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Contemporary management of acute kidney trauma

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ABSTRACT

Renal injury occurs in 1%–5% of all traumas, causing disability or even death. The American Association for the Surgery of Trauma (AAST) renal injury scale should be used when injuries are reported. Although there is a consensus regarding handling of lower-grade injuries conservatively, the same cannot be said for the higher-grades, for which different specialists handle either conservatively or surgically. A search of the MEDLINE database was undertaken by using the following filters: English language articles, full-text availability, last five years, humans. Pediatric studies were excluded. For most renal injuries in hemodynamically stable, patients can be safely handled conservatively. An organized assessment and treatment system can reduce the need for nephrectomy in most other cases, as has occurred in the last two decades. The AAST injury scale should be updated in light of the advancements in imaging techniques, in order to fine tune grading and treatment.

1. Introduction

Trauma is a leading cause of death and disability worldwide. Renal injury occurs in approximately 8%–10% of blunt or penetrating abdominal trauma[1,2], and 1%–5% of all traumas[3,4]. Renal trauma is more commonly seen in young males, with a mean age of 30.8 years. Blunt trauma is caused primarily by motor vehicle collisions, followed by falls, contact sports and pedestrian accidents[5]. In the majority of cases, renal injuries are minor and self-limiting. In urban areas, the percentage of penetrating injuries can reach 20% or higher, caused mostly by fire arms and stab wounds. The latter tend to be more severe and are more likely to require surgical management[6].

The evolution in the management of renal trauma has been made possible by advances in both imaging and minimally invasive techniques. Nowadays, CT plays a major role in investigation of renal trauma and is currently the imaging modality of choice[7,8]. The improvements in imaging and the use of a validated renal injury grading system has helped to predict, more acutely and with greater ease, outcomes such as mortality and the need for nephrectomy. The treatment of renal trauma is still controversial, but over the last decade a consistent trend has been noted, in which conservative management is being more commonly used over surgical management[9]. The benefits of this approach have become increasingly apparent with reductions in nephrectomy rate, complications, and hospital stay. Despite improvements in diagnosis and grading of the severity of kidney injuries, a surgical management still has to be made in some cases.

A search of the MEDLINE database was undertaken by using the PubMed (www.pubmed.gov) interface with the following keywords: kidney trauma, renal injuries, and the following filters: last five years, full text available, English language and humans, have been used. Additional papers referenced in bibliographies, but not initially retrieved from MEDLINE, were also examined. Pediatric studies were excluded.

2. Grade system

In 1989, the American Association for the Surgery of Trauma (AAST) created a renal injury scale based primarily on findings at surgical explorations[10]. It classified renal injuries into five grades in order of increasing severity (Table 1, Figure 1). Since then the renal AAST grading system has been widely used for clinical and scientific research. Even though the AAST classification is based on findings during surgery, it has a strong correlation with CT findings[11]. Recently, many authors have acknowledged that the current scale does not adequately classify certain subtypes of injuries within grades IV and V[12,13]. In 2011, a revision of the original scale was proposed by Buckley and McAninch, including segmental vascular

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Table 1
AAST renal injury grade system.

Grade	Type of injury	Description
I	Normal contusion	Microscopic or gross hematuria, urologic studies normal
	Hematoma	Subcapsular, non-expanding without parenchymal laceration
II	Hematoma	Non-expanding perirenal hematomas confined to the retroperitoneum
	Laceration	Superficial parenchymal lacerations less than 1 cm in depth without urinary extravasation
III	Laceration	Parenchymal lacerations greater than 1 cm in depth without urinary extravasation
IV	Laceration	Parenchymal lacerations extending through the renal cortex, medulla, and collecting system
	Vascular injury	Injuries involving the main renal artery or vein with contained hemorrhage
V	Vascular injury	Completely shattered kidney
		Complete avulsion of renal hilum which devascularized kidney

injuries and ureteral pelvic injuries, and to establish a more rigorous definition of severe grade IV and V renal injuries[14].

3. Initial assessment and resuscitation

Optimum treatment of injured trauma victims requires rapid and organized assessment and treatment system. Nowadays Advanced Trauma Life Support is the common language of trauma care[15], defining two phases in the initial management of patients with multiple injuries: a primary survey, which aims to identify and treat injuries that endanger the patient's life; and a secondary survey, which attempts to detect all the injuries and initiate definitive treatment.

3.1. Primary survey

During the primary survey, life-threatening conditions are rapidly identified and life-saving treatment is expeditiously initiated. Resuscitation efforts occur coincident with the primary survey and continue throughout the next phase of care. During the primary phase the assessment of airway, breathing, circulation, disability, exposure/environment is crucial[16].

The biggest cause of preventable death is early hemorrhage within the first six hours after incurring an injury[17]. The secondary survey "head-to-toe evaluation" starts only after the primary survey of airway, breathing, circulation, disability, exposure is complete, and the patient responds to resuscitation.

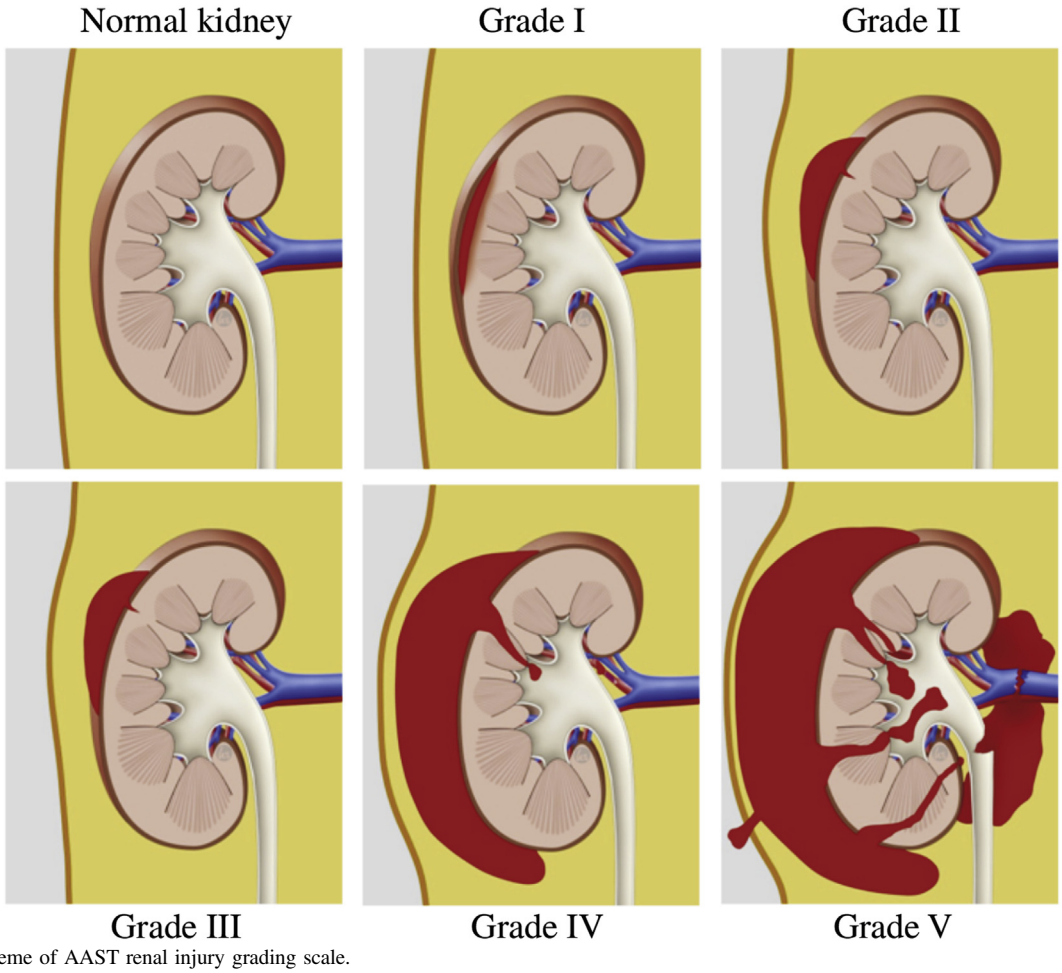

Figure 1. Scheme of AAST renal injury grading scale.

The focused assessment with sonography in trauma is an adjunct to the Advanced Trauma Life Support primary survey, which is used to identify the presence of free intraperitoneal or pericardial fluid[18]. Sonography is limited in the evaluation of the renal parenchyma. It can detect renal lacerations, but cannot definitely assess their depth and extent and does not help in differentiating extravasated blood from an urinoma.

If the patient is hemodynamically unstable, with no or transient response to resuscitation, the surgical team must intervene immediately [surgery or angioembolization (AE) in selected situations]. Also, if the surgical team elects to perform an exploratory laparotomy to manage an associated abdominal injury, the decision can be made to mend significant renal injuries at that time in order to prevent later complications.

When patients are selected for immediate operative interventions (too unstable to undergo CT), they should undergo intra-operative single-shot intravenous pyelogram in the operating suite (using 2 mL/kg intravenous contrast). The main purpose is to assess the presence of a functioning contralateral kidney and to stage the injured side according to injury of the renal pelvis and the ureter, even though some authors have argued against the reliability of this procedure[19,20].

3.2. Secondary survey

The secondary survey occurring after all life-threatening injuries from the primary survey have been identified and treated, allowing further investigations. It aims to identify all the injuries sustained, involves a thorough head-to-toe examination, including full neurological and spine examinations, log roll and digital rectal exam.

3.3. Urological assessment

When taking the patient's history, it's important to ask for details, namely, velocity, rapid deceleration, blow to the back, fall height, seat belt and airbag. In penetrating injuries, the weapon characteristics (the type and caliber of the weapon or size of the blade) may provide clues to the extent of injury. Preexisting abnormality in a kidney can increase the risk for injury, usually making the severity of the patient's symptoms disproportionate to the degree of injury suffered[21], which is why prior pathologies like cysts, nephrolithiasis, hydronephrosis, ureteropelvic junction obstruction, accessory renal arteries and renal tumors must be taken into consideration.

During physical examination, signs of rib fracture, significant flank ecchymosis, and penetrating injury of abdomen, flanks or lower chest may all be indicators of renal trauma[22].

Laboratory findings such as hematocrit, prior creatinine and urinalysis are the most important tests to evaluate renal trauma. As most trauma patients are evaluated within 1 h after injury, creatinine measurement reflects renal function prior to the injury, with an increased value usually reflecting preexisting renal pathology. The degree of hematuria does not correlate with the degree of injury; in fact, renal pedicle avulsion or acute thrombosis of segmental renal arteries can occur in the absence of hematuria while renal contusions can present with gross hematuria.

Since the mid-eighties, CT has replaced intravenous urography and become the diagnostic tool of choice for the assessment of renal trauma, because it provides essential anatomical and functional information needed to determine the type and extent of parenchymal, vascular, or collecting system injuries and associated abdominal injuries, all with short examination times[23,24]. The indications for CT imaging evaluation of renal injury in stable patients can be gross hematuria, microscopic hematuria and hypotension (systolic blood pressure < 90 mmHg) or other associated injuries requiring CT evaluation and blunt trauma with other injuries known to be associated with renal injury (*e.g.*, rapid deceleration, fall from a height, direct contusion or hematoma of flank soft tissues, fractures of the lower ribs or thoracolumbar spine), regardless of the presence of hematuria.

When the injury is reported, the AAST classification should be used (Table 1), particularly because of its prognostic implications.

Indications for angiography include suspected renal arterial thrombosis or segmental arterial injuries for which embolization or stenting is considered.

4. Management

4.1. Grade I injuries

Grade I injuries are the most common type of renal injury (75%–85% of cases) and, in most cases, are generally managed conservatively[25], characterized by small contusions and non-expanding subcapsular hematomas with no associated lacerations. Contusions should be differentiated from segmental infarctions in CT, the latter being usually caused by thrombotic occlusion of an accessory renal artery, capsular artery or intrarenal subsegmental branch[6].

4.2. Grade II injuries

It includes non-expanding perinephric hematomas confined to the retroperitoneum and superficial cortical lacerations measuring less than 1 cm in depth without collecting system injury. As in grade I injuries, most of these cases are treated conservatively in stable patients[26]. In patients with renal trauma that does not involve the renal vessels, the conservative management success rate is up to 95%[27].

4.3. Grade III injuries

The difference between grade II and grade III is the depth of renal laceration, with grade III corresponding to a laceration greater than 1 cm, without the collecting system's involvement. Exclusion of collecting system injury is made on the excretory phase CT image by demonstrating a lack of urinary extravasations. Grade III injuries can be managed conservatively in stable patients, but for many of them an expectant approach should be considered[2].

4.4. Grade IV injuries

By definition, grade IV injuries involve deep parenchymal lacerations extending through the renal cortex and medulla into the collecting system and injuries involving the main renal artery or vein with contained hemorrhage and segmental infarctions without associated lacerations (Figure 2). The management of patients with these injuries can be particularly challenging;

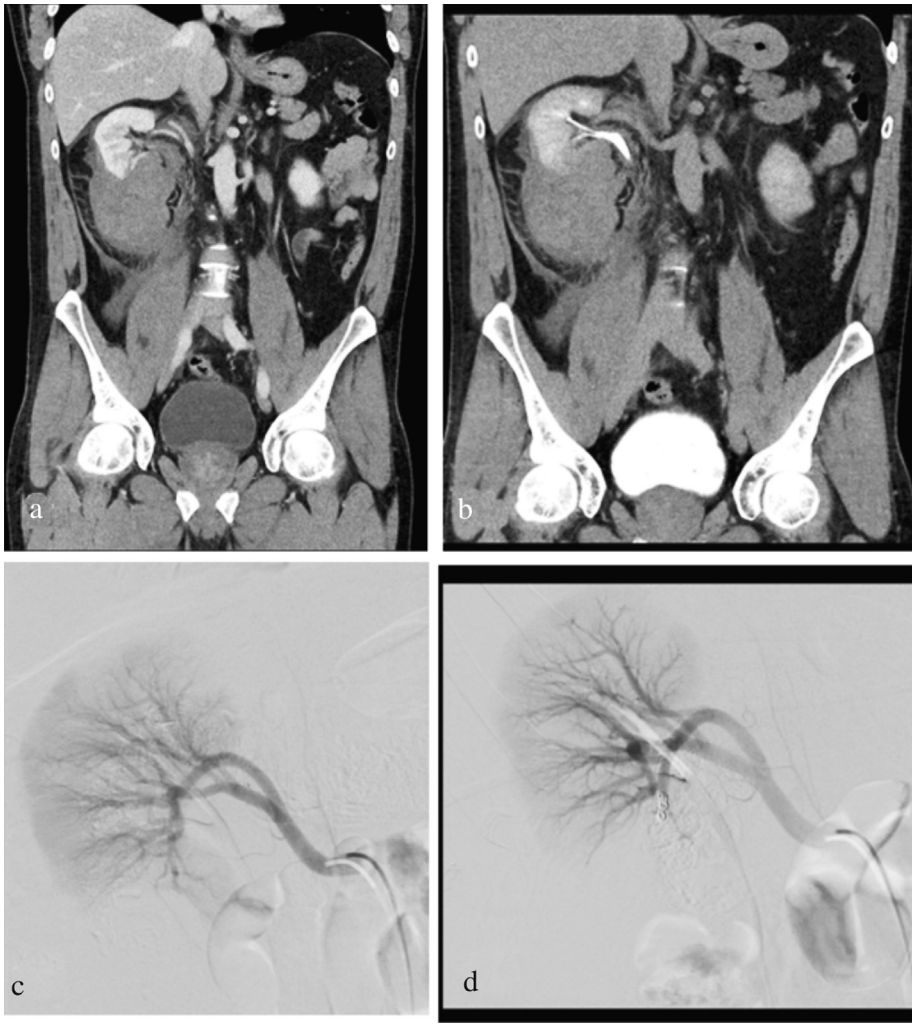

Figure 2. CT scan, urography and angiography of the grade IV renal trauma.
a: Grade IV trauma with segmental renal artery injury: contrast enhanced CT scan, coronary view with perfused upper and middle part of the kidney, missing perfusion in the lower pole; b: Urography shows no sign of extravasation; c: Angiography with persistent arterial bleeding from a segmental branch of the lower pole; d: Angiography after placing of coils for the embolization of the segmental branch showing a cessation of the bleeding.

sometimes they can be observed expectantly, but often require either urgent or delayed repair[28].

AE is effective in patients with grade IV injuries who have failed a trial of conservative therapy.

While almost all patients with penetrating injury require renal exploration, only 20% of those with blunt trauma do. Of the patients that undergo exploration, renography is more commonly chosen over nephrectomy. Patients with these injuries usually also suffer from non-renal isolated injuries requiring an operative exploration, which may not need to include renal exploration. Nevertheless, unless absolute indications for renal exploration are present, Gerota's fascia should stay intact, seeing that patients with mild to moderate trauma who underwent renal exploration have twice the risk of developing a complication than those with similar injuries who do not undergo exploration[2]. By isolated grade IV renal injuries, a conservative management is used more frequently[29].

4.5. Grade V injuries

Grade V injuries include multiple renal lacerations and vascular injuries involving the renal pedicle (Figures 3 and 4). The most significant vascular injury in blunt trauma is thrombosis of the main renal artery, represented in CT by nonvisualization of the kidney (other possible situations: renal vascular spasm, avulsion of the renal pedicle, and high-grade urinary obstruction). The management of grade V injuries is more controversial, since conservative, interventional and surgical approaches have been reported. Usually grade V injuries are an absolute indication for exploration, but stable patients with only parenchymal injury may be safely treated conservatively[30].

4.6. Conservative management

Conservative management consists of regular monitoring of vital signs, physical examinations, laboratory analyses (hemoglobin, hematocrit). Bed rest is proposed until clinical signs become stable and macroscopic hematuria has cleared. The role of antibiotics is not clear, but IV broad spectrum antibiotics should be used if there is suggestion of damage to the collecting system and urine leak, to prevent secondary infection of the retroperitoneal hematoma. Re-imaging may be only necessary in all renal trauma of grade III, based on the high complication rate in this group. A reevaluation to consider a re-imaging or other management approach is reasonable if there is an alteration in the patient's condition.

Figure 3. Grad V trauma with a scattered kidney after traffic accident.
CT scans show normally perfused right kidney, while the left kidney is irregularly perfused with scattered parenchyma fragments and a prominent retroperitoneal hematoma. Images are prior to the subsequent nephrectomy.

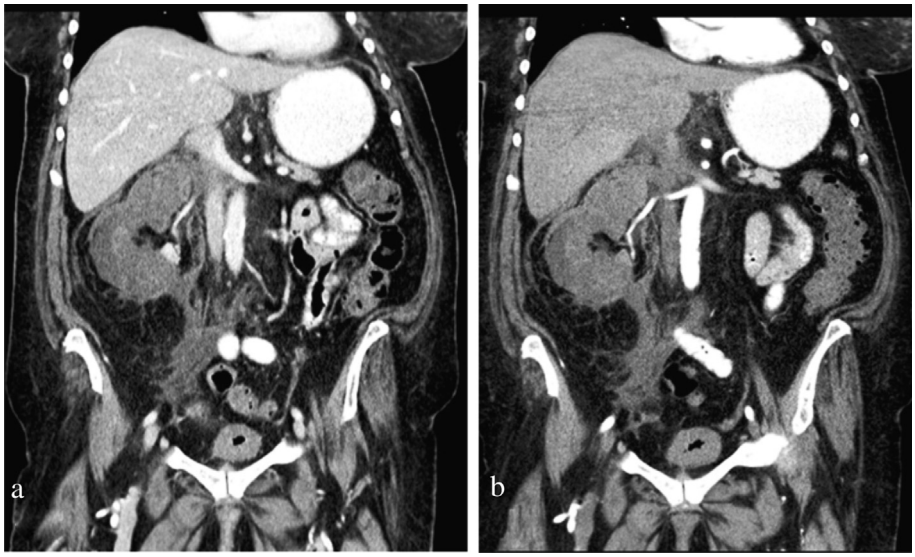

Figure 4. Grad V trauma.
Both images show a non-perfused right kidney with a visible arterial influx over the main renal artery with truncation of arterial flow due to an intima laceration after blunt abdominal trauma.

4.7. Interventional radiology

Interventional procedures may be indicated in more stable patients as well as in postoperative patients with persistent or recurrent hematuria[31]. The main indications for angiography are: embolization for active hemorrhage, pseudo-aneurysm, and vascular fistula[4]. With advances in embolization techniques, there is an increasing body of literature supporting the use of AE in the management of grade IV and grade V injuries. Factors that may influence the practice of AE are individual clinical experience, procedure knowledge, availability of newer technologies[32]. While a variety of clinical and CT criteria, as well as algorithms, have been proposed, there are currently no validated criteria for optimal selection of renal trauma AE candidates[33], leading to discrepancies in the practice of AE between specialists[34].

4.8. Surgical management

The goals of renal exploration following renal trauma are control of hemorrhage and renal salvage. There are few absolute

indications for surgical exploration of the kidney in trauma patients, while relative indications are still a controversial theme. The absolute indications are life-threatening hemorrhage, renal pedicle avulsion, or pulsatile/expanding retroperitoneal hematoma at the time of laparotomy. In addition, all unstable patients with penetrating renal trauma and with a retroperitoneal hematoma should undergo exploration.

In the case of exploring an injured kidney, nephron sparing is the primary goal, but in some cases total nephrectomy may be deemed as inevitable for uncontrolled hemorrhage[34]. Some of the nephron preservation methods are: early vascular control, renorrhaphy, partial nephrectomy and revascularization[35]. The decision to attempt either renal reconstruction or nephrectomy should be taken after careful assessment of the patient's overall condition.

5. Complications

Complications after renal trauma occur in between 3% and 33% of the cases. They can be classified as either early complications, developed within the first month after injury, or late complications.

Extravasation of urine is the most common complication of renal trauma. Urinomas occur in 1%–7% of cases and consist of a collection of urine that may be encapsulated, although they can also manifest as free fluid. Delayed phase CT imaging is the study of choice in the diagnosis of renal urine leaks and urinomas[36]. Urinomas may also be complicated by superinfection or perinephric abscess formation. In most instances, small urinomas will be reabsorbed spontaneously, and drainage is not necessary. If the volume does not decrease, or if it increases, further intervention will be necessary, such as ureteral stenting with or without percutaneous drain placement. If an infection from the urinoma or an abscess develops, it may benefit from drainage under ultrasound or CT guidance.

Secondary hemorrhage is commonly a complication found in grade IV and V injuries and in penetrating traumas. It is most often a result of an arteriovenous fistula or pseudo-aneurysm[37]. Most patients may present with: gross hematuria, falling hematocrit, flank pain, mass, abdominal bruit, or hypertension[38]. Angiography is considered the gold standard to diagnose. When conservative measures fail and clinical symptoms or a relevant hemoglobin decrease occur, AE should be considered. These patients constitute a group with renal trauma that is well suited for angiographic therapy[39].

Late or delayed complications of renal trauma include hypertension, hydronephrosis, calculus formation and chronic pyelonephritis.

Arterial hypertension may result as a late complication of trauma to the kidney with an incidence as high as 40%[40]. It may appear early within a few days after the injury or after months or even years, thus making long term follow-up with regular blood pressure measurements is advisable. It's usually renin-dependent and associated with vascular or parenchymal injury[41].

6. Follow-up

The general recommendation is a three-month follow-up after major renal injury hospitalization. The follow-up should include a physical examination, urinalysis, selective re-imaging, serial blood pressure measurement and renal function test. A re-imaging should be done if worsening signs or symptoms, signs of complications occur in patients who had suffered a high-grade injury[3,42,43].

7. Discussion

The number of renal trauma cases has been rising over the last two decades, due to a growing use of transportation vehicles. Blunt trauma injuries are more common in comparison with penetrating injuries, with this ratio being different from country to country, depending on social and economic factors. With the increased number of cases came changes in management, with gradually more interests in taking a conservative approach to treatment, as opposed to surgery; thanks to advancements in technology, nowadays the main focus in any renal trauma case is organ preservation, while keeping the patient safe.

The AAST classification is used worldwide for grade renal injury, but advances in imaging technology has led to disagreement regarding grades IV and V of the grading scale created in 1989, and there has not been a formal revision of the AAST injury scale until now.

In 2010, Dugi *et al.*, showed a correlation between important CT findings, such as large perirenal hematoma, intravascular contrast extravasation and medial renal laceration, and the need for urgent intervention. Therefore, in this study, the authors conclude that the AAST renal injury grading system should be reviewed and that grade IV should be substratified into grades IVa (low risk) and IVb (high risk)[44].

In 2011, Buckley and McAninch, made a study with the goal of updating the AAST renal injury grading system. The suggestions made were only for grades IV and V, with no changes proposed for grades I to III. For grade IV, the changes were to include the following injuries: all collecting system injuries, including ureteropelvic junction injury (Figure 5), segmental arterial and venous injuries. Grade V injuries, which before had included "shattered kidneys", were reduced to only renal hilar injuries (including thrombotic events)[29]. An update of the AAST grading system could improve its correlation with modern CT imaging in predicting the need for surgical intervention, and to bring a consensus between the different specialists.

In 2015, Chiron *et al.* proposed also an update of the AAST grade IV renal injury scale. Three factors are proposed to be incorporated: perirenal hematoma > 3.5 cm, intravascular contrast extravasation and medial renal laceration, to help to determine the time and need for intervention[45].

Current management practices dictate that most renal injuries can be managed conservatively, with this approach being the norm and receiving wide support.

But a conservative approach may not always be possible. The mechanism and severity of injury, associated injuries and hemodynamic stability of the patient all play a role in determining the management strategy, with CT findings being the standard diagnostic tool to dictate the optimal course of action. Specialists agree that grades I to III are to be conservatively managed, but grade IV and V injuries are more controversial, as they can be conservatively managed, or undergo a surgical repair, and approach which, in opposition to conservative, is still not stan-

Figure 5. Grade IV trauma with injury of the ureteropelvic junction.
CT imaging after blunt abdominal trauma; a: In the contrast enhanced phase, there are no signs of arterial or venous bleeding, no retroperitoneal hematoma; b: The CT urography shows a laceration of the pyelon at the ureteropelvic junction.

dardized among different specialists, namely, urologists and trauma surgeons[46].

8. Conclusions

Renal injuries occur in 8%–10% of blunt or penetrating abdominal trauma, being in some cases a life-threatening situation. An organized assessment and treatment system can safely reduce the need for nephrectomy in most cases. The AAST renal injury should be updated to bring consensus between specialists and improve the management of the patients. Most renal injuries in hemodynamically stable patients can be safely handled conservatively. AE is an effective treatment, in some selected cases. As imaging techniques and an optimized approach system have improved over the past decades, the incidence of surgical repair of renal injuries has gradually decreased, and nephron sparing surgery should be the choice whenever possible.

Conflict of interest statement

The authors report no conflict of interest.

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