Evaluation of renal trauma in the emergency context: the role of computed tomography

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Learning objectives

1. To review the role of computed tomography (CT) on the evaluation of renal trauma.
2. To illustrate, describe and illustrate the findings in renal trauma according to the American Association for the Surgery of Trauma (AAST) classification.
3. To review additional findings in renal trauma not included in AAST classification with prognostic and treatment relevance.

Background

Contrast enhanced computed tomography (CT) is the imaging technique of choice in the evaluation of renal trauma. Computed tomography is widely available in emergency context being an accurate and fast screening exam for lesions involving not only the kidneys but also other abdominal or retroperitoneal structures. In addition to a non enhanced scan, a vascular phase should be obtained (at least in high impact trauma), ideally with automatic bolus tracking due to the wide range of hemodynamic status in these patients. Additionally, nephrographic (usually portal phase) and excretory phases should be obtained. Selective acquisition of the excretory phase is acceptable in patients with confirmed lesions in portal phase.

Although kidney injury is relatively frequent in high-impact blunt abdominal trauma (8-10% of all blunt and penetrating abdominal traumas) most kidney injuries have little clinical relevance (about 90% of patients with blunt trauma have minor injuries).

Findings and procedure details

The AAST kidney injury scale is currently the most widely used and accepted classification for traumatic renal lesions. This classification has five grades (I to V) of increasing severity and correlates with CT findings. Grades I and II injuries are managed conservatively. Grades III and IV more often require surgical exploration but, even the later, can often be managed without renal exploration if carefully staged and selected. However, life threatening hemodynamic instability due to renal hemorrhage or pedicle avulsion are absolute indications for surgery. Surgery is also considered in a severely damaged "shattered kidney". Urine extravasation usually resolves spontaneously and, as such, expectant management is appropriate in most patients.
AAST CLASSIFICATION FOR RENAL TRAUMATIC LESIONS

Grade I*
Contusion: Hematuria with normal imaging findings, renal contusion (Fig. 1 on page 5)
Hematoma: subcapsular non-expanding hematoma without laceration of the parenchyma (Fig. 2 on page 6)

Grade II*
Hematoma: Non expansive perinephric hematoma confined to the retroperitoneum
Laceration: <1cm depth into the renal cortex without urine extravasation (Fig. 3 on page 16 and Fig. 4 on page 7)

Grade III*
Laceration: >1 cm depth into the renal cortex without expansion to the collecting system or urine leakage (Fig. 5 on page 8)

Grade IV**
Laceration: across the renal cortex, medulla, and collecting system (Fig. 6 on page 9 and Fig. 7 on page 10);
Vascular: injury to the renal artery or vein with contained hemorrhage (Fig. 9 on page 12);***

Grade V****
Laceration: completely fragmenting the kidney - "shattered kidney" (Fig. 10 on page 12);
Vascular: injury to the renal hilum with kidney devascularization: avulsion of the arterial pedicle (Fig. 11 on page 13)

*advance one grade for bilateral lesions up to grade III
** some authors include expanding subcapsular hematomas that compress the kidney as grade IV lesions
***some authors include segmental artery thrombosis without parenchymal laceration as grade IV vascular lesions
****some authors include avulsion of the ureteropelvic junction as grade V lesion
some authors include thrombosis of the main renal artery or vein that devascularizes the kidney as grade V vascular lesions Fig. 8 on page 11

Computed tomography findings in lesions depicted in the AAST classification for renal traumatic lesions:

- Renal contusion: ill-defined and discrete areas of low density and decreased enhancement; it may present well-delineated margins or appear as hyperattenuating areas on pre-contrast images once blood clots fill the injured area Fig. 1 on page 5.
- Subcapsular hematoma: round or elliptical high density fluid collection between the renal capsule and renal parenchyma without contrast enhancement, indenting or flattening the renal margin Fig. 2 on page 6.
- Perinephric hematoma: ill defined, high density fluid collection between the renal parenchyma and Gerota’s fascia Fig. 13 on page 15; usually there is no mass effect on the renal contour despite their size.
- Renal parenchyma laceration: irregular or linear parenchymal defects, which may contain blood clots Fig. 3 on page 16.
- Segmental infarction: well circumscribed linear or wedge-shaped (with the apex toward the hilum and the base to the renal capsule) multifocal non-enhancing areas in the renal parenchyma.
- Traumatic renal infarction: caused by complete thrombosis (related to intimal dissection from a deceleration injury) or laceration/avulsion of the main renal artery; lack of enhancement in the nephrographic phase on the affected side, retrograde opacification of the renal vein from the inferior vena cava and abrupt truncation of the renal artery lumen at the point of occlusion Fig. 8 on page 11 and Fig. 9 on page 12. Complete infarction is less common than segmental or subsegmental infarction in patients sustaining blunt trauma.
- Avulsion of the renal artery: rare but life threatening; characterized on CT by global infarction of the kidney associated with extensive medial perirenal hematoma with or without active bleeding Fig. 11 on page 13.
- Injury to the collecting system: the excretory phase is especially useful to evaluate for urinary extravasation since contrast extravasation helps characterize the nature of a perinephric fluid collection Fig. 14.
- "Shattered kidney": multiple severe renal lacerations, usually associated with one or more devitalized fragments, severe compromise in contrast material excretion, lacerations of the collecting system, extensive hemorrhage and/or active arterial bleeding. At CT, foci of active arterial extravasation should be distinguished from islands of viable renal parenchyma that are still enhancing Fig. 10 on page 12.
- Venous injuries: rare in blunt trauma; usually there is coexistent arterial pedicle injuries or severe parenchymal injuries. At CT an intraluminal thrombus in the distended veins may be seen associated with renal changes secondary to acute renal venous hypertension: nephromegaly, a diminished
nephrogram, delayed nephrographic progression and decreased excretion of contrast material

**Other CT findings in lesions not clearly depicted in the AAST classification for renal traumatic lesions:**

- **Active hemorrhage:** ill defined, appearing as patchy areas described as linear, flame shaped or waterfall shaped with high attenuation values. Active hemorrhage is often associated with fresh hematoma, which commonly presents fluid levels representing layers of blood in different clotting stages Fig. 12 on page 14.

- **Underlying renal abnormalities:** increase the risk of injury and reduce the likelihood of renal recovery from trauma. Renal cysts are the most common preexisting anomalies, but tumors, chronic hydronephrosis and congenital abnormalities may be present. Trauma in abnormal kidneys tends to be confined to the kidneys, to occur with lower impact trauma and to result in macrohematuria more frequently. In fact, renal trauma may be the first manifestation of the underlying disorder. Typical lesions include disruption of the renal pelvis or uroteropelvic junction in patients with hydronephrosis or extrarrenal pelvis, intracystic hemorrhage or ruptured renal cyst with or without communication with the collecting system Fig. 14 on page 17, rupture of tumor, laceration of poorly protected ectopic, horseshoe or transplanted kidney and laceration of fragile, infected kidney. Computed tomography is also useful by providing both anatomical and functional evaluation of the opposite kidney.

*Images for this section:*
Fig. 1: Renal contusion (grade I lesion): ill-defined area that present as hyperattenuating area on pre-contrast images due to blood clots filling the injured area (arrow)
Fig. 2: Subcapsular non-expanding hematoma (grade I lesion): high density fluid collection between the renal capsule and renal parenchyma indenting the renal margin
Fig. 4: Laceration less than 1cm depth into the renal cortex without urine extravasation (grade II lesion): an irregular parenchymal defect is seen
Fig. 5: Laceration more than 1 cm depth into the renal cortex without urine extravasation (grade III lesion)
Fig. 6: Laceration across the renal cortex, medulla and collecting system (grade III lesion). An excretory phase is needed to detect active urine leakage, which can not be evaluated in this image
Fig. 7: Laceration across the renal cortex, medulla and collecting system (grade III lesion). The excretory phase reveals active urine leakage.
**Fig. 8:** Some authors include thrombosis of the main renal artery or vein that devascularizes the kidney as grade V vascular lesions. Note the interruption of the right renal artery at its origin, the lack of enhancement of the right kidney and the retrograde filling of the renal vein.

**Fig. 9:** Grade IV lesion with injury to the right renal artery with contained hemorrhage. Note the retrograde filling of the renal vein.
Fig. 10: "Shattered kidney" (grade V lesion): multiple severe renal lacerations with several fragments and extensive hemorrhage
Fig. 11: Avulsion of the renal artery (grade V lesion): the presence of extensive medial perirrenal hematoma and a devascularized kidney suggests avulsion. An arterial phase should have been obtained to confirm arterial blood leakage.
Fig. 12: Active hemorrhage: ill defined image of contrast extravasation on an arterial phase (image 12). There is associated expanding perinephric hematoma with compression of the renal parenchyma (better appreciated in Fig 13)
Fig. 13: Active hemorrhage: ill defined image of contrast extravasation on an arterial phase (image 12). There is associated expanding perinephric hematoma with compression of the renal parenchyma (Fig 13)
Fig. 3: Laceration less than 1cm depth into the renal cortex without urine extravasation (grade II lesion): a linear parenchymal defect is seen (arrow)
Fig. 14: Ruptured renal cyst with communication with the collecting system. Contrast extravasation is seen. The arrows point to the undulating cyst wall denoting cyst rupture.
Conclusion

Contrast-enhanced CT is the imaging technique of choice in the assessment of renal trauma. Although CT frequently is used as part of a broader examination, the imaging protocol should be adapted if urological injury is clinically suspected.

Personal information

References