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The Predictive Value of Repeated Abdominal Ultrasonography in Patients with Multiple Trauma and Decreased Level of Consciousness: The Experience of a Resource-Limited Centre

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ABSTRACT

Objective: To determine the predictive value of repeated abdominal ultrasonography in patients with multiple trauma and decreased level of consciousness (LOC).
Methods: This prospective cross-sectional study was conducted over a six-month period at Shahid Rajaee Trauma Hospital, Shiraz, Iran. We included hemodynamically stable blunt abdominal trauma patients with a decreased LOC (Glasgow Coma Scale≤13) who were referred to the neurosurgery ICU ward. Included cases underwent 1 contrast-enhanced CT scan and two-time ultrasonographic study of the abdomen with an interval of 48 hours. The diagnostic accuracy of the ultrasonography was determined according to the CT-scan results.
Results: Overall 80 patients with mean age of 37.75±18.67 years were included. There were 17 (21.3%) women and 63 (78.8%) men among the patients. Compared with the CT-Scan, the first ultrasonography showed a sensitivity of 60%, specificity of 80%, PPV of 16.60%, NPV of 96.80%, and a diagnostic accuracy of 70%. The same values for the second ultrasonographic study were 80%, 79%, 20%, 98%, and 79%, respectively. In 4 (5%) patients whose first ultrasonography and CT scan results were negative, the second ultrasonography was positive for injury.
Conclusion: In patients with blunt trauma to the abdomen, when the only indication of abdominal CT scan is a decreased LOC, two ultrasonographic studies can replace a CT imaging.

Keywords: Blunt injury; Computed tomography; Ultrasonography; Traumatic brain injury; Sensitivity; Specificity.

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Introduction

Trauma still remains a major cause of mortality and morbidity, particularly in developing countries [1]. A major group of trauma patients will experience blunt abdominal trauma (BAT). In these cases, an accurate assessment of the abdomen is needed to detect any possible damage to the intra-abdominal structures. This may significantly influence a patient's outcome [2,3].

The presence of a concomitant decreased level of consciousness (LOC) is common in patients with BAT. This mental status change makes physical examination of the abdomen unreliable [4,5]. According to the current trauma management guidelines, patients with simultaneous BAT and decreased LOC should be admitted to the intensive care unit (ICU) and evaluated with contrast-enhanced abdominal computed tomographic (CT) scanning to detect any possible intra-abdominal injury [6]. Nevertheless, intra-abdominal injury may not be present in all of these patients necessarily [7]. Thus, a large number of the CT scans may be performed unnecessarily. This will lead to a variety of adverse consequences, such as increased risk of contrast-induced nephropathy, unessential patient exposure to high-dose radiation, etc. [8]. Another major limitation of a contrast-enhanced CT scan is that it can only feasibly be performed for hemodynamically stable patients [5,6]. Considering these facts, it seems that determining an alternate method to contrast-enhanced CT scan for assessing the aforementioned group of patients will be justifiable and cost-effective.

Based on a literature search, there is no strong documentation about the clinical usage of two-times abdominal ultrasound (US) examination compared with contrast-enhanced CT scan in BAT patients with concomitant decreased LOC. The aim of the current study was to determine the predictive value of repeated abdominal ultrasonography in patients with multiple trauma and decreased level of consciousness (LOC).

Materials and Methods

Study Design

This prospective cross-sectional study was performed during a 6-month period (from July to December, 2011) at Shahid Rajaee (Emtiaz) Trauma Hospital, a Level I Trauma Centre in Shiraz, Iran. The study protocol was approved by both the Institutional Review Board and the Ethics Committee of Shiraz University of Medical Sciences. An informed consent was obtained from each patient or patient's legal guardian. During the study period, all admitted hemodynamically stable (heart rate < 100, systolic blood pressure ≥90 mmHg), high-energy, blunt trauma patients who had evidence of a decreased LOC [Glasgow Coma Scale (GCS) ≤13] were included in the study. An attending trauma surgeon was responsible for making the enrolment based on the patients on admission vital signs and GCS. Participants were selected from those patients who were referred to the neurosurgery ICU (ICU number 2) of Shahid Rajaee Trauma Hospital. All patients underwent brain CT scan.

Test Methods

All the enrolled patients underwent a focused assessment with sonography for trauma (FAST) examination and an abdominal CT with intravenous contrast. Additionally, each patient undergone two-times abdominal US studies with an interval of 48 hours (was performed by an expert radiologist). Another expert radiologist, unaware of the report of the US, interpreted the abdominal CT images. For each patient, the results of the CT imaging, as well as each of the US evaluations, were independently documented in the data registration forms. It should be said that radiologists were involved in this study to standardize the readings of CT and US examinations, as there may be disparity between different trauma surgeons in image interpretation based on their different experience levels. Solid organ injuries, retroperitoneal injuries, and significant intraperitoneal free fluid were considered as positive findings in either CT scan or US. Notably, if either clinical or para-clinical examination showed any significant change (like peritoneal signs), the patient was assessed by means of a CT scan before the occurrence of the potential haemodynamic instability.

Statistical Analysis

Data was analysed using statistical package for social sciences (SPSS Inc., Chicago, Illinois, USA) version 14.0. Data are presented as mean±SD and proportions as appropriate. In this work, simple random sampling method was used to determine the participants. According to a 95% confidence interval, a 90% power, and a 0.1 sampling error, the maximum required sample size was determined to be 96 patients. The CT-scan was considered as the gold standard and the ultrasonography findings were interpreted accordingly. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy were reported with 95% CI.

Results

Participants

During the study period, a total of 190 patients were referred to our Trauma Centre neurosurgery ICU, of whom 80 cases were enrolled. No evidence of metabolic abnormality or intoxication was detected. The study population consisted of 17 (21.3%) female and 63 (78.8%) male patients with mean age of 37.75±18.67 (ranging from 10 to 81) years, and the median age was 31 years. Duration of hospital stay

ranged from 1 to 58 days (median was 10 days). Motor vehicle accidents and fall from a significant height (over 20 ft) were two main causes of injury (Table 1).

Table 1. Characteristics of 80 trauma patients who included in the study.

	Mean±SD
Age (years)	37.75±18.67
Duration of hospital stay (days)	14.66±13.63
Body T[a] (°C)	37.40±0.68
SBP[b] (mmHg)	124.74±23.97
DBP[c] (mmHg)	74.93 ±19.94
HR[d] (per minute)	92.81±21.51
RR[e] (per minute)	20.55±10.18
ISS[f]	7.47±5.65

[a]T: temperature; [b]SBP: systolic blood pressure; [c]DBP: diastolic blood pressure; [d]HR: heart rate; [e]RR: respiratory rate; [f]ISS: injury severity score. These parameters were recorded at the time of hospital arrival.

The included cases were categorized into the following three groups based on their admission GCS: (1) GCS of 13: 37/80 (46.2%) patients; (2) 13 > GCS ≥ 8: 30/80 (37.5%) cases; and (3) 8> GCS: 13/80 (16.2%) patients were classified into this group. From the aspect of ISS, the mean value was 7.4±1.8 (ranging from 1 to 29), and the median was 4 (46 patients had an ISS less than 8, ISS of 24 patients was between 8-16, and 10 patients received a score equal or more than 16).

Test Results

The results of the first and the second abdominal US scans and the abdominal CT scans are presented in Table 2. In 4/80 (5%) (95% CI: 0.22% to 9.78%) cases, the CT and the first US studies were negative for any significant finding; however, the second US evaluation was positive for significant intra-abdominal free fluid. The operative assessment of these patients revealed jejunal injury. Missed findings in US studies were presented in Table 3. Data regarding the comparison of contrast-enhanced abdominal CT scan and US studies is summarized in Table 4. According to our results, two-times US assessment had a diagnostic accuracy of 78.75% for detection of intra-abdominal injuries. However, its negative predictive value was 100%.

Discussion

The presence of some factors, such as contusions and abrasions of the abdominal wall, fractures of the lower chest ribs, etc., can confound abdominal physical examination in BAT patients. The issue is more challenging when a concomitant decreased LOC occurs [4,5]. In addition, laboratory tests are unreliable in detecting intra-abdominal injuries [3]. These difficulties make the use of imaging tools essential for precise evaluation of intra-abdominal structures and the detection of any possible injuries [9].

Presently, contrast-enhanced CT scan is the gold-standard imaging modality for emergency evaluation of cases with decreased LOC and suspected BAT [6]. Nevertheless, CT imaging has some disadvantages. Among these are its cost, the risk of contrast-induced nephropathy, patients' exposure to radiation, probable anaphylactic reaction to intravenous contrast, and

Table 2. The results of the 1st abdominal US, the 2nd abdominal US, and abdominal CT scans with IV contrast evaluation of BAT patients.

	Positive	95% CI[a]	Negative	95% CI
First Abdominal US[b]	18/80 (22.5%)	13.3% - 31.6%	62/80 (77.5%)	68.3% - 86.6%
Second Abdominal US[b]	20/80 (25%)	15.5% - 34.4%	60/80 (75%)	65.5% - 84.4%
Contrast-enhanced abdominal CT scan	10/80 (12.5%)	5.2% - 19.7%	70/80 (87.5%)	80.2% - 94.7%

[a]CI: Confidence Interval; [b]US: ultrasonography

Table 3. Missed findings in ultrasonographic studies. These abnormalities were detected by abdominal CT imaging.

Finding	Number of Patients
Spleen Laceration	1
Liver Contusion	2
Subcapsular Liver Haematoma	3

[a] 1 patient experienced liver contusion and spleen laceration simultaneously.

Table 4. The values resulted from the use of two-times abdominal US in patients with BAT and decreased levels of consciousness.

Value	First US	Second US[a]	Both
Sensitivity (%)	60	80	100
Specificity (%)	80	79	77.30
PPV[b] (%)	16.60	20	22.70
NPV[c] (%)	96.80	98	100
Diagnostic Accuracy (%)	79	79	78.75

[a]US: ultrasonography; [b]PPV: positive predictive value; [c]NPV: negative predictive value

its time-consuming nature (the need to patient transport) [7,8,10]. Another concern is that CT scan study of the children with trauma may increase the risk of cancer in the future [11,12]. The cost of maintenance and wear and tear of the equipment is the other problem. From another point of view, lack of suitable access to this facility in some regions of the world, mainly in developing countries like Iran, is greatly evident [10,13]. Moreover, in disaster or mass casualty conditions, such as hurricanes and tornadoes, major earthquakes, floods, etc., the need to alternative methods to the CT scan shows itself. Therefore, determining an alternate diagnostic modality and documenting its clinical value is legitimate concerns.

Based on the long-term experience from daily practice, the presence of a decreased LOC was (and is) one of the prevalent indications for CT evaluation of patients with BAT in our busy trauma centre. Moreover, our data shows that a significant number of abdominal CT scans showed no important finding. Although we know the benefits of CT imaging, the aforementioned facts and our trauma centre's high patient load (more than 15,000 trauma patients per year), convinced us to design the current study.

Some previous studies generally examined the clinical value of a one-time abdominal US scan in BAT patients. The retrospective study of Bakker et al. on 1,149 patients was one of the largest studies. Based on their results (NPV of 96% for US in acute BAT), the authors concluded that US is an adequate modality for the assessment of this group of patients [14]. According to another retrospective work by Nural et al. that included a total number of 454 cases, one-time abdominal US with sensitivity, specificity, PPV, NPV, and accuracy values of 86.5%, 95.4%, 62.7%, 98.7%, and 94.7%, had a high diagnostic performance in the screening of patients with BAT [15]. Taş et al., [16] performed a prospective study in which they evaluated 96 children who experienced BAT; they reported sensitivity, specificity, PPV, NPV, and accuracy values of 90.2%, 100%, 100%, 63.6%, and 91.7%, respectively, for abdominal US. The authors concluded that US is a highly sensitive diagnostic modality for the detection of liver, kidney, and spleen injuries, whereas its sensitivity is moderate for the detection of damage to the gastrointestinal tract and pancreas.

The results of the current work conducted to evaluate a specific approach, similar to those of previous general studies, defend the role of US in evaluating blunt trauma patients, mainly because of its high NPV. This work evidenced that the first US scan and even the CT scan may be non-diagnostic in some patients, an issue which can be addressed by performing a second US study. The current results have also shown that a second US examination will significantly increase diagnostic accuracy, and this will positively affect subsequent decisions about treatment for clinicians.

From the aspect of the false-negative results of US studies, it can be claimed that the missed injuries did not require operative intervention and the patients received appropriate care. It is worth noting that, in spite of its weakness in diagnosing retroperitoneal injury, US is an appropriate diagnostic tool for recognizing free intra-abdominal fluid and solid organ injuries, particularly when it is contrast-enhanced [17]. Furthermore, both US and CT scans are weak in diagnosing hollow viscous injuries [18,19]. Although US is an operator-dependent imaging modality, its use has many advantages in trauma patients compared with CT scan. It is an available and easy-to-use diagnostic tool with no significant side effects. Non-invasiveness, easy repeatability, fewer non-therapeutic laparotomies, lack of interference with subsequent imaging, and the ability to continue resuscitative efforts concurrently are some of the benefits of this modality [20]. Although costs may differ in various parts of the world, US is cheaper than CT scan (in Iran, the cost of IV contrast-enhanced abdominal CT scan is about 4 times that of abdominal US). Thus, applying US instead of CT scan would be beneficial for busy and limited-resource centres.

The work had some limitations, mainly the limited time of the study and, consequently, the limited number of evaluated cases. Another limitation was that both US studies were performed by one radiologist. However, due to the high patient turnover rate and high number of US scans performed at this busy trauma centre, this limitation probably does not contribute any consistent bias to the study results. In addition, the radiologist did not have access to the reports of previous US studies of the patients for comparison.

To conclude, when there is a limited access to the CT imaging facilities or when available facilities do not fit the requirements (such as disaster situations, regions with high rate of major trauma, etc) two abdominal US studies may be an appropriate and safe alternative method for the CT scan. According to the present study's findings, when the only indication of the CT scan in patients that have suffered multiple trauma is a decreased LOC, a precise clinical examination together with two abdominal US scans may be an appropriate and safe alternative method for the contrast-enhanced CT scan. This approach could be helpful mainly when the number of patients exceeds the number of available CT scanners. However, based on the study's limitations, it is recommended that this method be evaluated in other studies that include a larger number of patients.

Conflicts of Interest: None declared.

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