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Imaging diagnostics of renal trauma

Trauma is the leading cause of death in the developed countries. It is difficult to determine the extent of abdominal injury. The renal injures are often in patients with blunt abdominal trauma. The imaging diagnostics is therefore very important (3, 5, 6). Imaging modalities used in the evaluation of patients with abdominal trauma include ultrasound, often used as the first examination method and computed tomography, imaging modality of choice. In the cases of renal injuries intravenous urography may also be used. US examination is quick, and noninvasive. In CT examination in patients with renal injury the presence of retroperitoneal haematoma is often found without the presence of the peritoneal haematoma (3, 5, 6).

The aim of the study is presenting the diagnostic value of different imaging modalities in the evaluation of renal injury.

MATERIAL AND METHODS

The material comprises a group of 16 patients (4 women and 12 men) aged 12–82 years with blunt abdominal trauma. Six of them were treated surgically. The examinations were performed between 1996 and 2003 in the 2nd Department of Radiology, Medical University of Lublin. Plain abdominal radiography was performed in 9 patients, urography in 7, US examination in 16 patients and CT in 12 cases. The US examination was performed with Hitachi EUB 410 apparatus.

CT examination was performed with Somatom AR. T scanner by Siemens, equipped with two matrixes, 512 x 512 pixels and 320 x 320 pixels. High resolution reconstruction algorithm was used with the possibility of performing spatial reformations. Five- and 10-mm axial sections were performed before and after administering of contrast agents. Delayed scans were performed to reveal extravasations of contrast agent.

RESULTS

The renal injuries in US were found in 16 cases, 7 of them were isolated and in 9 patients multi--organ injuries were found, with liver injury in 2 of them.

The minor injuries were found in 8 cases. In other 8 cases severe renal injuries were found. The perirenal haematomas were visible as non-enhancing areas adjacent to kidney (Fig. 1A). The parenchymal laceration appeared as linear non-enhancing areas in the renal parenchyma (Fig. 1B). In the group of minor renal lesion in 3 cases the renal contusion was found and small parenchymal and subcapsular haematomas in 2 cases appearing as hyperdense subcapsular areas (Fig. 2A), without evident contrast enhancement (Fig. 2B). On plain radiography indirect signs were found, including

enlargement of renal shadow with hazy margin of kidney and iliopsoas muscle. In 2 cases simultaneous injury of the kidney and spleen was found.

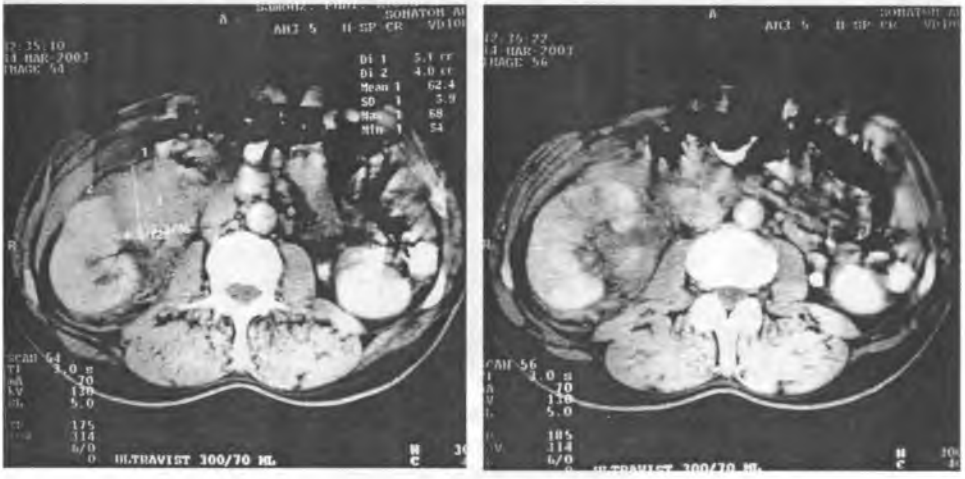

Fig. 1. Large inhomogeneous area adjacent to right kidney, not revealing contrast enhancement representing the perirenal haematoma (A). Linear, non-enhancing areas in the renal parenchyma representing renal lacerations (B)

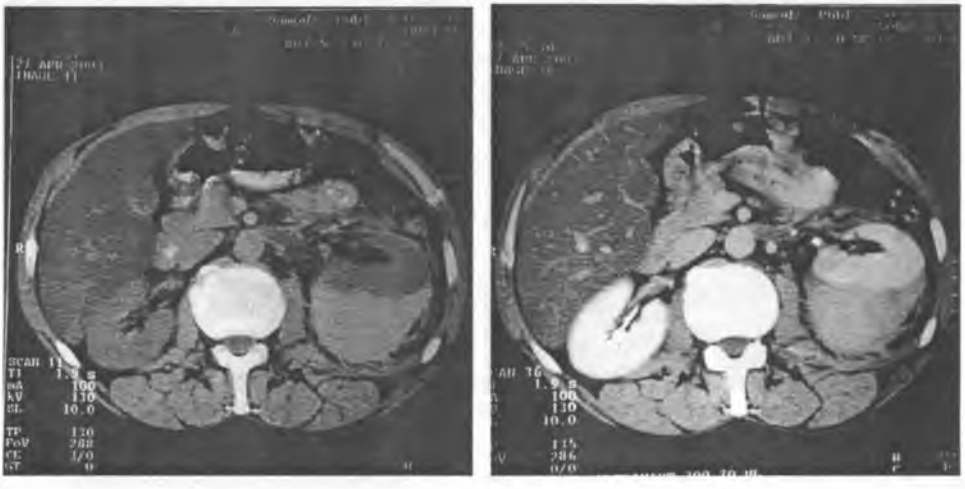

Fig. 2. Large hyperdense area adjacent to the left kidney on unenhanced section represents subcapsular haematoma (A). Decreased contrast enhancement of the left kidney and lack of enhancement of the haematoma on section after administering of contrast agent (B)

In 4 cases of severe renal trauma US examination revealed the laceration of the renal parenchyma. In 2 cases CT revealed perirenal extravasations of blood, appearing as perirenal masses (density of 50 HU), and not revealing contrast enhancement. In 2 cases in CT retroperitoneal haematomas were found (Fig. 3AB). The absence of excretion was found in 2 cases, representing severe injury of the renal pedicle. In 3 cases the injury of ureteropelvic system with extravasations of the contrasted urine into perinephric area was found in CT, and in urography (Fig. 4). That was the most frequent urographic sign of renal laceration. In 3 cases axial sections revealed injuries of renal collecting system, with

Fig. 3. Hyperdense areas surrounding the right kidney on unenhanced sections (A). The perirenal areas do not reveal contrast enhancement, after administering of contrast agent (B) represent perirenal haematoma

Fig. 4. The extravasation of contrast agent in urography

Fig. 5. The subtle extravasation of contrast agent on CT section represents injury of ureteropelvic system. The right kidney surrounded by hipodense area of perirenal haematoma

subtle extravasation of contrasted urine (Fig. 5). In 2 other cases of extensive parenchymal injuries US examination revealed irregular areas of inhomogeneous reflectivity. In one case the perirenal abscess was found on CT examination representing complication of perirenal haematoma (Fig. 6AB).

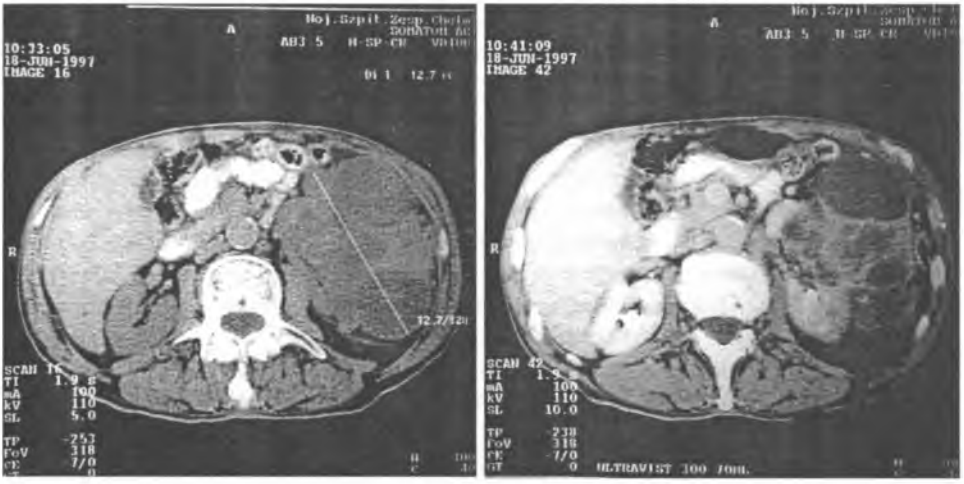

Fig. 6. Perirenal abscess on the left on CT examination representing complication of perirenal haematoma. Fragmentation of renal parenchyma
(A – unenhanced section; B – section after administering of contrast agent)

DISCUSSION

Injury to the kidney is seen in approximately 8–10% of patients with blunt or penetration abdominal injuries. Serious renal injuries are frequently associated with injuries to other organs. About 98% of isolated renal injuries are classified as minor injuries (3, 4).

Radiographic evaluation of the urinary tract is indicated in patients with penetrating abdominal injury, blunt trauma associated with hematuria, microscopic hematuria and hypotension (< 90 mmHg). Moreover, the imaging diagnosis is indicated in patients with other injuries known to be associated with renal injury, e.g., fractures of lower ribs, or thoraco-lumbar spine (3, 4). CT has replaced intravenous urography as the primary modality for assessment of suspected renal injuries, and become the imaging modality of choice in evaluating of blunt abdominal trauma. CT provides precise delineation of renal laceration; helps determine the presence and location of renal haematoma and urinary extravasations or devascularized segments of the renal parenchyma. CT can help differentiate trivial injuries from those requiring intervention (1, 3, 4).

Although urography is no longer the primary modality for the assessment of suspected renal injuries, it may be helpful in situations in which there would be a significant delay in obtaining high--quality CT scans. When urographic findings are abnormal, CT is necessary to help determine the nature and extent of a parenchymal injury. The primary role for urography is the assessment of gross function and the evaluation of the uninjured kidney in thermodynamically unstable patients to undergo CT and in those who are already in the operating room (4). The use of arteriography in the assessment of renal injuries has diminished because most vascular injuries can be assessed with CT. However, selective renal arteriography can provide more detailed information regarding the exact anatomic area of vascular injury than is possible with CT. Arteriography with transcatheter embolization may be used for non- surgical therapy in hemodynamically stable patients with renal injuries associated with hemorrhage (1, 4). US is well accepted as a method for detecting haemoperitoneum in patients with suspected intraperitoneal injuries following blunt trauma, but is limited compared with CT in the evaluation of the renal parenchyma (4, 6).

Renal injuries can be classified into four categories: Category I – minor injuries – includes renal contusions, subcapsular haematoma, minor lacerations with limited perinephric haematoma without

extension to the collecting system or medulla, and small cortical infarcts. Category I renal injuries constitute 75–85% of all renal injuries and are generally managed conservatively. The majority of minor injuries represent small intrarenal haematoma (renal contusions) which may appear as ill-defined, round or ovoid hypo attenuating areas at CT. They may also appear at focal areas of striation on delayed nephrograms or persistent contrast material staining in nephrograms obtained even later. A subcapsular haematoma appears as a round or elliptic hyper attenuating fluid collection indenting or flattening the renal margin. The fluid density of 40–70 HU is typical of acute bleeding. Minor lacerations appear as defect in the periphery of the renal parenchyma without involvement of the collecting system. A limited perinephric haematoma may be present. Subsegmental infarcts are recognized at CT and appear as small, sharply demarcated, wedge-shaped areas of decreased contrast enhancement, whereas renal contusions are not as well defined or sharply demarcated (3, 4).

Category II comprises approximately 10% of renal injuries and includes major lacerations through the cortex extending to the medulla or collecting system with or without urinary extravasations. Major lacerations of renal parenchyma appear as deep clefts that fill with haematoma with or without devascularized renal parenchyma and extend through the renal capsule associated with a perirenal haematoma. When the laceration extends into the renal collecting system, extravasations of excreted contrast material will be present on delayed views. Urine leakage due to a deep renal parenchymal laceration usually occurs into the lateral perinephric space (1, 4). Segmental infarcts appear as a sharply demarcated segmental region of decreased enhancement of the parenchyma (3, 4). The management of category II lesions is variable. Affected patients are usually treated conservatively but occasionally require surgical intervention, depending on haemodynamic status and the evolution of the injury (4).

Category III accounts for approximately 5% of cases and generally requires surgical exploration, often nephrectomy. They include multiple renal lacerations and vascular injures involving the renal pedicle (4). Multiple severe renal lacerations are usually associated with one or more devitalized fragments, severe compromise in the excretion of contrast material, lacerations of the renal pelvis and collecting system, extensive hemorrhage and active artery bleeding. A devitalized segment due to a major laceration may not be appreciated at CT if it is surrounded by a haematoma. Active arterial extravasations appear as patchy areas of hyper attenuating contrast material (85–370), within a lower--attenuation haematoma. The presence of active arterial bleeding indicates a category III renal injury. Intraarterial embolization may by used to salvage the kidney (3, 4).

The most significant vascular injury following the blunt trauma is thrombosis of the main renal artery. Lacerations and tearing of the intima, which is less elastic than the media and adventitia, induce thrombosis. Global infraction is less common than segmental or subsegmental in patients who sustain blunt trauma. No visualization of the kidney is consistent with thrombosis of the main renal artery, but can also characterize other conditions including congenital or surgical absence of the kidney, renal ectopia, renal vascular spasm due to severe contusion, avulsion of the renal pedicle and high grade urinary obstruction. Contrast enhanced CT typically reveals an abrupt termination of the renal artery and global renal infraction with or without the cortical rim sign. The cortical rim sign usually appears several days after the initial injury, but may be seen even 8 hours afterwards. The absence of the perinephric haematoma is characteristic of the renal arterial occlusion (3, 4).

Avulsion of the renal artery is a rare but life threatening injury, that usually requires immediate surgical intervention (4).

Category IV is a rare consequence of blunt trauma and is caused by sudden deceleration, which creates tension on the renal pedicle. The diagnosis may be delayed because hematuria is absent in 1/3 of patients. Urography and CT typically reveal excellent excretion of contrast material with an intact intrarenal collecting system. A circumferential urinoma may be seen around the affected kidney, but typically there is no perinephric haematoma. Ureteropelvic junction injuries are classified into two

groups: avulsion (complete transaction) and laceration (incomplete tear). The presence of the contrast material in the ureter distal to the ureteropelvic junction helps differentiate laceration from avulsion. When neither CT nor intravenous urography unequivocally demonstrates ipsilateral ureteral filling, retrograde pyelography should be performed (4).

In the widely used classification system of American Association of Surgeons in Trauma there are 5 categories (2): 1) microscopic and gross hematuria with normal findings of imaging studies; renal contusion; nonexpanding subcapsular haematoma without parenchymal laceration; 2) nonexpanding perirenal haematoma confined to the retro-peritoneum; superficial lacerations (< 1 cm depth) in the renal cortex; 3) laceration > 1 cm depth in the renal cortex without extension into the collecting system or urinary extravasation; 4) lacerations extending through the renal cortex, medulla, and collecting system; injuries to the main renal artery or vein with contained hemorrhage; thrombosis of a segmental renal artery without parenchymal laceration; 5) laceration that completely shatters the kidney; injuries to the renal hilum with devascularization of the kidney; traumatic renal arterial disruption; traumatic renal arterial occlusion (2).

CT plays the main role in the assessment of the patients with renal injuries. The classification of the injury based on the CT examination is very important (2, 4). The CT protocol includes both unenhanced and enhanced sections. Examination after administering of contrast agent is essential in patients with suspected reno-vascular lesions. Unenhanced sections are useful in assessing the renal hemorrhage, parenchymal calcifications or evaluation of pathological masses. In case of renal trauma unenhanced sections are usually unnecessary. Enhanced CT is useful in direct visualization of renal vessels and identifying of nephrogram abnormalities due to vascular lesions (2, 3).

CONCLUSIONS

Radiological evaluation of kidney in patients which sustained abdominal trauma is generally indicated in patients with hypotension < 90 mm Hg and hematuria. CT is a preferred image method, enabling the evaluation of the injury category. CT is essential in qualifying patients for conservative or surgical management. USG is also useful in initial diagnosis, but usually precise renal evaluation requires additional CT examination.

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SUMMARY

The aim of the study is presenting the diagnostic value of different imaging modalities in the evaluation of patients with renal injury. The material comprises a group of 16 patients with blunt abdominal trauma. Six of them were treated surgically. Plain abdominal radiography was performed in 9 patients, urography in 7, US examination in 16 patients and CT in 12 cases. The renal injuries in US were found in 16 cases, 7 of them were isolated and in 9 patients multi-organ injuries were found, with liver injury in 2 of them. The minor injuries were found in 8 cases. In other 8 cases severe renal injuries were found. The perirenal haematomas were visible as non-enhancing areas adjacent to kidney. The parenchymal laceration appeared as linear non-enhancing areas in the renal parenchyma. In the group of minor renal lesion in 3 cases the renal contusion was found and small parenchymal and subcapsular haematomas in 2 cases appearing as hyperdense subcapsular areas, without evident contrast enhancement. In 2 cases CT revealed perirenal extravasations of blood, appearing as perirenal masses (density of 50 HU), and not revealing contrast enhancement. In 2 cases in CT retroperitoneal haematomas were found.

The absence of excretion was found in 2 cases, representing severe injury of the renal pedicle. In 3 cases the injury of ureteropelvic system with extravasations of the contrasted urine into perinephric area was found in CT and in urography. That was the most frequent urographic sign of renal laceration. In 3 cases axial sections revealed injuries of renal collecting system, with subtle extravasation of contrasted urine. In 2 other cases of extensive parenchymal injuries US examination revealed irregular areas of inhomogeneous reflectivity. Radiological evaluation of kidney in patients which sustained abdominal trauma is generally indicated in patients with hypotension < 90 mm Hg and hematuria. CT is preferred image method, enabling evaluation of the injury category. CT is essential in qualifying of patients for conservative or surgical management. USG is also useful in initial diagnosis, but usually precise renal evaluation requires additional CT examination.

Diagnostyka obrazowa urazów nerek

Celem pracy jest przedstawienie wartości diagnostycznej różnych metod obrazowania w ocenie pacjentów z urazami nerek. Materiał stanowi grupa 16 pacjentów z tępymi urazami brzucha. Sześciu z nich było leczonych chirurgicznie. Zdjęcie przeglądowe było wykonane u dziewięciu z nich, urografia u siedmiu, USG u 16 i TK u 12. Uszkodzenie nerek było stwierdzone w USG w 16 przypadkach, w 7 było to izolowane uszkodzenie, a w 9 wielonarządowe, z uszkodzeniem wątroby w 2 przypadkach. Urazy nerek niewielkiego stopnia stwierdzono u 8 pacjentów, u pozostałych stwierdzono urazy ciężkie. Krwiaki okołonerkowe były widoczne jako niewzmacniające się obszary okołonerkowe. Pęknięcia miąższu nerek były widoczne jako linijne niewzmacniające się pasma miąższu nerki. Stłuczenie nerek z małymi krwiakami podtorebkowymi stwierdzono u trzech pacjentów. W dwu przypadkach stwierdzono wynaczynienie krwi, tworzące obrazy mas okołonerkowych densyjności ok. 50 J. H. niewykazujących wzmocnienia kontrastowego. Brak wydzielania stwierdzono w dwu przypadkach ciężkich uszkodzeń szypuły naczyniowej. W trzech przypadkach uszkodzenia układu kielichowo-miedniczkowego stwierdzono wynaczynienie kontrastowego moczu w TK i urografii. W trzech przypadkach przekroje osiowe TK wykazały uszkodzenie układu zbiorczego nerki. Radiologiczna ocena nerek u pacjentów z tępymi urazami jamy brzusznej jest ogólnie wskazana u pacjentów z ciśnieniem poniżej 90 mm Hg oraz z obecnością krwinko- lub krwiomoczu. TK jest preferowaną metodą obrazowania, umożliwia ocenę stopnia uszkodzenia nerek oraz umożliwia kwalifikację pacjentów do leczenia zachowawczego lub do leczenia chirurgicznego. USG jest również użyteczne jako badanie wstępne, ale zwykle do pełnej oceny wymaga wykonania badania TK.