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Diagnostic value of ultrasonography in the evaluation of blunt abdominal trauma

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PURPOSE
To evaluate the diagnostic value of ultrasonography (US) in detecting intraabdominal injuries in patients with blunt abdominal trauma.

MATERIALS AND METHODS
Blunt trauma patients admitted to the emergency department from January 2002 to August 2003 were retrospectively evaluated. A total of 454 patients with blunt abdominal trauma who underwent US examination were included. Ultrasonography results were compared with findings of CT, diagnostic peritoneal lavage, laparotomy and clinical course. Sensitivity, specificity, positive and negative predictive values of US in detecting free fluid, intraabdominal parenchymal organ injury or both were calculated.

RESULTS
Computed tomography, diagnostic peritoneal lavage and laparotomy results showed that intraabdominal organ injury was present in 37 of 454 patients. Ultrasonography examinations were positive in 51 patients. True-positive findings were seen in 32 of these patients. In these 32 patients, US examination showed free fluid in 19, fluid and abdominal organ injury in 11 and only abdominal organ injury in 2. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of US in detecting intraabdominal injury were 86.5%, 95.4%, 62.7%, 98.7% and 94.7%, respectively.

CONCLUSION
Ultrasonography has high diagnostic performance in the screening of patients with blunt abdominal trauma. Abdominal US is a useful and valuable diagnostic tool after clinical evaluation in patients with blunt abdominal trauma. Because of its high negative predictive value, we recommend that clinical follow up is adequate for patients whose US results are negative for intraabdomial organ injury.

Key words: • *abdominal injuries* • *ultrasonography* • *wounds, non-penetrating*

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General body traumas are being increasingly encountered as a health problem due to the facts that transportation is being widespreadly used and that population is growing at a rapid pace. General body traumas cover a wide spectrum ranging from a mild bruise to severe injuries of several organs and systems. Early diagnosis and treatment is of utmost importance as the delays result in increased rates of mortality and morbidity. Physical examination and laboratory tests provide guidance for the diagnosis, yet they are not always reliable (1). Blunt abdominal trauma (BAT) is generally together with multiple organ injuries, thus physical examination might yield misguiding information.

Diagnostic peritoneal lavage (DPL) is a sensitive diagnostic tool for those intraabdominal injuries resulting in hemoperitoneum. However, it is not of value in isolated organ injuries or retroperitoneal injuries (2). Furthermore, it is an invasive technique and the positive results also in intraabdominal injuries that do not require surgery are its disadvantages. This brings about the necessity to evaluate these patients with other diagnostic techniques. Computed tomography (CT) has high levels of sensitivity in diagnosing intraabdominal injuries. It is not usually the first option, because it requires exposure to X-rays, administration of contrast material and has high costs. Following clinical evaluation, ultrasonography (US) is the primary imaging modality of choice for diagnosis due to its being a non-invasive, easily accessible, and less costly tool which yields rapid results in screening.

The purpose of this study is to evaluate the diagnostic value of US in identifying intraabdominal injuries in patients with BAT.

Materials and methods

From January 2002 to August 2003, the files of the patients who have had emergency service admissions due to trauma were collected; among these, the ones having patient notes that could be evaluated, having a history of BAT, and having an US examination were included in the study. Patients with penetrating injuries were excluded from the study. The age and the gender of the patients, the mechanism of injury, the laboratory test results, the radiological reports, the procedures that were performed, the type of the treatment delivered, and the obtained results were recorded. Injury severity score of the patients was calculated with the method described by Baker et al. (3).

The US examinations were performed by the radiology residents. The presence of free fluid within the abdominal cavity was accepted as a positive sign for hemoperitoneum. US examinations were performed with SSA-270A (Toshiba, Japan) sonography device with a 3.75 MHz convex probe.

CT examinations were carried out with spiral CT (Xpres/GX, TSX-002a, Toshiba, Japan). A scout image was obtained while the patient was lying down on supine position and the area from the lower thoracic level to the pubic symphysis was identified as the field of examination. During the examination all patients were administered 120 ml of intravenous non-ionic contrast material at a flow rate of 3 ml/sec. Before performing the examination patients also received 1,000 ml of 3% diluted oral contrast within 45-60 min to the extent their general conditions allowed them. Patients with unfavorable general conditions had the examination performed with only the intravenous contrast material. CT examination started 60 seconds after the initiation of contrast material injection. Scanning parameters were 150 mAs, 120 kV, slice thickness of 10 mm, table moving speed of 10 mm/s (step rate 1). DPL was performed by the related department (i. e., general or pediatric surgery) at the emergency unit .

US findings were compared with those findings obtained by CT, DPL and laparotomy. Patients who had not undergone any examination other than US were evaluated by clinical observation. Patients who were followed up by clinical observation and then discharged were considered as being normal. In case of identification of free fluid, intra-abdominal organ injuries or both sensitivity, specificity, positive and negative predictive values of US were calculated.

Results

A total of 454 patients (318 males and 136 females) who have undergone US examination for BAT were included in the study. The ages of these patients ranged between 1 to 88 years, mean age was 30 years. The injury severity score was 11.7 ±11.5. The causes for BAT are summarized on Table 1.

Of these 454 patients, 24 had CT, 54 had DPL, 23 had laparotomy and 3 had control US while the remaining 331 were followed up with clinical observation in the emergency service or in the relevant department until the time of discharge. Thirty-one patients were operated on for co-existing craniofacial trauma, 12 of whom died. Seven patients died because of craniocervical trauma and 2 others due to thorax and extremity traumas.

Based on the results of CT, DPL and laparotomy, 37 patients were identified with intra-abdominal injuries. Five patients had more than one organ injury of which 10 were splenic, 6 were renal, 6 were gastrointestinal (GI) and 2 were ruptures of the urinary bladder while one was the rupture of diaphragm.

With US, positive findings were present in 51 patients. In US examination, 34 patients had free intraabdominal fluid only, 13 had both free intraabdominal fluid and intraabdominal organ injury and 4 had intraabdominal organ injury only. Laparotomy, CT, DPL and US findings were compared to each other. Out of the 34 patients who had free fluid detected by US, 15 were normal, 6 had free fluid, and 13 had both free fluid and intraabdominal injury. Of those 15 patients who had free fluid detected by US and then considered to be normal, 12 were followed up clinically and then discharged as they had no sign of worsening and 3 patients had negative DPL results. Out of the 13 patients, who had both free fluid and intraabdominal injury detected by US, two were normal and 11 actually had both free fluid and intraabdominal injury. Out of the 4 patients who had intra-abdominal injury only, two were normal, one had intraabdominal injury only and the remaining patient had both free fluid and intraabdominal injury.

The sensitivity, specificity, positive and negative predictive values of US for detecting free fluid, intraabdominal injury or both conditions co-existing are shown in Table 2. Of the US results, 32 were true positive, 19 false positive, 398 true negative, and 5 were false negative.

Four hundred and three patients were reported as normal by US findings. Of those patients, three had intra-abdominal injury (one patient with liver laceration, one renal hemorrhage, one small bowel injury), two had both free fluid and intra-abdominal injury (one patient with liver laceration and small bowel injury, the other patient with mesenteric hemorrhage), based on CT and laparotomy results.

Based on laparotomy and CT results, a total of 6 patients had GI system injuries. Of those patients, three had no positive findings on US and three had free fluid only.

Discussion

Evaluation of BAT patients poses a clinical problem due to the fact that most of these patients have several organ injuries. Changes seen in the level of consciousness of patients having co-existent cranial trauma further complicates this issue. Spiral or multi-slice CT is being used at increasing rates in trauma patients. It is recommended to use CT examinations from cranium to pelvis for examining the patients with clinically suspected multiple organ trauma, or when trauma can possibly lead to multiple organ injuries, as well as for patients with thoracic and cranial injuries other than abdominal trauma (4, 5). In abdominal trauma cases, the completion of the CT examination within minutes is an advantage and the contrast delineating even the smallest lacerations is a further advantage, which renders CT significantly superior to US. Although this is the case, the use of thoracic, abdominal and pelvic CT examinations in patients with only head trauma or the indications for cranial or thoracic CT in patients with only abdominal trauma are still controversial issues. This discussion is valid because of the use of x-rays, administration of contrast material and cost issues. US is a less costly and easily accessible tool. In addition, the fact that x-rays are not being

Table 1. Etiologies of blunt abdominal trauma in our study

Etiology	Patients (n) (%)
Intravehicular crashes	209 (46)
Extravehicular crashes	117 (26)
Falls from height	114 (25)
Strikes	14 (3)

Table 2. Sensitivity of intraabdominal free fluid and/or organ damage in detecting the intraabdominal injury

Parameter	Data	%
Sensitivity	32 of 37	86.5
Specificity	398 of 417	95.4
Positive predictive value	32 of 51	62.7
Negative predictive value	398 of 403	98.7
Accuracy	430 of 454	94.7

used during the procedure renders US a routine technique for use in patients who are transferred to the hospital with suspected abdominal trauma and in patients in whom physical examination had not been optimal. However, US results are operator dependent and the fluid that accumulates in the abdominal cavity physiologically or due to reasons other than trauma cannot be differentiated from hemorrhages due to trauma; all of which result in decreased reliability of US for BAT evaluation.

A review of the literature reveals that the sensitivity of US in identifying intraabdominal trauma in BAT patients ranges between 63% to 98% (2, 6, 7). In a prospective study by Richards et al. performed on 3,264 patients, sensitivity, specificity, the positive and negative predictive values of the intra-abdominal fluid identified by US in revealing intraabdominal injury were reported as 60%, 98%, 82% and 95%, respectively, as well as 67%, 98%, 83%, and 96% for free fluid and/or intra abdominal injury, respectively (2). In a study by Katz et al., sensitivity, specificity, positive and negative predictive values for US in identifying intraabdominal injuries were 90.9%, 83.6%, 55.5% and 98.9%, respectively (8). These values were reported as 94.6%, 95.1%, 88.3% and 97.8%, respecively, in the study by Yoshii et al. (9) and 84%, 96%, 61% and 99%, respectively, in the retrospective study performed on 2,693 patients by Brown et al. The results obtained in our study were similar to those of Katz et al. and Brown et al.

In our study, there were 5 false negative and 19 false positive results. In the study by Yoshii et al. that was performed on 1,239 patients, 19 false negative and 44 false positive results were reported. In all of these false positive results, minimal free fluid was identified by US; among these, 18 patients were identified with thoracic trauma, 10 with pelvic fractures and one with vertebral fracture, while 18 did not have any extraabdominal injury (9). In the study by Richards et al. on 3,264 patients, 132 false negative and 57 false positive results were reported (2). In most of the false positive results, minimal free fluid was reported in US, yet this was not confirmed by other diagnostic tests (2). In a different study by Richards et al. on 744 patients, out of 51 patients who had free fluid identified by US, 9 were false positive results; of these 9 patients 7 were female patients who had pelvic free fluid (1). Hence, most of these false positive results were reported to be originating from the physiological fluid observed in females (1). A study by Brown et al. on 92 patients, who had false positive results by US, revealed that 31 had no evidence of pathology on CT and 26 had had normal physiological free fluid (10). In a study conducted by Katz et al. on 121 pediatric patients, 18 false positive results were reported, which was considered to be due to the fact that the pelvic fluid that could be observed under normal conditions in pediatric patients was accepted as a positive finding (8). There are some studies which report that pelvic fractures might themselves cause intraabdominal free fluid in the absence of intraabdominal injuries (11, 12). When the number of patients in our study is considered, the false positive rate is somewhat higher when compared to these studies. Of the 19 patients who had false positive results by US, 12 did not undergo any other examination than US and yet evaluation was made by clinical observation. One of these 12 patients had pelvic fracture. It is difficult to comment on whether these patients really had intraabdominal injuries. Furthermore, even the patients having intraabdominal injuries can be followed up only with clinical observation and then discharged once it was proven that they were clinically stable (13). In a study by Eanniello et al., 66 patients were identified to have free fluid by CT, and of these only 19% required laparotomy (14). In this regard, it might be better understood why we had more false positive results than other studies. The fact that 4 of the 15 patients who had false positive diagnosis with only free fluid were in fact females is another factor explaining the cause of this problem.

In the screening of BAT patients with US, the most important problem is false negative results, not the false positive ones. In a study by McKenney et al. performed on 200 patients, false positive results by US examination, that were not correlated with the results of CT or DPL, were reported (15). Of those patients in the study, 4 had solid organ injuries (spleen and liver), and 2 had both hemoperitoneum and solid organ injuries (15). In a study by Porter et al. on 1,631 patients with BAT, repeat US examination was performed on 110 patients who had normal initial US examinations. Of these 110 patients, 23 had minimal free fluid only, 9 had significant degree of free fluid and/or intraabdominal injuries, and 3 of them were reported to have been operated on afterwards (16). In the same study, of the 7 patients who were identified to have GI system injuries, 3 (42.9%) did not have any finding in US examination. In a by Richards et al., of the 132 false negative results that were reported; 50 were splenic injuries, 46 were liver injuries, 40 were GI and 19 were renal injuries (1). In a study by Yoshii et al, 19 false negative results were reported, 11 of which had GI injuries (9). In our study, there were 5 false negative results. Three of these patients were diagnosed to have GI injuries. It is clear that both in the previous studies and also in our current study, one of the most important reasons that has led to false negative results was GI injury. When no free fluid is present in the abdomen, US is not successful in detecting the GI injuries. An isolated solid organ injury is another reason for false negative results. We believe when US examinations are performed by an experienced radiologist, especially solid organ injuries can be better diagnosed. In our study, the follow up control US examinations were performed only in 3 of the 15 patients who had false positive results and the results were then reported as normal. When the initial US examinations are normal, yet clinical findings are not in support of this observation (or vice versa), performing control US examinations will increase the reliability of the technique.

US is a technique of high diagnostic value for patients with BAT. For patients who are transferred to emergency department with BAT, following the physical examination, US should be the first technique of choice for diagnosis. Since US has a high negative predictive value, we think that it is sufficient to follow up the patients with clinical observation if their US results are normal. In case of any change in the clinical course of the patient, repeat US or CT examination has to be performed. If US findings are not normal, another examination (like CT) can be performed with the condition that the patient is stable. In instances where US results and clinical findings are not supporting each other, repeating the US examination provides significant support for planning the treatment of the patient.

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