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ORIGINAL RESEARCH

Diagnostic Accuracy of Ultrasonography in the Initial Evaluation of Patients with Penetrating Chest Trauma

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Abstract

Introduction: Traumatic chest injuries (TCI) are one of the most common causes of referring to the emergency departments, with high mortality and disability. This study was designed to evaluate the diagnostic accuracy of ultrasonography versus chest X ray (CXR) in detection of hemo-pneumothorax for patients suffering penetrating TCI. **Methods:** The present cross-sectional study was performed to evaluate the diagnostic accuracy of ultrasonography in penetrating TCI victims referred to the emergency department of Shahid Kashani and Alzahra Hospitals of Isfahan, Iran, from July 2012 to June 2013. Bedside ultrasonography and plain CXR was done on arrival and three hours after admission. The results of ultrasonography and radiography were separately evaluated by an emergency medicine specialist and a radiologist, who were blind to the aims of the study. Then, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and kappa coefficient was considered to evaluate the accuracy of ultrasonography. **Results:** In this research, 64 patients with penetrating chest trauma were assessed (98.4% male). The mean age of them was 25.6±8.5 years (rang: 13-65). The plain radiography revealed the eight (12.5%) cases of pneumothorax and one (1.6%) hemothorax. The findings of primary ultrasonography also showed the same number of hemo-pneumothorax. Sensitivity and specificity of primary ultrasound in diagnosis of pneumothorax were 100% (95% Cl: 60.7- 100) and 100.0% (95% Cl, 92.0% to 100.0%) and in detection of hemothorax were 100% (95% Cl: 50.5-100) and 100% (95% Cl: 92.8-100), respectively. Sensitivity and specificity of ultrasound in the third hour were 100% (95% Cl: 31.3-100) and 100% (95% Cl: 91.4-100), respectively. **Conclusion:** Findings of the present study have shown that ultrasonography has an acceptable diagnostic accuracy in the initial assessment of patients with penetrating chest trauma. However, because of its dependency on operator proficiency and other limitations more studies are needed in this area.

Key words: Thoracic injuries; trauma; diagnostic evaluation; ultrasonography; radiography

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Introduction:

Traumatic chest injuries (TCI) are one of the most common causes of referring to the emergency departments, with high mortality and disability (1). Of all these traumatic injuries penetrating traumas cause more complications (2). Pneumothorax and hemothorax are the most important and prevalent problems seen in a remarkable percent of these patients (3). Although pneumothorax and medium hemothoraxes did not life-threatening, tension hemopneumothorax could accompany with harmful conditions such as cardiac arrest (4). Therefore, a prompt diagnosis and treatment of these patients could improve their conditions considerably. Chest radiography (CXR) and computed tomography (CT) scan are two important diagnostic tools used for detecting these injuries. However, missing of about half of all pneumothoraxes by radiography caused that CT scan has been shown as a gold standard tool for detection of chest injuries (5). However, most patients did not have the CT indications and on the other hand, using this diagnostic test is time consuming and leads to delay in diagnosis of patients. Thus, today radiography is used as the initial diagnostic test in patients with TCI. Even though radiography is a non-invasive and inexpensive tool, using it in all patients suffering trauma lead to considerable increase in treatment costs, exposure of patients to radiation, and crowdedness of emergency department (6). Ultrasound is maybe a reliable alternative for radiography. Using ultrasound because of its high speed in diagnosis and portable property causes that it turn to be the first step in diagnosis of many clinical conditions (7). However, the diagnostic accuracy of ultrasonography much depends on the operator proficiency and it is

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not adequately reliable in diagnosis of parenchymal injuries and those with no hemorrhage or free flow liquid (8-12). Nevertheless, structural changes occurred in ultrasonography equipment, leads to improve the quality of ultrasound image and particularly its spatial resolution. Therefore, that with a brief training for physicians the diagnostic sensitivity of this test could be increased enough. These changes cause patients, especially those who are hemodynamically unstable, have been treated in the least possible time (13).

Recent studies have also shown high sensitivity and specificity of ultrasound in comparison with radiography in detecting of TCI (5, 14).

Considering all above mentioned, this study was designed to evaluate the diagnostic accuracy of ultrasonography versus CXR in detection of hemo-pneumothorax for patients suffering penetrating TCI.

Methods:

Study design and setting

This project is a cross-sectional study designed to evaluate the diagnosis accuracy of ultrasonography versus CXR in detection of hemo-pneumothorax for patients suffering penetrating TCI, referred to Shahid Kashani and Alzahra hospitals of Isfahan, Iran, from July 2012 to June 2013. Data gathering and ultrasonography was done by an emergency medicine specialist. CXR findings were interpreted by a radiologist who was blind to clinical and ultrasonographic findings. The protocol of this study was reviewed and approved by Isfahan University of Medical Sciences Ethics Committee. During the study, researchers committed to the principles of Helsinki protocol. This study had no interference with treatment process of patients. Before doing the project, the patients signed the informed consent form.

Participants

In this review, the patients with penetrating TCI were enrolled. The exclusion criteria concluded pregnancy, non-penetrating trauma, hemodynamic instability, respiratory distress and asthma, diminished lung sounds, limiting of damage to the skin and subcutaneous, and not satisfaction of participation.

Sample selection was done consecutively. To identify the sample volume, considering to 80% prevalence of normal CXRs in patients with penetrating TCI (14), taking 95% confidence interval (α=0.05) , 97% power (β=0.1), and 1% maximum error (d=0.1) in estimation of lesion prevalence, 62 samples were taken as a minimum required sample.

Measurements

The emergency specialist prospectively evaluated the clinical and demographic (age, sex, and trauma location) information of patients and recorded them to the gathering form. After data gathering, the patient immediately underwent CXR. Lateral and anterposterior CXR was performed in standing position. Then, ultraultrasonography evaluation was done by a trained emergency medicine specialist with bedside ultrasound machine (Honda HS-2000, Japan), using micro-convex transducer (2-4 MHz). Assessments were done based on four sections of each hemi thorax concluded: 1. The second intercostal space in the midclavicular line, 2. The fourth intercostal space in the anterior axillary line, 3. The sixth intercostal space in the midaxillary line, and 4. The sixth intercostal space in the posterior axillary line. Finally, according to protocols for patients who their primary graphy was normal, the control CXR was requested next three hours (15). After CXR, the patient underwent chest ultrasonography. All radiography clichés was interpreted and recorded in separate forms by a radiologist who was blind to clinical and ultrasonographic findings.

Statistical analysis

Data was entered to the SPSS program (version 21.0). Based on CXR findings final diagnosis of chest injury was done. The results were reported as a frequency and percentage. Sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), positive predictive value (PPV), and negative predictive value (NPV) of ultrasonography in detection of hemo-pneumothorax were separately evaluated in both of times mentioned above. In addition, Cohen's Kappa coefficient was used for analysis of similarities between the results of CXR and ultrasonography. In all cases $p<0.05$ was considered as significant.

Results:

Finally, 64 patients were enrolled the study (98.4% male). The mean age of subjects was 25.6± 8.5 years (range: 13-61). The injury in 30 patients (46.9%) was in upper-posterior quarter of rib cage (Table1). The initial radiographic findings revealed that eight patients (12.5%) had pneumothorax and one (1.6%) hemothorax. In addition, the primary ultrasonography showed

Table1: Demographic variables of studied patients

Variability	Frequency (%)
Age (year)	
<18	5 (7.8)
18-39	55 (85.9)
41-60	3 (4.7)
>60	1 (1.6)
Sex	
Male	63 (98.4)
Female	1 (1.6)
Location of injury	
Upper anterior quadrant	11 (17.2)
Posterior upper quadrant	30 (46.9)
Lower anterior quadrant	1 (1.6)
Posterior inferior quadrant	6 (9.4)
Diffuse injury	16 (25.0)

Table 2: Accuracy of ultrasonography in detection of pneumothorax and hemothorax

Index	Baseline	After three hours
Pneumothorax (95% CI)[a]		
Sensitivity	100 (60.7-100)	100 (31.3-100/0)
Specificity	100 (92-100)	100 (91.4-100/0)
Positive predictive value	100 (60.7-100)	100 (31.3-100/0)
Negative predictive value	100 (92-100)	100 (91.4-100/0)
Positive likelihood ratio	-----	-----
Negative likelihood ratio	1 (0.92-1)	1 (0.92-1)
Hemothorax (95% CI)[b]		
Sensitivity	100 (50.5-100)	-----
Specificity	100 (92.8-100)	-----
Positive predictive value	100 (50.5-100)	-----
Negative predictive value	100 (92.8-100)	-----
Positive likelihood ratio	-----	-----
Negative likelihood ratio	1 (0.93-1)	-----

[a] CI: Confidence interval

[b] the blank cells are representative the lack of any detectable case of hemothorax ultrasonography or chest x-ray three hours after observation

the same findings. Accordingly, sensitivity and specificity of primary ultrasonography for detection of pneumothorax in patients suffered penetrating TCI was respectively achieved 100% (95% Cl: 60.7-100) and 100% (95% Cl: 92- 100). In addition, sensitivity and specificity of primary ultrasonography for detection of hemothorax were 100% (95% Cl: 50.5- 100) and 100% (95% Cl: 92.8-100), respectively (Table2). The agreement between two tests was 100%. Kappa Cohen's coefficient was 1 (95% Cl: 89- 100), representative a 100% inter rater- reliability between two tests.

After three hours for 55 patients, who had normal findings of primary CXR, the control graphy was requested. Among them, three (5.2%) additional pneumothoraxes were detected. Ultrasonography after three hours also showed the same numbers of pneumothoraxes. Thus, the sensitivity and specificity of ultrasonography after three hours were 100 (95%Cl: 31.1- 100) and 100% (95% Cl: 91.4- 100), respectively (Table 2). At this time, the agreement of these two tests was 100%. In addition, Kappa Cohen's coefficient was 1 (95%Cl: 87-100), representative a 100% inter rater- reliability between two tests.

Discussion:

The findings of the present study have shown that the accuracy of ultrasonography in the initial assessment of patients referred with penetrating TCI is completely similar to radiography. Sensitivity and specificity of ultrasonography in detection of pneumothorax and hemothorax was 100%. It was confirmed by other studies that revealed the high sensitivity and specificity of ultrasonography in detecting pneumothorax. For instance, Knudtson and his colleges in evaluation of 328 patients showed 99.7% sensitivity and specificity of ultrasonography in diagnosis of pneumothorax (14). Kirkpatrick and his colleges demonstrated that although the sensitivity of ultrasonography in diagnosis of TCI is 48.8%, this diagnosis test has more sensitivity in comparison with radiography. It is worth noting that the specificity of ultrasonography in detection of pneumothorax was 99.1% (5).

Hyacinthe and colleges showed that diagnostic accuracy of chest ultrasonography is more than CXR; so that sensitivity and specificity of ultrasonography in detection of chest injuries have a range of 37% to 61% and 61% to 96%, respectively (16). However, Gentry Wilkerson and Stone in their studies reported a sensitivity of 85% to 100% for ultrasonography detection in chest injuries. Other studies also revealed the similar findings (17-20). As can be seen, there are lots of variability in studies' findings, which arises more from differences in study methodology because of using the portable graphies. Since sensitivity and specificity of portable graphies in detection of pneumothorax and hemothorax are less than standing radiography, these differences are justified. This is the cause of difference between the present study and findings of Kirkpatrick (5) and Hyacinthe (16). However, generally most of studies stated that ultrasonography is the better diagnostic test versus radiography in detection of TCI. Based on these studies, Advanced Trauma Life Support (ATLS) suggested that ultrasonography could be used in the initial assessment of some conditions like the presence of free fluid, organ damage, and pneumothorax. The sensitivity of CXR for detection of pneumothorax and hemothorax is low. The results of the present study revealed that ultrasonography has a similar diagnostic accuracy to chest radiography.

One of the limitations in the present project was the low sample size. As a result, the 95% confidence interval of findings has a very wide range specifically for sensitivity. On the other hand, in the present study radiography

was used as a golden standard. By doing control ultrasonography and radiography three hours after the initial assessments of imaging, three additional pneumothoraxes were added to the abnormal findings. If CT scan was applied, it was probable that occult pneumothoraxes or hemothoraxes was detected and it could be lead to change the findings.

Conclusion:

The results of this study has shown that ultrasonography in the initial assessments of patients with penetrating TCI has an acceptable diagnostic accuracy. However, because of its dependency on operator proficiency and other limitations more studies are needed in this area.

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Conflict of interest:

None

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