I	Contusion: Microscopic or gross hematuria, urologic studies normal Hematoma: Subcapsular, nonexpanding without parenchymal laceration
II	Hematoma: Nonexpanding perirenal hematoma confined to retroperitoneum Laceration: <1.0 cm parenchymal depth of renal cortex without urinary extravasation
III	Laceration: >1.0 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation
IV	Laceration: Parenchymal laceration extending through the renal cortex, medulla, and collecting system Vascular: Main renal artery or vein injury with contained hemorrhage
V	Laceration: Completely shattered kidney. Vascular: Avulsion of renal hilum which devascularizes Department of Surgery the kidney.

hematoma. In the hemodynamically stable blunt trauma patient, a zone II hematoma may be left undisturbed if it is not ruptured and freely bleeding, pulsatile, or expanding after a period of observation. Hemodynamically stable patients who do not have a zone II hematoma explored should undergo postoperative CT scan to evaluate the type and severity of renal injury. For any hemodynamically unstable patient without another source of acute blood loss or a patient with a zone II hematoma that is ruptured and actively bleeding, pulsatile, or expanding, the retroperitoneum and kidney should be explored.

ZONE II HEMATOMA EXPLORATION

Prior to exploring a zone II hematoma for suspected renal injury, the surgeon should palpate the contralateral kidney to make sure it is not absent, atrophic, or polycystic. If the contralateral kidney feels normal, the surgeon can be reasonably reassured that it is safe to proceed with a nephrectomy of the injured kidney if necessary. Once the decision has been made to explore a zone II hematoma, the surgeon has two options for exposure, the medial approach or the lateral approach.¹⁶ The medial approach isolates the renal artery and vein prior to mobilization of the kidney, whereas the lateral approach completely mobilizes the kidney prior to controlling the renal hilum. Both approaches have risks and benefits and the approach to a particular case should be individualized to the patient and the skill set of the operating surgeon. The medial approach requires careful dissection of the renal hilum to identify, isolate, and control the renal vessels, and thus takes significantly longer to accomplish. This approach may also be more difficult or impossible in the patient with a large hematoma that is covering the renal hilum and distorting the local anatomy. In general, the medial approach can be applied in the stable patient who is not actively bleeding, while the lateral approach is preferred in the patient who is actively bleeding and time is of the essence. Once the kidney has been mobilized, bleeding can be easily controlled with manual compression of the hilum or entire kidney, allowing time for injury evaluation and planning.

GRADES I TO III INJURY DISCOVERED AT LAPAROTOMY

Lower-grade (I-III) renal injuries involve only parenchymal disruption, while the collecting system and vasculature remain intact. If after retroperitoneal exploration a low-grade renal injury is encountered, the operative repair should be simple and straightforward.^{6,9,12,16,17} Devitalized tissue should be debrided and hemostasis of the raw parenchyma can be achieved with cautery or topical hemostatic agents, and larger vessels may be suture ligated with absorbable suture. The capsule is usually easily reapproximated over the injured area. If the capsule cannot be closed, omentum may be applied to the raw surface.

GRADES IV AND V INJURIES DISCOVERED AT LAPAROTOMY

Higher-grade injuries discovered during retroperitoneal exploration will likely require a more complex reconstruction or a nephrectomy. In an unstable patient, a complex renal repair should not be attempted, and the patient should undergo nephrectomy. However, in stable patients without associated life-threatening injuries, a kidney-preserving repair should be performed.^{16,17} Parenchymal injuries can be managed in the same fashion as lower-grade renal injuries. Collecting system injuries can be repaired primarily with absorbable suture and should be water tight. If an injury involving the collecting system is on either the superior or inferior pole, a partial nephrectomy can be performed. A pedicle of omentum may be used to buttress any renal repair or partial resection. A renal vein injury can be repaired if the repair will not compromise the lumen more than 50%, otherwise, a venous injury should be ligated. There are several options for treating a renal artery injury including primary repair, primary anastomosis, reversed saphenous vein interposition graft, and vascular shunt. Because renal vascular injuries are rare, there is a paucity of literature to guide management, the decision to perform a complex renal arterial repair should be based on the status of the patient, associated injuries, ischemic time to the kidney, and the skill set of the operating surgeon. Nephrectomy is always an option for a patient with a renal vascular injury and a normal contralateral kidney.

AUTHORSHIP

C.V.R.B. participated in the literature review. C.V.R.B., H.A., K.B., C.H., M.dM., M.M., E.E.M., S.R., G.V., K.I. participated in the study design. C.V.R.B., H.A., K.B., C.H., M.dM., M.M., E.E.M., S.R., G.V., K.I. participated in the data interpretation. C.V.R.B. participated in the writing. C.V.R.B., H.A., K.B., C.H., M.dM., M.M., E.E.M., S.R., G.V., K.I. participated in the critical revision.

DISCLOSURE

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REFERENCES

- Moore EE, Shackford SR, Pachter HL, McAninch JW, Browner BD, Champion HR, Flint LM, Gennarelli TA, Malangoni MA, Ramenofsky ML, et al. Organ injury scaling: spleen, liver, and kidney. *J Trauma*. 1989;29:1664-1666.
- Kuan JK, Wright JL, Nathens AB, Rivara FP, Wessells H. American Association for the Surgery of Trauma Organ Injury Scale for kidney injuries

predicts nephrectomy, dialysis, and death in patients with blunt injury and nephrectomy for penetrating injuries. *J Trauma*. 2006;60:351–356.

3. Shariat SF, Roehrborn CG, Karakiewicz PI, Dhami G, Stage KH. Evidence-based validation of the predictive value of the American Association for the Surgery of Trauma kidney injury scale. *J Trauma*. 2007;62:933–939.
4. Tinkoff G, Esposito TJ, Reed J, Kilgo P, Fildes J, Pasquale M, Meredith JW. American Association for the Surgery of Trauma Organ Injury Scale I: spleen, liver, and kidney, validation based on the National Trauma Data Bank. *J Am Coll Surg*. 2008;207:646–655.
5. Dugi DD 3rd, Morey AF, Gupta A, Nuss GR, Sheu GL, Pruitt JH. American Association for the Surgery of Trauma grade 4 renal injury substratification into grades 4a (low risk) and 4b (high risk). *J Urol*. 2010;183:592–597.
6. Zinman LN, Vanni AJ. Surgical management of urologic trauma and iatrogenic injuries. *Surg Clin North Am*. 2016;96:425–439.
7. Morey AF, Brandes S, Dugi DD III, Armstrong JH, Breyer BN, Broghammer JA, Erickson BA, Holzbeirlein J, Hudak SJ, Pruitt JH, et al. Urotrauma. *American Urological Association Clinical Guideline 2014*; Amended 2017. [http://www.aauanet.org/guidelines/urotrauma-\(2014-amended-2017\)](http://www.aauanet.org/guidelines/urotrauma-(2014-amended-2017)), accessed 10/7/17.
8. Serafetinides E, Kitrey ND, Djakovic N, Kuehhas FE, Lumen N, Sharma DM, Summerton DJ. Review of the current management of upper urinary tract injuries by the EAU trauma guidelines panel. *Eur Urol*. 2015;67:930–936.
9. Johnsen NV, Betzold RD, Guillaumondegui OD, Dennis BM, Stassen NA, Bhullar I, Ibrahim JA. Surgical management of solid organ injuries. *Surg Clin North Am*. 2017;97:1077–1105.
10. Chow SJ, Thompson KJ, Hartman JF, Wright ML. A 10-year review of blunt renal artery injuries at an urban level I trauma centre. *Injury*. 2009;40:844–850.
11. Wright JL, Nathens AB, Rivara FP, Wessells H. Renal and extrarenal predictors of nephrectomy from the national trauma data bank. *J Urol*. 2006;175(3 Pt 1):970–975.
12. de Costa IA, Amend B, Stenzl A, Bedke J. Contemporary management of acute kidney trauma. *J Acute Dis*. 2016;5:29–36.
13. Alsikafi NF, McAninch JW, Elliott SP, Garcia M. Nonoperative management outcomes of isolated urinary extravasation following renal lacerations due to external trauma. *J Urol*. 2006;176:2494–2497.
14. Pereira Júnior GA, Muglia VF, Dos Santos AC, Miyake CH, Nobre F, Kato M, Simões MV, de Andrade JJ. Late evaluation of the relationship between morphological and functional renal changes and hypertension after non-operative treatment of high-grade renal injuries. *World J Emerg Surg*. 2012;7:26.
15. Chedid A, Le Coz S, Rossignol P, Bobrie G, Herpin D, Plouin PF. Blunt renal trauma-induced hypertension: prevalence, presentation, and outcome. *Am J Hypertens*. 2006;19:500–504.
16. Brown CVR, Galante JM. Operative management of renal injuries. In: Martin M, Beekley AC, Eckert MJ, eds. *Front Line Surgery*. 2nd ed. Cham, Switzerland: Springer; 2017:169–184.
17. Master VA, McAninch JW. Operative management of renal injuries: parenchymal and vascular. *Urol Clin North Am*. 2006;33:21–31.

EDITORIAL CRITIQUE

The present algorithm reflects the evolution of our management of patients sustaining renal trauma. In the ED, CT scanning has now entirely replaced the use of IVP (once described as “the cornerstone of renal trauma imaging”). Over 90% of renal injuries are identified as low-grade, and the vast majority of these are managed without further intervention. Evidence has shown that routine exploration of renal injuries results in an increased nephrectomy rate when compared to patients managed non-operatively. As a result, nephrectomy rates have decreased as non-operative management has become widely utilized. With the ready availability of interventional radiology, recommendations are made in the algorithm for angiographic examination and potential embolization of renal injuries demonstrating evidence of vascular involvement. Consideration is given for stenting of vascular injuries, all in an effort to preserve renal function.

Despite these important changes, the fundamental principles of treatment are unaltered. Patients with hemodynamic instability belong in the operating room. At exploration, patients who have major renal injury, and are unstable, require a nephrectomy. The goal of preserving the kidney should never eclipse achieving hemostasis and halting the progression of the shock state. Some questions still need to be fully explored and answered, specifically the utility and timing of routine follow-up imaging for higher grade renal injuries, optimal management of the devascularized kidney, and the incidence and risk factors for post-injury hypertension.

This delineation of a clearly defined process to address renal injuries is another in the series from the Western Trauma Association dealing with critical decisions in trauma. The development of evidence-based algorithms is beneficial, both to the clinician in guiding optimal management for an individual patient, and also for the trauma community as a whole, creating pathways to compare current to previous treatments and serving as a foundation for future investigations. Our ability to provide care that leads to the best outcomes for our patients depends on the thoughtful and ongoing examination of available data, which the present authors have accomplished.

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