Accuracy of sonography in detection of renal injuries caused by blunt abdominal trauma: a prospective study

Künt abdominal travmanın neden olduğu böbrek yaralanmalarının saptanmasında sonografinin doğruluğu: Prospektif bir çalışma

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BACKGROUND
This prospective study was conducted to evaluate the accuracy of sonography in detection of renal injuries caused by blunt abdominal trauma.

METHODS
One hundred sixty-four patients (131 M, 33 F) with a history of recent blunt abdominal trauma who were stable enough to undergo both sonography and CT scan were included in this study. All of the cases had accepted indications for renal imaging. Ultrasound, as simultaneous gray scale B-mode scan and color-Doppler study, was achieved in all of the patients as the first imaging modality. Considering CT scan as the imaging modality of choice in evaluation of renal injuries caused by trauma, sonography findings were compared with CT scan results.

RESULTS
Of the 164 patients referred for kidney sonography and CT scan, renal damage was detected in 103 cases by CT scan (63%). In 14 patients (13.5%), bilateral renal injuries were identified. Considering grading classification proposed by the American Association for the Surgery of Trauma (AAST), 57%, 24%, 9.5%, 6% and 3.5% of renal injuries were diagnosed as grade I, II, III, IV and V, respectively, by CT scan. O f the 164 patients, ultrasound results were consistent with renal damages in 66 cases (40%). Of these patients, signs of parenchymal hematoma, perinephric hematoma and pelvocaliectasis associated with internal echogenicity were the most prevalent ultrasound findings. Overall sensitivity and specificity of sonography in detection of renal injures were 48% and 96%, respectively, with a 0.8 positive predictive value, a 0.57 negative predictive value and an overall accuracy of 79%.

CONCLUSION
In spite of the availability and ease of performance of sonography in evaluation of trauma victims, this imaging modality has low sensitivity in detection of renal injuries and overlooks significant damages. CT scan should be considered as the diagnostic modality in victims of kidney trauma who are hemodynamically stable and have clear indications for renal imaging.

Key Words: Kidney; trauma; sonography.

AMAÇ
Bu prospektif çalışmada, künt abdominal travmanın neden olduğu böbrek yaralanmalarının saptanmasında sonografinin doğruluğu değerlendirildi.

GEREÇ VE YÖNTEM
Bu çalışmaya, yakın zamanlarda künt karın travma öyküsü olan, hem sonografi hem de bilgisayarlı tomografi (BT) alacak kadar stabil durumda olan 164 hasta (131 erkek, 33 kadın) dahil edildi. Olguların hepsi renal görüntüleme endikasyonunu kabul etti. Ultrason, bütün hastalarda ilk görüntüleme yöntemi olarak, simültane gri skala B-mod tarama ve renkli Doppler çalışması şeklinde gerçekleştirildi. Travmanın neden olduğu böbrek yaralanmalarının değerlendirilmesinde BT'nin seçkin görüntüleme yöntemi olduğu göz önünde bulundurularak, sonografi bulguları BT sonuçları ile karşılaştırıldı.

BULGULAR
Böbrek sonografisi ve BT taraması için gönderilen 164 hastanın 103'ünde (%63), BT görüntüleme ile böbrek yaralanması saptandı; 14 hastada (%13,5), bilateral böbrek yaralanması saptandı. Amerikan Travma Cerrahisi Birliği (AAST) tarafından önerilen grade sınıflaması göz önünde bulundurularak, böbrek yaralanmalarının %57'si, %24'ü, %9,5'i, %6'sı ve %3,5'ine BT tarama ile sırasıyla grade I, II, III, IV ve V olarak tanı konuldu. Yüz altmış dört hastanın 66'sında (%40) ultrason bulguları, böbrek yaralanmalarıyla uyumlubulundu. Bu hastalarda, internal ekojenite ile birlikte olan parankimal hematom, perinefrik hematom ve pelvokaliektazi en yaygın ultrason bulguları idi. Böbrek yaralanmalarının saptanmasında sonografinin genel duyarlılığı ve özgüllüğü, 0,8'lik bir pozitif öngörme değeri, 0,57'lik bir negatif öngörme değeri ve %79'luk bir genel doğrulukla birlikte sırasıyla %48 ve %96 olarak bulundu.

SONUÇ
Travmalı olguların değerlendirilmesinde sonografinin kullanılabilirliği ve uygulanmasının kolay olmasına karşın, bu görüntüleme yöntemi, böbrek yaralanmalarının saptanmasında düşük duyarlılığa sahiptir ve önemli hasarları gözden kaçırır. BT görüntüleme, hemodinamik olarak stabil olan ve böbrek görüntülemesi bakımından açık endikasyonu bulunan böbrek travmalı kişilerde tanı yöntemi olarak göz önünde bulundurulmalıdır.

Anahtar Sözcükler: Böbrek; travma; sonografi.

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Traumatic injury is a leading national and international health problem and is the leading cause of mortality and morbidity for persons between 1 and 44 years of age.[1] Renal trauma occurs in 3% of patients hospitalized for trauma and in 8 to 10% of all patients with abdominal trauma. Blunt force is responsible for 70 to 80% of renal trauma, whereas 6 to 14% of penetrating abdominal wounds result in kidney damage.[2] Since conservative, non-operative management is preferred even in major renal injuries, accurate assessment with imaging modalities becomes central for guiding patient management.

Sonography is an easy-to-perform imaging modality with relatively high diagnostic yield, and its availability and lack of ionizing radiation are other advantages of its use in the early investigation of patients, including cases of blunt abdominal trauma. In spite of considerable accuracy of sonography in detection of free fluid in the abdomen of trauma victims, there is significant controversy about the accuracy of this imaging modality in the diagnosis of renal damage caused by blunt trauma. Our prospective study was thus conducted to determine the usefulness of this imaging modality in this respect.

MATERIALS AND METHODS

This prospective study was carried out over 26 months (February 2003 to May 2006) at the trauma center of Namazee Hospital, the largest hospital and referral center in the south of Iran, which is under the purview of Shiraz University of Medical Sciences. Of all trauma victims referred to the trauma center, 164 patients with history of recent blunt abdominal trauma (131 M, 33 F), who had accepted indications for radiological evaluation of the kidneys[3] and were stable enough to be evaluated by both sonography and computerized tomography (CT) scan, were selected and underwent investigation. Adult patients with gross or microscopic hematuria and shock (systolic blood pressure <90 mm Hg) as well as pediatric cases with any degree of hematuria were our indications for renal imaging in the cases of blunt abdominal trauma. Patients with blood in the urethral meatus or hematuria associated with pelvic fractures were evaluated for lower genitourinary trauma and were excluded from the study. Ultrasound, including Doppler study, preceded CT scan in all of the cases and the time gap between the two studies was kept to a minimum to make the studies comparable (mean interval: approximately 3 hours). Any longer interval may cause urinoma formation and render any comparisons inaccurate.

The patients' ages ranged from 2.5 to 71 years old (mean: 24.2 years). Ultrasound study was based on gray scale B-mode scanning and color-Doppler encoding in all of the patients, and was performed by an expert radiologist in genitourinary imaging on one of two machines (General Electric LOGIQ 500 or General Electric LOGIQ700, both manufactured in Milwaukee, Wisconsin). Certain conditions such as obesity, overlying gas-distended bowel loops and inappropriate positioning of the patients owing to rib fracture were the limiting and disturbing factors for optimal ultrasound investigation of kidneys in our study.

Computed tomography scan of the patients was performed on one of two CT units (Toshiba X vision 1/EX, Japan, and High Speed NX/I, General Electric Medical Systems). Routine oral contrast agent, in the form of 2% diluted ionic iodinated contrast, was given 40-60 minutes before the study. All of the patients received intravenous (i.v.) bolus of nonionic iodinated contrast agent (1.5-2 ml/kg of 300 mg iodine/ml). CT scan of the patients was done 30 seconds after the start of injection of contrast agent. The protocols employed in this study were: rate of 2 ml/s, collimation 7 mm, pitch 1.2 and reconstruction interval of 7 mm.

Delayed scans were also incorporated whenever there was suspicion of kidney injury (mean delay: 15 minutes). CT scan images were reviewed by an experienced radiologist disregarding the ultrasound results. Considering CT scan as the modality of choice for investigation of renal injuries caused by trauma, sensitivity and specificity of ultrasound in detection of renal injuries were determined.

RESULTS

Of the 164 selected patients who were referred to the Radiology Department for sonography and CT scan, kidney damage was detected in 103 patients by CT scan (67%). Bilateral renal injury (13.5%) was determined in 14 patients, so the overall renal injuries were 117 in our study (Fig. 1). Using the grading classification developed by the American Association for the Surgery of Trauma (AAST) 6, 67 (57%), 28 (24%), 11 (9.5%), 7 (6%) and 4 (3/5%) of the cases had grade I, II, III, IV and V renal injuries, respectively. Due to conclusive results of CT scan,

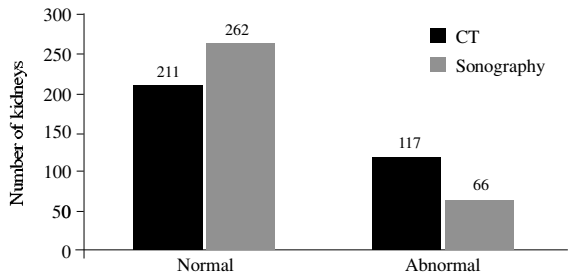

Fig. 1. Number of normal and abnormal kidneys detected by sonography and CT scan in 328 kidneys (164 patients) with blunt abdominal trauma.

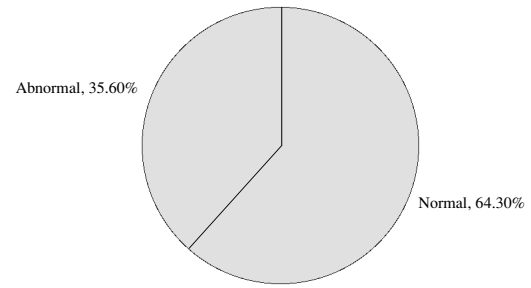

Fig. 2. CT scan results in 328 kidneys (164 patients) with blunt abdominal trauma.

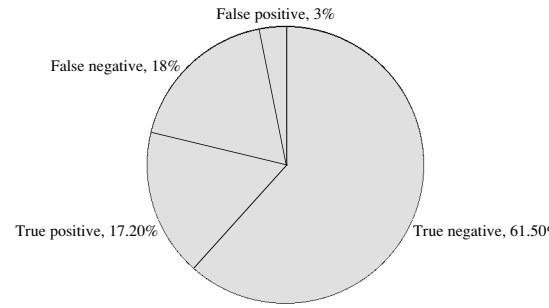

Fig. 3. Sonography results in 328 kidneys (164 patients) with blunt abdominal trauma.

angiography was not performed in suspected cases of renal pedicle injury. Fifteen (14.5%) patients underwent surgical intervention [4 patients with grade III (3.8%), 7 with grade IV (6.7%) and 4 with grade V (3.8%) renal injury], and operative findings were completely consistent with CT results (Table 1). CT scan results in 328 kidneys (164 patients) with blunt abdominal trauma were normal in 64.3% and abnormal in 35.6% of kidneys (Fig. 2).

Of 328 kidneys investigated by sonography in 164 patients (2 kidneys in each patient), ultrasound results were normal in 262 kidneys (80%) and varying abnormalities (related with trauma) were detected in the others (20%) (Fig. 1). Of 117 renal injuries confirmed by CT scan, sonography and Doppler study did not reveal any trauma-related abnormality in 69 kidneys (59%). In others, sonographic abnormalities were subcapsular hematoma in 12 patients (10.2%), disturbance of parenchymal ECHO texture of the kidneys in 19 patients (16.2%), pelvocaliectasis with internal echogenicity in the collecting system in 13 patients (11%), perinephric hematoma in 16 cases (13.6%) and shattered kidneys in 4 patients (3.5%). Accompanied Doppler study in all of the patients revealed disturbance of renal blood flow in 2 cases (1.7%); others had no Doppler flow encoding abnormality. Some of the patients revealed two or several ultrasound findings concurrently.

All of the shattered kidneys and cases of impaired renal vascularity diagnosed by sonography were grade V renal damage in CT scan (Table 2). CT scan disclosed no abnormality in 61 patients (37%); however, ultrasound results were consistent with parenchymal hematoma in 9 of these cases (false-positive results) (Fig. 3).

Statistical analysis revealed sensitivity and specificity of sonography for detection of renal injuries as high as 48% and 96%, respectively, with a 0.8 posi-

Table 1. CT findings in 164 cases of blunt kidney trauma (328 kidneys)

CT findings	Number of kidneys
Normal	211
Grade I	67
Grade II	28
Grade III	11
Grade IV	7
Grade V	4

Grade I: Contusion of kidney or subcapsular hematoma;
Grade II: Cortical laceration <1 cm not extending to a calyx;
Grade III: Cortical laceration >1 cm not extending to a calyx;
Grade IV: Cortical laceration extending to the collecting system or main renal artery or vein injury with contained hemorrhage;
Grade V: Shattered kidney or avulsed hilum causing devascularized kidney.

Table 2. Sonographic findings in 164 cases of blunt kidney trauma (328 kidneys)

Sonographic findings	Number of kidneys
Normal sonogoraphy and Doppler study	262
Subcapsular hematoma	12
Signs of parenchymal hematoma*	19
Pelvocaliectasis with internal echogenicity	13
Perinephric hematoma	16
Shattered kidney	4
Impaired blood flow in Doppler study	2

* In 9 of these cases, no abnormality was detected in CT scan.

tive predictive value, a 0.57 negative predictive value and an overall accuracy of 79% in our study.

DISCUSSION

Renal trauma can result from a variety of mechanisms. Motor vehicle accidents are the most common cause of blunt abdominal trauma leading to renal injury.[4] Penetrating injuries comprise 10-20% of cases of renal trauma. Most renal injuries are associated with hematuria (95%), which can be profuse in more severe renal trauma; however, in vascular pedicle injury or avulsion of ureteropelvic junction (UPJ), hematuria may not be present.[5] Because the most contemporary trends in trauma care, including renal trauma, call for less-invasive procedures, kidney imaging by a skilled radiologist is increasingly important.

Categorizing renal injuries according to severity helps in selecting appropriate therapy and predicting results of treatment. Several classifications of renal injuries exist but the most widely used and accepted classification was developed by the AAST. This grading system is based on CT findings (Table 1).[6]

Computed tomography scan is the imaging modality of choice in evaluating renal trauma; it is the overwhelming leader in diagnosing and staging renal traumatic injuries. It has several advantages: non-invasiveness, clear delineation of parenchymal laceration, sensitive detection of urinary extravasations, outlining of nonviable tissue, detection of associated injury in other organs, and overall accuracy near to 100% in detection of renal injuries.[7] CT scan has also been useful in detecting vascular injury to the kidneys.

The use of abdominal sonography for trauma patients remains controversial, particularly for detecting renal injuries. In the trauma setting, sonography is usually performed as a focused abdominal sonography for trauma (FAST) for the primary purpose of identifying free fluid in the abdomen. Availability and ease of performance of sonography are the main advantages of this modality in evaluation of traumatic patients.

More recently, several authors have reported an increased detection rate of solid organ injury in patients with blunt abdominal trauma using contrast-enhanced sonography.[8,9] In a study done by McGahan et al., among their patients with renal injuries, they detected 11 subcapsular hematomas on contrast-enhanced sonography compared with detection of only 4 of the 11 on non-contrast-enhanced sonography. There were three renal injuries in which only a renal laceration with a subcapsular hematoma was seen on non-contrast-enhanced sonography; these injuries were better seen with contrast-enhanced sonography. An avulsed kidney was not seen on non-contrast-enhanced sonography, whereas it was identified on contrast-enhanced sonography. A renal laceration was not seen with contrast-enhanced sonography. They concluded that contrast-enhanced sonography performed better than non-contrast-enhanced sonography for the detection of solid organ injuries. They mentioned that CT scan is the gold standard in the evaluation of patients with blunt abdominal trauma but that non-contrast-enhanced sonography continues to have an important role in the triage of patients with blunt abdominal trauma who are not hemodynamically stable and cannot undergo CT scan.[10]

As proposed by Miele et al.[11] and Catalano et al.,[9] there may be a future role for contrast-enhanced sonography in the initial evaluation of patients with blunt abdominal trauma. However, Poletti et al.[12] compared three different types of sonograms to CT. The initial or admission FAST examination was compared with a non-contrast-enhanced sonography control examination followed by contrast-enhanced sonography. They determined detection rates of solid organ injuries for the admission FAST examination, non-contrast-enhanced sonography, and contrast-enhanced sonography as 40%, 57%, and 80%, respectively. Although encouraged by this improved detection rate with contrast-enhanced sonography, they were discouraged because 18% of solid organ injuries were missed on contrast-enhanced sonography even after low-quality examinations had been eliminated. Their conclusion was that contrast-enhanced sonography cannot be recommended as a replacement for CT in hemodynamically stable trauma patients. In these patients, ultrasound is limited mainly by its low sensitivity in directly demonstrating organ injuries.

McGahan et al. investigated 32 patients with 37 renal injuries confirmed by CT scan or operative findings retrospectively. Among their patients, sonography was normal in 78% of cases, and they concluded that a negative sonography does not exclude renal injury and that other imaging modalities should be performed based on clinical and labo-

ratory findings.[13] Five hundred patients with a history of blunt abdominal trauma were investigated by sonography by McGahan et al. for detection of solid organ injuries. In this study, only one-fourth of kidney damages were identified by ultrasound, and the author suggested low accuracy of sonography in this respect.[14] In contradiction to the previously mentioned studies that showed limited value of sonography in detection of renal injuries caused by blunt trauma, Kshitish et al. reported nine patients with kidney injuries in their study. Sensitivity and specificity of sonography for detection of kidney injuries were 67% and 100%, respectively, and they suggested that sonography can be a useful imaging modality for detection of renal injuries caused by blunt trauma.[15]

In our study in over 164 patients with history of recent blunt kidney trauma, sensitivity and specificity of sonography for detection of renal injuries were 48% and 96%, respectively, with a 0.8 positive predictive value, a 0.57 negative predictive value and an accuracy of 79%. The prospective nature of the study as well as the higher number of investigated patients seem to be discriminating factors in comparison with some other reports; however, certain conditions such as fractured ribs with resultant limitation in the patient's position, superimposed gas-distended bowel loops and patient obesity were the interfering and limiting factors for optimal ultrasound study in this research.

On the basis of the aforementioned results, the major conclusion of our study, in contrast to some previous reports, is that in spite of the availability and ease of performance of sonography in the evaluation of trauma victims, this imaging modality has limited value in the detection of renal injuries caused by blunt abdominal trauma, and it may overlook significant damages. Thus, in hemodynamically stable patients who have clear indications for renal imaging, CT scan is the modality of choice in this respect.

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