CME Article

Computed tomography of blunt renal trauma

Razali M R, Azian A A, Amran A R, Azlin S

ABSTRACT

Renal injury is observed in 10 percent of cases of abdominal trauma, and the majority (80 percent to 90 percent) of these are attributable to blunt trauma. Intravenous urography and ultrasonography of the abdomen were previously the modalities of choice in the imaging of renal injuries. However, computed tomography (CT) is currently the imaging modality of choice in the evaluation of blunt renal injury, since it provides the exact staging of renal injuries. The purpose of this article is to describe the CT staging of renal injuries observed in blunt abdominal trauma based on the Federle Classification and the American Association for the Surgery of Trauma renal injury severity scale.

Keywords: blunt renal trauma, kidney injuries, renal haemorrhage, renal trauma

Singapore Med J 2010;51(6):468-474

INTRODUCTION

Renal injury is observed in about 10% of cases of abdominal injury. However, the majority (80%–90%) of renal injuries are attributable to blunt trauma,[1,2] while the rest are due to penetrating renal injuries, commonly from gunshot and stab wounds.[1,3,4] Renal injuries from blunt trauma usually occur as a consequence of a direct blow to the flank or from rapid deceleration.[3,4] A direct blow crushes the kidney, causing a laceration or lacerations of the renal parenchyma and resulting in a subcapsular, intrarenal or perinephric haematoma.[4] A deceleration injury causes an acute tension on the renal pedicle, resulting in the laceration of the renal vein or artery, an intimal tear in the vessel causing thrombosis or laceration, or an avulsion of the ureteropelvic junction (UPJ).[4]

Intravenous urography (IVU) was previously the imaging modality of choice in the investigation of renal injuries. However, it has been noted that IVU fails to detect and accurately stage some types of renal injuries.[5] A limited IVU (one-shot intravenous pyelography) may still be performed in the emergency department in patients who are not stable enough to undergo computed tomography (CT), or in patients already in the operating room.[6] Ultrasonography (US) has also been found to be very useful in the early evaluation of renal trauma, especially in the emergency room, as well as for detecting haemoperitoneum. However, US may also miss some types of renal injuries.[7]

CT is currently the imaging modality of choice in the evaluation of blunt renal injury. It can provide the exact delineation and staging of the extent of the renal injuries, and is superior to IVU, US and angiography.[2,8] CT had also become the imaging method of choice for the assessment of blunt trauma in most trauma centres. However, CT needs to be performed in multiple phases for a complete assessment of renal injuries. In certain cases, a delayed CT may need to be repeated after 2–3 days in order to detect ureteropelvic injuries and other complications.[9,10]

The indications for renal imaging in trauma patients include gross haematuria, microscopic haematuria with shock (systolic blood pressure [SBP] < 90 mmHg), microscopic haematuria with flank bruising, lower rib and lumbar spine transverse process fractures, penetrating trauma, and a child with blunt trauma and haematuria (> 50 red bloods cells/high power field).[11] In this article, we review the radiological classifications of renal injuries in blunt renal trauma cases seen in Hospital Tengku Ampuan Afzan, Kuantan, Malaysia.

CT SCANNING PROTOCOL IN RENAL TRAUMA

For a complete assessment of renal injuries, CT is performed in multiple phases. It is usually done as part of the CT abdomen and pelvis protocol for abdominal injuries. The corticomedullary phase is performed from the dome of the diaphragm to the pelvis, approximately 60 seconds after an intravenous injection of nonionic iodinated contrast media (iohexol 300 mg I/ml) at 2 mg/kg via the antecubital vein. This phase would identify any renal contusion, laceration, perinephric haematoma and arterial injury. Other associated injuries to the liver, spleen, pancreas and intraperitoneal haemorrhage could also be assessed. However, collecting system injuries may be missed if an excretory phase is not performed.[9] The excretory phase is then obtained about 3–5 minutes later, which include both the kidneys and the urinary bladder.

Department of Radiology, Faculty of Medicine, International Islamic University Malaysia, Kuantan 25710, Malaysia

Razali MR, MBBS, MMed Radiologist and Head

Azian AA, MD, MMed Radiologist

Amran AR, MBBS, MRad Radiologist

Azlin S, MBBS, MRad Radiologist

Correspondence to:
Dr Ahmad Razali Md Ralib
Tel: (60) 9571 6400
Fax: (60) 9517 8548
Email: arazali@iiu.edu.my

Table I. Federle Classification (imaging-based)[1,8]

Category	Type	Injury
I	Minor injury	Renal contusion; intrarenal and subcapsular haematoma; minor laceration with limited perinephric haematoma without extension in the collecting system or medulla; small subsegmental cortical infarct
II	Major injury	Major renal laceration through the cortex extending to the medulla or collecting system with or without urine extravasation; segmental renal infarct
III	Catastrophic injury	Multiple renal lacerations; vascular injury involving the renal pedicle
IV	Ureteropelvic injury	Avulsion (complete transaction); laceration (incomplete tear)

Table II. The American Association for the Surgery of Trauma (AAST) renal injury severity scale.[2,11]

Grade*	Type	Description
I	Contusion	Microscopic or gross haematuria; urological studies normal
	Haematoma	Subcapsular; not expanding with no parenchymal laceration
II	Haematoma	Not expanding perirenal haematoma confirmed to be renal retroperitoneum
	Laceration	< 1.0 cm parenchymal depth of renal cortex with no urinary extravasation
III	Laceration	> 1.0 cm parenchymal depth of renal cortex with no collecting system rupture or urinary extravasation
IV	Laceration	Parenchymal laceration extending through renal cortex, medulla and collecting system
	Vascular	Main renal artery or vein injury with contained haemorrhage
V	Laceration	Completely shattered kidney
	Vascular	Avulsion of renal hilum which devascularises kidney

* Advance one grade for bilateral injuries up to Grade III. Access online at http://www.aast.org/injury/injury.html.

This is important in detecting urine extravastion which would indicate collecting system, ureteropelvic or bladder injuries. The timing of the excretory phase may be delayed until more than 10–20 minutes so as to allow more urine extravasation to be visualised.[11] In haemodynamically unstable patients, or patients with Category II or higher injuries, CT of the abdomen may need to be performed 2–3 days later to detect delayed complications, such as urinoma, infected urinoma or expanding haematoma, which may require intervention.[10] All these multiphasic imagings of the renal system allow for appropriate and complete assessment of the renal injuries.

For all the patients in this review, CT was performed using a 4-slice Siemens Somatom scanner with a slice width of 10 mm, collimation of 2.5 mm, rotation time of 0.75 seconds and table feed of 15 mm. For post processing, the images were reconstructed at 3 mm. Sagittal and coronal images were then acquired using the maximum intensity projection technique, whenever the need arises. For the purpose of this review, we retrospectively reviewed the renal trauma cases from the CT registration records from December 2004 to April 2006. In all, 14 cases of renal trauma were identified, but five cases were excluded due to missing images, leaving a total of nine cases.

CT CLASSIFICATION OF RENAL TRAUMA

There are several classifications of renal injuries, based on either imaging or surgery. Federle Classification is a widely used imaging-based grading system (Table I),[1,8] while the American Association for the Surgery of Trauma (AAST) renal injury severity scale is a commonly used urological surgical staging in renal trauma (Table II).[2,11] However, considerable overlapping is observed in both classifications. Staging is important as it guides surgeons and radiologists in the management of the patient, although it is not absolute and needs to be tailored for individual patients. Out of the nine cases that we have identified, two (22%) cases were in Category I (minor injury), three (33%) were in Category II (major injury), and two (22%) were in Category III (catastrophic injury) and Category IV (ureteropelvic junction injury) each.

FEDERLE CLASSIFICATIONS

Category I

This category includes minor injury to the kidney such as renal contusion, intrarenal and subcapsular haematoma, minor laceration with limited perinephric haematoma without extension to the collecting system or medulla, and small subsegmental cortical infarct. Category I corresponds to Grade I and II of the AAST renal injury

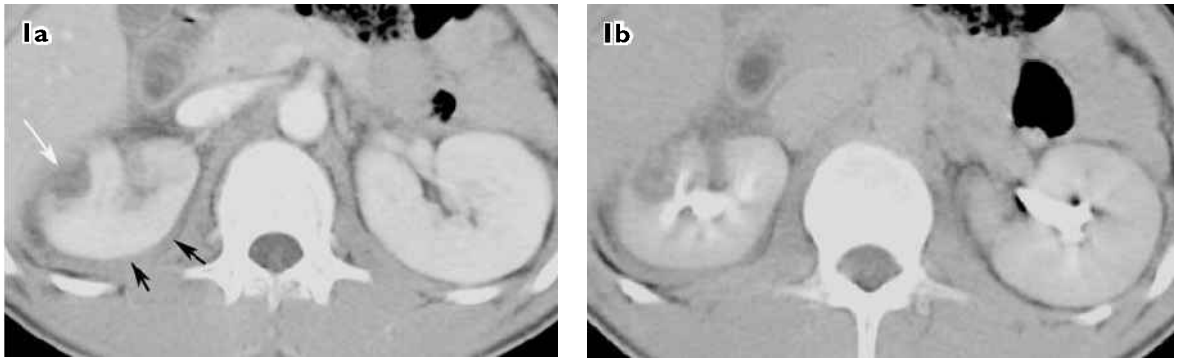

Fig. 1 Category I: A 16-year-old boy with blunt abdominal trauma. (a) Axial CT image shows minor renal contusion (white arrow) with mild perinephric haematoma (black arrows) in the right kidney. No extension into the medulla or collecting system is seen. (b) Axial CT image in the excretory phase shows no contrast extravasation.

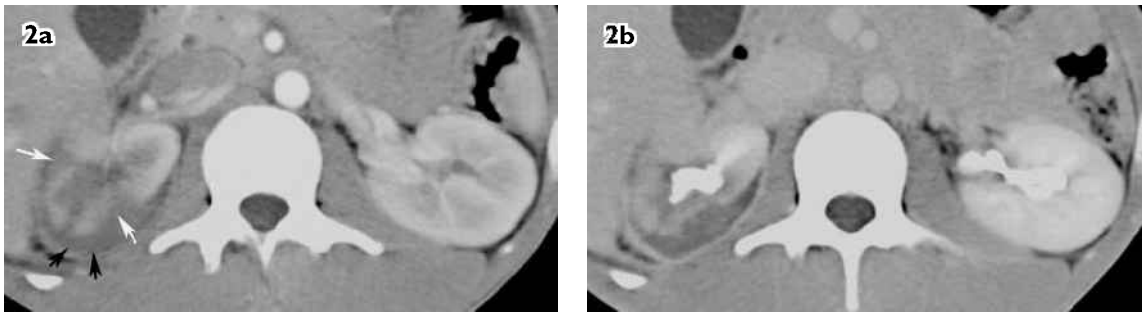

Fig. 2 Category I: A 23-year-old man with blunt abdominal trauma. (a) Axial CT image shows multiple renal contusions (white arrows) in the right kidney. There is also associated subcapsular haematoma (black arrows). No extension into the medulla or collecting system is seen. (b) Axial CT image in the excretory phase shows no contrast extravasation.

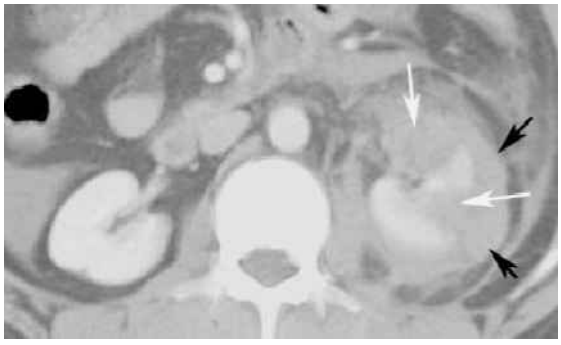

Fig. 3 Category II: A 33-year-old man with blunt trauma. Axial CT image shows major renal laceration with extension into the medulla (white arrows) in the left kdiney. Minimal perinephric haematoma is also seen (black arrows).

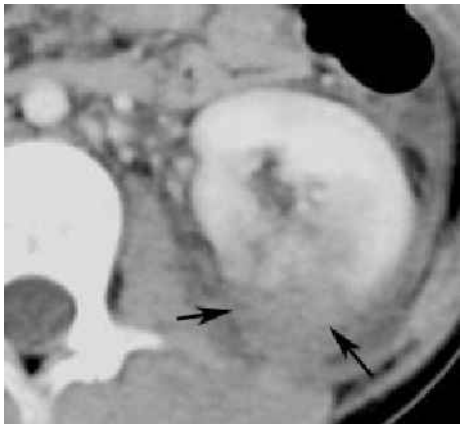

Fig. 4 Category II: A 10-year-old girl who sustained blunt abdominal trauma. Axial CT image shows major renal laceration with extension into the medulla (arrows) in the left kidney.

severity scale. Renal contusion is usually small and appears as small nonenhancing areas within the renal parenchyma without extension into the collecting system (Figs. 1a & b). A small subcapsular haematoma appears as a hypodense lesion flattening the renal capsule (Figs. 2a & b). No evidence of contrast extravasation would be seen in the excretory phase, since the collecting system is not involved (Figs. 1b & 2b). Other findings would include small subsegmental cortical infarcts (small wedge-shaped, well-defined hypodensity) and limited perinephric haematoma. Category I injuries usually constitute 75%–85% of all renal injuries in most series.[2,8] These category I injuries are usually managed conservatively.[1,8]

Category II

This category consists of major injury of the kidney, including major renal laceration through the cortex extending to the medulla or collecting system, with or without urine extravasation and segmental renal infarct. Category II corresponds to Grade III of the AAST renal injury severity scale. However, Grade III excludes the

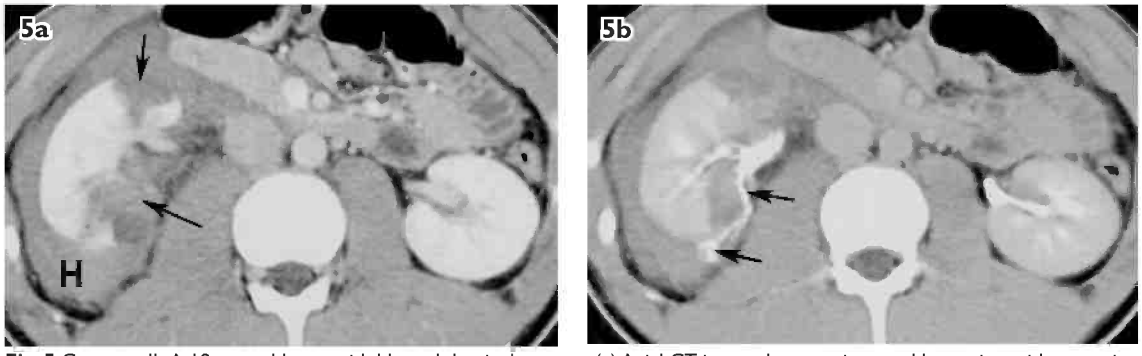

Fig. 5 Category II: A 19-year-old man with blunt abdominal trauma. (a) Axial CT image shows major renal laceration with extension into the medulla and collecting system (arrows) in the right kidney. A large perinephric haematoma is seen (H). (b) Axial CT image in the excretory phase shows contrast extravasation into the perinephric space (arrows).

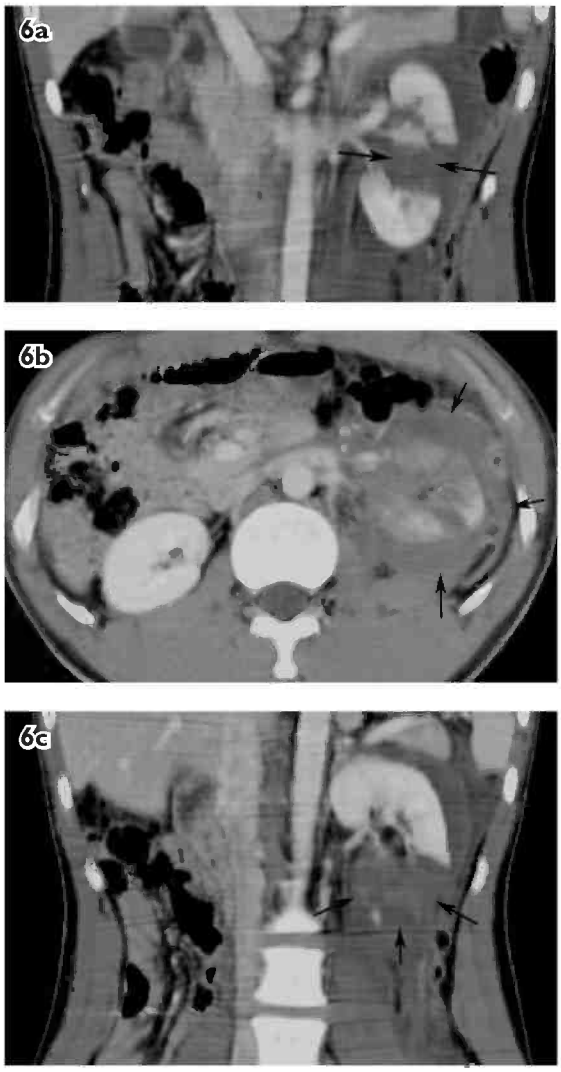

Fig. 6 Category III: A 27-year-old man with blunt abdominal trauma. (a) Coronal reformatted CT image shows major renal laceration through the midportion of the left kidney (arrows). (b) Axial CT image shows massive perinephric haematoma (arrows). (c) Coronal reformatted CT image shows a large devitalised fragment in the lower pole of the left kidney (arrows).

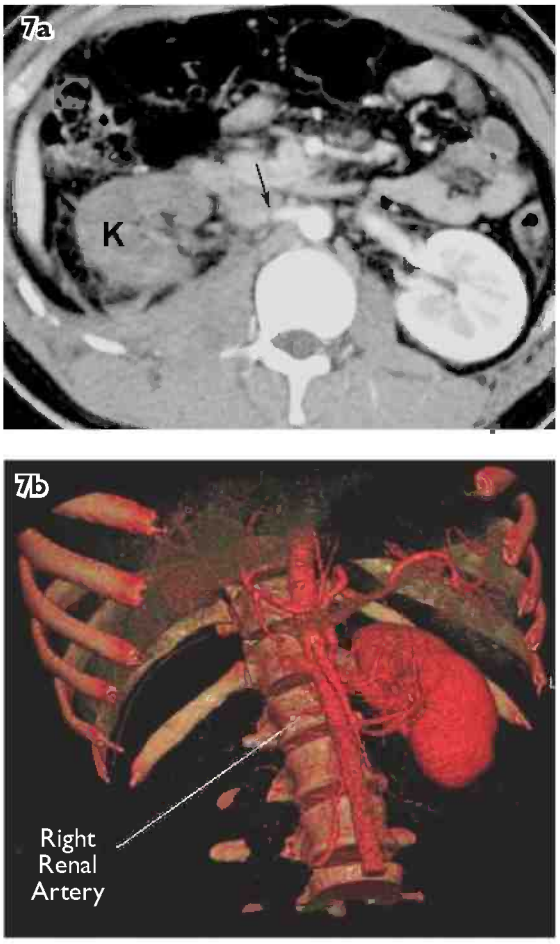

Fig. 7 Category III: A 19-year-old man with blunt abdominal trauma. (a) Axial CT image shows truncation of the right renal artery about 1 cm after the aorta (arrow). This is associated with a non-perfused right kidney (K). (b) A 3-D reconstructed image shows a complete truncation of the right renal artery with multiple fractures of the right transverse processes of the lumbar vertebra.

cases with urinary extravasation or collecting system rupture. Major renal laceration appears as a larger hypodense lesion involving the renal cortex and extending into the medulla and collecting system (Figs. 3 & 4). If the laceration extends through the kidney, it would appear as a cleft extending into the collecting system on reconstructed views, depending on the site of the laceration. A large perinephric haematoma that appears as a hypodense nonenhancing perinephric collection

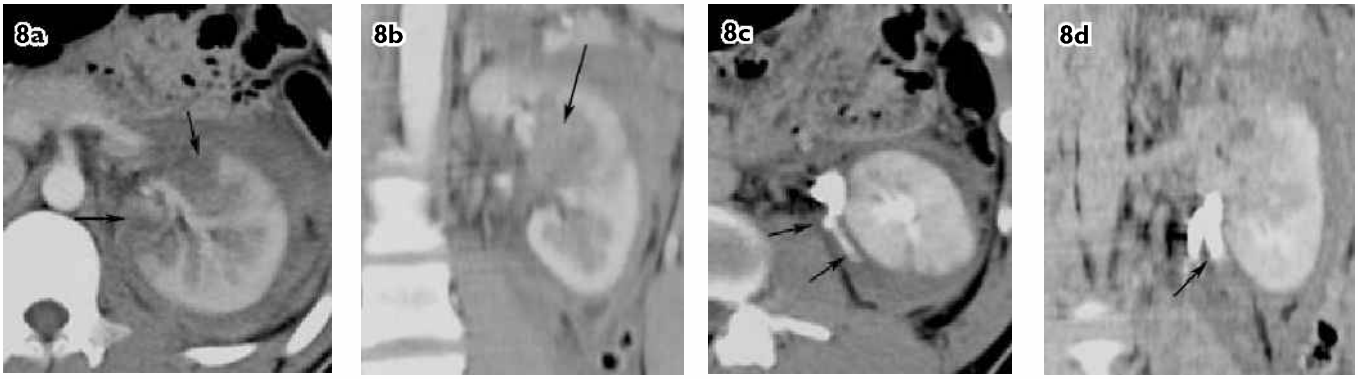

Fig. 8 Category IV: A 21-year-old man with blunt abdominal trauma. (a & b) Axial and coronal reformatted CT images show major renal laceration involving the medulla (arrows). (c & d) Axial and coronal reformatted CT images in the excretory phase show laceration at the ureteropelvic junction (UPJ) as evidence by the leaking of contrast at the UPJ (arrows).

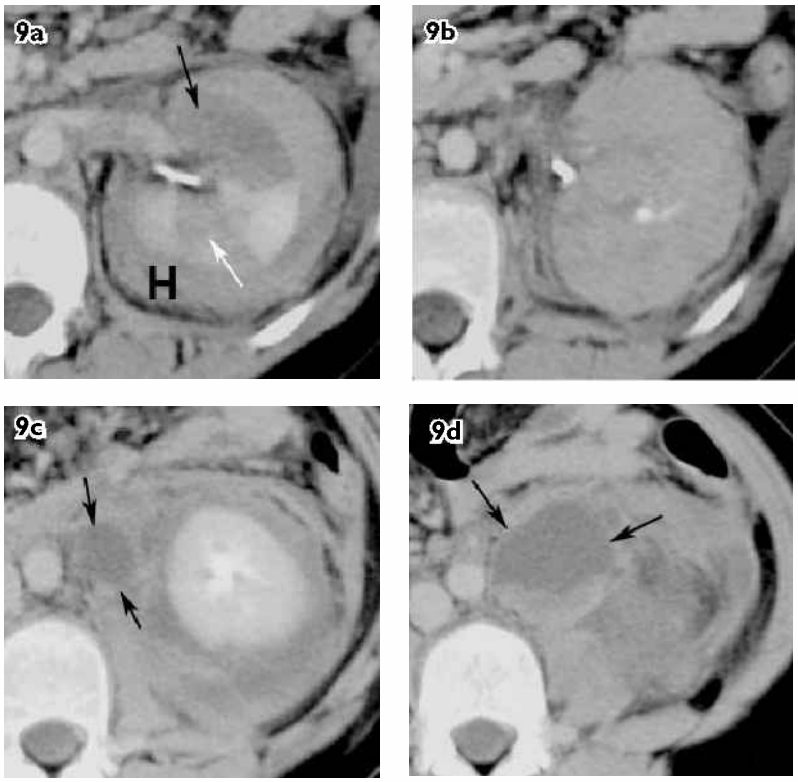

Fig. 9 Category IV: A 10-year-old boy with blunt abdominal trauma. (a) Axial CT image shows major laceration involving the medulla (white arrow) with massive perinephric haematoma (H) and devitalised fragments (black arrow). (b) Axial CT image in the excretory phase shows no contrast extravasation. (c & d) A repeat CT imaging was performed four days later due to shock. Axial CT images show massive collection in the periureteric region (arrows), suggestive of ureteropelvic injury.

is associated with major renal laceration, and is more extensive than in category I (Figs. 3 & 5a). If the collecting system is involved, there would be urine extravasation in the excretory phase (Fig. 5b). Other findings, such as segmental infarct (wedge-shaped, well-defined hypodense lesion involving the renal parenchyma), may also be observed. This usually comprises approximately 10% of renal injuries.[1,2] Management is variable; most are treated conservatively, but occasionally, some may require surgical intervention, depending on the evolution of the injury.[1,4] Due to this, category II patients need close follow-up and observation.

Category III

Category III lesions are catastrophic injuries, which include multiple renal lacerations and vascular injury involving the renal pedicle. Category III corresponds to Grade IV of the AAST renal injury severity scale. Multiple renal lacerations or a shattered kidney would appear as multiple clefts extending through the renal parenchyma and collecting system (Fig. 6a). With a shattered kidney, devitalised fragments can occur due to a lack of vascular supply (nonenhancing segments) (Figs. 6b & c). A devitalised fragment may be obscured by a large perinephric haematoma (Fig. 6c), and a large perinephric haematoma

would appear as a large hypodense perinephric collection (Fig. 6a). If there are multiple devitalised fragments, severe impairment in renal excretion would be observed.

Vascular injury includes renal artery thrombosis, renal artery avulsion or renal vein thrombosis. Renal artery thrombosis results from severe deceleration that causes tearing of the tunica intima. The intimal flap would cause thrombosis of the renal artery.[12] On CT, global renal infarction with an abrupt termination of the proximal renal artery (Figs. 7a & b) can be seen. The absence of perinephric haematoma is characteristic of renal artery thrombosis (Fig. 7a). A cortical rim sign may be seen several days after the injury.[13] Renal arteriography is not indicated since a 3-D reformation would exquisitely show the truncation of the affected renal artery (Fig. 7b).

Renal artery avulsion is caused by the tearing of the tunica adventitia and muscularis. There is an associated large perinephric haematoma and contrast extravasation with associated global renal infarction.[14] Renal vein thrombosis is a rare vascular injury in blunt renal trauma. On CT, a filling defect within the renal vein associated with distension of the renal vein can be observed.[15] Category III renal injuries account for about 5% of the cases. The management of category III renal injuries is controversial and has been a source of much debate for many years. However, it can be successfully managed conservatively. Surgical interventions may be necessary only in patients with other associated intraabdominal injuries or in those who are haemodynamically unstable.[5]

Category IV

UPJ injury constitutes category IV of the renal injuries, and can be caused either by avulsion (complete transection) or laceration (incomplete tear) of the UPJ. Category IV corresponds to Grade V of the AAST renal injury severity scale. The hallmark of category IV is the involvement of the UPJ. It results from a sudden deceleration that causes tension on the renal pedicle. In laceration, urine extravasation can be seen at the UPJ. Contrast can still be visualised in the proximal ureter due to the incomplete laceration (Figs. 8a–d). In avulsion, the diagnosis may be delayed due to the absence of haematuria. In early scans, contrast extravasation may not be seen due to impaired renal excretion secondary to multiple devitalised fragments (Figs. 9a & b). A repeat CT must be performed 2–3 days later in haemodynamically unstable patients.[10] A circumferential urinoma would appear around the renal pedicle (Figs. 9c & d). Category IV lesions are quite rare, and there may be a delay in diagnosis due to the absence of haematuria (30%).[1,9] Immediate surgical intervention is often required, especially with avulsion.[1,9]

CONCLUSION

CT has a major role in the investigation of renal trauma and is currently the imaging modality of choice. Categorising the renal injuries according to the Federle classification or the AAST renal injury severity scale is very helpful in the management of injured patients. The majority of renal injuries do not require surgical intervention, and conservative management has been universally accepted.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Hospital Director of Hospital Tengku Ampuan Afzan, Kuantan, Malaysia, for granting permission to use the CT images of the patients involved. We also thank all the surgical and radiological staff of Hospital Tengku Ampuan Afzan, Kuantan and International Islamic University Malaysia for their assistance in the care and treatment of the patients.

REFERENCES

1. Kawashima A, Sandler CM, Corl FM, et al. Imaging of renal trauma: a comprehensive review. Radiographics 2001; 21:557-74.
2. Carpio F, Morey AF. Radiographic staging of renal injuries. World J Urol 1999; 17:66-70.
3. McAninch JW, Santucci RA. Renal and ureteral injuries. In: Gillenwater JY, Grayhack JT, Howards SS, Mitchell ME, eds. Adult and Pediatric Urology. Philadelphia: Lippincott Williams & Wilkins, 2002: 479-506.
4. Dunnick NR, Sandler CM, Newhouse JH, Amis ES. Urinary tract trauma. In: Dunnick NR, Sandler CM, Newhouse JH, Amis ES, eds. Textbook of Uroradiology. Philadelphia: Lippincott Williams & Wilkins, 2001: 451-83.
5. Thall EH, Stone NN, Cheng DL, et al. Conservative management of penetrating and blunt type III renal injuries. Br J Urol 1996; 77:512-7.
6. Morey AF, McAninch JW, Tiller BK, Duckett CP, Carroll PR. Single shot intraoperative excretory urography for the immediate evaluation of renal trauma. J Urol 1999; 161:1088-92.
7. McGahan JP, Rose J, Coates TL, Wisner DH, Newberry P. Use of ultrasonography in the patient with acute abdominal trauma. J Ultrasound Med 1997; 16:653-62.
8. Federle MP, Kaiser JA, McAninch JW, Jeffrey RB, Mall JC. The role of computed tomography in renal trauma. Radiology 1981; 141:455-60.
9. Kawashima A, Sandler CM, Corriere JN Jr, Rodgers BM, Goldman SM. Ureteropelvic junction injuries secondary to blunt abdominal trauma. Radiology 1997; 205:487-92.
10. Blankenship JC, Gavant ML, Cox CE, Chauhan RD, Gingrich JR. Importance of delayed imaging for blunt renal trauma. World J Surg 2001; 25:1561-4.
11. Santucci RA, Wessells H, Bartsch G, et al. Evaluation and management of renal injuries: Consensus statement of the renal trauma subcomittee. BJU Int 2004; 93:937-54.
12. Kawashima A, Sandler CM, Ernst RD, et al. CT evaluation of renovascular disease. Radiographics 2000; 20:1321-40.
13. Glazer GM, Francis IR, Brady TM, Teng SS. Computed tomography of renal infarction: clinical and experimental observations. Am J Roentgenol 1983; 140:721-7.
14. Fanney DR, Casillas J, Murphy BJ. CT in the diagnosis of renal trauma. Radiographics 1990; 10:29-40.
15. Blankenship B, Earls JP, Talner LB. Renal vein thrombosis after vascular pedicle injury. Am J Roentgenol 1997; 168:1574.

SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 201006B)

	True	False
Question 1. Regarding intraabdominal injury:		
(a) Renal involvement is seen in 50% of all cases.	☐	☐
(b) The majority of renal injuries are due to blunt trauma to the abdomen.	☐	☐
(c) A direct blow to the abdomen usually results in renal pedicle injury.	☐	☐
(d) Injuries to the renal vessels only occur with penetrating abdominal trauma.	☐	☐
Question 2. Indications for renal imaging in trauma cases include the following:		
(a) Gross haematuria.	☐	☐
(b) Microscopic haematuria in a haemodynamically stable patient.	☐	☐
(c) Penetrating injury to the loin.	☐	☐
(d) Presence of flank bruising and collection of free fluid seen in abdominal ultrasonography.	☐	☐
Question 3. Regarding CT scanning protocol in renal trauma:		
(a) It is performed in the corticomedullary and excretory phases.	☐	☐
(b) The corticomedullary phase is performed after 5 seconds of contrast injection.	☐	☐
(c) CT of the abdomen needs to be repeated 2–3 days later in all patients.	☐	☐
(d) Urine extravasation can be seen in the corticomedullary phase.	☐	☐
Question 4. The following are the features of Category II Federle Classification of renal injuries:		
(a) Major renal laceration through the cortex.	☐	☐
(b) It extends to involve the medulla or collecting system.	☐	☐
(c) There must be associated urine extravasation.	☐	☐
(d) Segmental renal infarct.	☐	☐
Question 5. Regarding Category III Federle classification of renal injuries:		
(a) It corresponds to Grade III of the AAST renal injury severity scale.	☐	☐
(b) The absence of perinephric haematoma is characteristic of renal artery thrombosis.	☐	☐
(c) Renal vein thrombosis is more common than renal artery thrombosis.	☐	☐
(d) Category III renal injuries account for about 20% of cases.	☐	☐

Doctor's particulars:

Name in full: _____

MCR number: _____ Specialty: _____

Email address: _____

SUBMISSION INSTRUCTIONS:
(1) Log on at the SMJ website: http://www.sma.org.sg/cme/smj and select the appropriate set of questions. (2) Select your answers and provide your name, email address and MCR number. Click on "Submit answers" to submit.

RESULTS:
(1) Answers will be published in the SMJ August 2010 issue. (2) The MCR numbers of successful candidates will be posted online at www.sma.org.sg/cme/smj by 27 August 2010. (3) All online submissions will receive an automatic email acknowledgment. (4) Passing mark is 60%. No mark will be deducted for incorrect answers.(5) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council.

Deadline for submission: (June 2010 SMJ 3B CME programme): 12 noon, 20 August 2010.