

## ORIGINAL RESEARCH

## Diagnostic Accuracy of Ultrasonography and Radiography in Initial Evaluation of Chest Trauma Patients

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Received: April 2015; Accepted: June 2015

### Abstract

**Introduction:** Application of chest radiography for all multiple trauma patients is associated with a significant increase in total costs, exposure to radiation, and overcrowding of the emergency department. Ultrasound has been introduced as an alternative diagnostic tool in this regard. The aim of the present study is to compare the diagnostic accuracy of chest ultrasonography and radiography in detection of traumatic intrathoracic injuries. **Methods:** In the present prospective cross-sectional study, patients with traumatic intrathoracic injuries, who were referred to the emergency department from December 2013 to December 2014, were assessed. The patients underwent bedside ultrasound, radiographic and computed tomography (CT) scan examinations based on ATLS recommendations. Screening performance characteristics of ultrasonography and radiography were compared using SPSS 21.0. Chest CT scan was considered as gold standard. **Results:** 152 chest trauma patients with a mean age of  $31.4 \pm 13.8$  years (range: 4 – 67), were enrolled (77.6% male). Chest CT scan showed pulmonary contusion in 48 (31.6%) patients, hemothorax in 29 (19.1%), and pneumothorax in 55 (36.2%) cases. Area under the ROC curve of ultrasonography in detection of pneumothorax, hemothorax, and pulmonary contusion were 0.91 (95% CI: 0.86–0.96), 0.86 (95% CI: 0.78–0.94), and 0.80 (95% CI: 0.736–0.88), respectively. Area under the ROC curve of radiography was 0.80 (95% CI: 0.736–0.87) for detection of pneumothorax, 0.77 (95% CI: 0.68–0.86) for hemothorax, and 0.58 (95% CI: 0.5–0.67) for pulmonary contusion. Comparison of areas under the ROC curve declared the significant superiority of ultrasonography in detection of pneumothorax ( $p = 0.02$ ) and pulmonary contusion ( $p < 0.001$ ). However, the diagnostic value of the two tests was equal in detection of hemothorax ( $p = 0.08$ ). **Conclusion:** The results of the present study showed that ultrasonography is preferable to radiography in the initial evaluation of patients with traumatic injuries to the thoracic cavity.

**Key words:** Thoracic cavity; wounds and injuries; diagnostic imaging; ultrasonography; radiography

**Cite this article as:** Vafaei A, Hatamabadi HR, Heidary K, Alimohammadi H, Tarbiyat M. Diagnostic accuracy of ultrasonography and radiography in initial evaluation of chest trauma patients. *Emergency*. 2016;4(1):29-33.

### Introduction:

Trauma is the most important cause of death during the first four decades of life (1). In this context, traumatic intrathoracic injuries comprise 25-40% of mortalities (2). Prompt diagnosis of such injuries can decrease mortality and the resultant burden. Computed tomography (CT) scan is the gold standard for this diagnosis (3-5). Although this diagnostic tool is highly accurate in detection of intrathoracic injuries, patients undergoing CT scan examination receive a high radiation dose (6-8). Currently, chest radiography is used as the initial diagnostic tool in these cases. Although these techniques are inexpensive and non-invasive, their application for all multiple trauma patients is associated with a significant increase in total costs, exposure to radiation, and overcrowding of the emergency department (9). Some recent studies

have reported not very high sensitivity and specificity of chest radiography in this regard (10-13). These studies have shown the low diagnostic yield of chest x-rays (6.3–12.4%) in identifying intrathoracic injuries (9, 14-16). During recent years, chest ultrasonography has been introduced as a portable, inexpensive, safe, and fast alternative for radiography in detection of traumatic intrathoracic injuries (17). However, this tool is largely dependent on the experience and expertise of the operator and its results are not very reliable in identifying parenchymal injuries and where no fluid is present (18). Based on the above-mentioned points, the present study was designed to compare the diagnostic accuracy of chest ultrasonography and radiography in identifying traumatic intrathoracic injuries.



**Methods:****Study design and setting**

In the present prospective cross-sectional study, patients with traumatic intrathoracic injuries, who were referred to the emergency department of Imam Hossein Hospital, from December 2013 to December 2014, were assessed. The study was done to calculate the diagnostic accuracy of chest ultrasonography and radiography in the initial evaluation of patients with chest trauma. Thoracic CT scan was used as the gold standard. All patients in need for chest CT scan based on standard indications of advanced trauma life support (ATLS) guidelines were included in a consecutive manner. Exclusion criteria consisted of pregnancy, hemodynamic instability, and lack of interest in participating in the study. Chest ultrasonography and data collection were carried out by an emergency medicine specialist. Chest x-ray and CT scan were reported by two radiologists separately, who were blinded to the clinical findings of patients and aim of study. The protocol of the study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences. The researchers adhered to the guidelines

of Helsinki Declaration throughout the study procedures. The protocol of the study did not interfere with the patients' therapeutic and diagnostic procedures and the patients were not exposed to any risks. The data collection forms were anonymous and a code was assigned to each patient. All the patients submitted an informed consent form before being included in the study.

**Measurements**

Demographic (age, gender, and mechanism of trauma) and clinical data, as well as imaging findings of each patient were recorded using a checklist. Immediately after collection of data, the patients underwent chest ultrasonography, which was carried out using a bedside ultrasonography unit (Honda, HS 2100) and 3.5-7 MHz linear and curvilinear transducers. Examinations were carried out at 2-6 intercostal spaces on both sides of para-sternal, mid-clavicular, anterior axillary and mid-axillary lines. Then, the patients underwent an anterior posterior (AP) chest x-ray examination using a portable x-ray machine (Poxible, 100 BP-OP) and chest CT scan (Siemens, Emotion-16, 5-mm-thick slices) in supine position. Pneu-

**Table 1:** Baseline characteristics of the studied participants

Variable	Frequency	Percentage
<b>Age</b>		
Under 18	24	15.8
19-40	92	60.5
41-60	27	17.8
Over 60	9	6.9
<b>Gender</b>		
Male	118	77.6
Female	34	22.4
<b>Mechanism of trauma</b>		
Penetrating wound	22	14.5
Blunt trauma due to accident	93	61.2
Blunt trauma due to falling	23	15.1
Blunt trauma due to direct impact	14	9.2
<b>Subcutaneous emphysema</b>		
No	133	86.2
Yes	21	13.8
<b>Crepitation</b>		
No	131	86.2
Yes	21	13.8
<b>Trauma to thoracic spinal</b>		
No	137	90.1
Yes	15	9.9
<b>Glasgow coma scale</b>		
14-15	96	63.1
9-13	39	25.7
3-8	17	11.2
<b>Hemodynamic status</b>		
Stable	125	82.2
Unstable	27	17.8



mothorax, hemothorax, rib fracture, and pulmonary contusion were considered as traumatic intrathoracic injuries.

#### Statistical analysis

The sample size was calculated to be 139 cases by considering a minimum sensitivity of 98% for the ultrasonography in detection of traumatic intrathoracic injuries and a 30% prevalence rate of pneumothorax in patients with chest trauma (19), at 95% confidence interval ( $\alpha = 0.05$ ), a power of 90% ( $\beta = 0.1$ ) and maximum error of 1% ( $d = 0.12$ ). Data were analyzed with SPSS 21.0. In order to evaluate the adequacy of radiography and ultrasonography, receiver operating characteristic (ROC) curves were drawn and sensitivity, specificity, positive and negative likelihood ratio and positive and negative predictive values of radiography and ultrasonography were calculated. Significance level was set at  $p < 0.05$ .

#### Results:

152 chest trauma patients with a mean age of  $31.4 \pm 13.8$  years (range: 4 – 67), were enrolled (77.6% male). Table 1 presents baseline characteristics of patients. Chest CT scan showed pulmonary contusion in 48 (31.6%) patients, hemothorax in 29 (19.1%), and pneumothorax in 55 (36.2%) cases. Table 2 summarizes the screening performance characteristics of chest ultrasonography and radiography in detection of traumatic intrathoracic injuries (pneumothorax, hemothorax, contusion). Area under the ROC curve of ultrasonography in detection of

pneumothorax, hemothorax, and pulmonary contusion were 0.91 (95% CI: 0.86–0.96), 0.86 (95% CI: 0.78–0.94), and 0.80 (95% CI: 0.736–0.88), respectively. Area under the ROC curve of radiography was 0.80 (95% CI: 0.736–0.87) for detection of pneumothorax, 0.77 (95% CI: 0.68–0.86) for hemothorax, and 0.58 (95% CI: 0.5–0.67) for pulmonary contusion. Comparison of areas under the ROC curve declared the significant superiority of ultrasonography in detection of pneumothorax ( $p = 0.02$ ) and pulmonary contusion ( $p < 0.001$ ). However, the diagnostic value of the two tests was equal in detection of hemothorax ( $p = 0.08$ ).

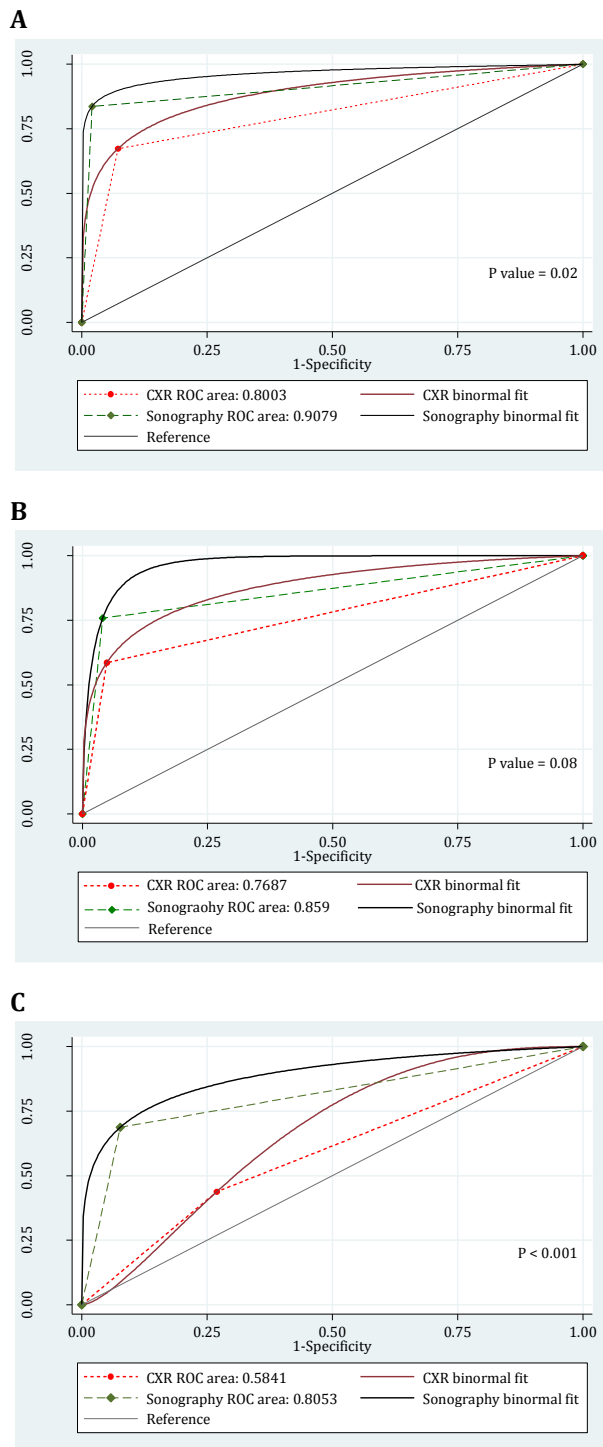
#### Discussion:

The results of the present study showed that chest ultrasonography had higher diagnostic value in detection of pneumothorax and pulmonary contusion compared to radiography. This value in detection of hemothorax for two studied tools was equal. Various studies have evaluated the diagnostic accuracy of ultrasonography in trauma patients (20, 21). In this context, Hyacinthe et al. showed that the diagnostic accuracy of ultrasonography was higher than that of chest x-ray. The study showed that the sensitivity and specificity of ultrasonography, compared to CT scan as the gold standard, in diagnosis of thoracic cavity lesions were in the 37–61% and 61–96% ranges, respectively (22). In the present study, the emergency medicine specialist who carried out ultrasonography examinations was aware of clinical findings

**Table 2:** Screening performance characteristics of chest ultrasonography and radiography in detection of traumatic intrathoracic injuries in comparison to CT scan

Index	Ultrasonography	Chest x-ray
<b>Pneumothorax</b>		
Sensitivity	83.6 (70.7–91.8)	67.3 (53.2–78.95)
Specificity	97.9 (92.0–99.6)	92.7 (85.1–96.8)
Positive predictive value	95.8 (84.6–99.3)	84.1 (69.3–92.8)
Negative predictive value	91.3 (83.8–95.7)	83.2 (74.5–89.5)
Positive likelihood ratio	45.6 (10.2–160.7)	9.2 (4.4–19.3)
Negative likelihood ratio	0.17 (0.09–0.3)	0.35 (0.24–0.52)
<b>Hemothorax</b>		
Sensitivity	75.9 (56.1–90.0)	58.6 (39.1–75.9)
Specificity	95.9 (90.3–98.5)	95.1 (89.2–98.0)
Positive predictive value	81.5 (88.4–97.5)	73.9 (51.3–88.9)
Negative predictive value	94.4 (88.4–97.5)	90.7 (84.0–94.9)
Positive likelihood ratio	18.7 (7.7–45.1)	12.0 (5.2–27.8)
Negative likelihood ratio	0.25 (0.13–0.48)	0.1 (0.06–0.18)
<b>Pulmonary contusion</b>		
Sensitivity	68.8 (53.6–80.9)	43.8 (29.8–58.7)
Specificity	92.3 (84.9–96.4)	73.1 (63.3–81.1)
Positive predictive value	80.5 (64.6–90.6)	42.8 (29.1–57.7)
Negative predictive value	86.5 (78.4–92.0)	73.7 (64.0–81.7)
Positive likelihood ratio	8.9 (4.5–17.7)	1.6 (1.0–2.55)
Negative likelihood ratio	0.34 (0.2–0.52)	0.77(0.6–0.99)





**Figure 1:** Comparison of areas under the receiver operative characteristics curve in radiography and ultrasonography for pneumothorax (A), hemothorax (B), and contusion (C).

and could, concentrate on areas with higher odds of injuries to some extent. However, in the Hyacinthe et al. study a blinded specialist carried out ultrasonography,

which might be the reason for the higher sensitivity rate in the present study. Wilkerson and Stone meta-analysis reported a sensitivity of 85–100% for ultrasonography in diagnosis of thoracic cavity injuries (10). Other studies, have also reported similar findings (23, 24). The differences might be attributed to inclusion and exclusion criteria of the studies. Those studies have excluded patients with subcutaneous emphysema and intubated patients. Subcutaneous emphysema interferes with examination of the parietal pleura using ultrasonography, making it difficult to identify hemothorax or pneumothorax in these areas. On the other hand, in the present study there was about 1–2-hour time interval between ultrasonography and CT scan examinations. During this time, the lesions might have extended to reach a size that could make diagnose them easier. An attempt was made in this study to evaluate the diagnostic accuracy of ultrasonography as an alternative to x-ray. Comparison of the results of these two techniques with those of CT scan showed that ultrasonography is superior to chest x-ray in initial evaluations. However, ultrasonography alone has a lower diagnostic value. Therefore, it is advisable to find ways to increase the efficacy and accuracy of the ultrasonography technique. One of these ways is to combine ultrasonography with other indexes used for the diagnosis of traumatic lesions (25). This needs to be studied further.

#### Conclusion:

The results of the present study showed that ultrasonography is preferable to radiography in the initial evaluation of patients with traumatic injuries to the thoracic cavity. However, the low sensitivity of the ultrasonography technique in comparison to CT scan, its reliance on operator skill, and some other limitations have made it only an initial test, necessitating confirmation using other techniques.

#### Acknowledgments:

We are pleased to acknowledge from all staff of Imam Hossein Hospital for their contribution in the present study.

#### Conflict of interest:

We declare that the authors of this article have no competing interests.

#### Funding support:

None.

#### Authors' contributions:

All authors met four criteria for authorship contribution based on recommendations of the International Committee of Medical Journal Editors.

#### References:

1. Søreide K. Epidemiology of major trauma. *Br J Surg*. 2009;96(7):697-8.
2. Heron M. Deaths: leading causes for 2008. *Natl Vital Stat Rep*. 2012;60(6):1-94.



3. Danielsen M, Højgaard L, Kjær A, Fischer BM. Positron emission tomography in the follow-up of cutaneous malignant melanoma patients: a systematic review. *Am J Nucl Med Mol Imaging*. 2014;4(1):17-28.
4. Schulze C, Hoppe H, Schweitzer W, Schwendener N, Grabherr S, Jackowski C. Rib fractures at postmortem computed tomography (PMCT) validated against the autopsy. *Forensic Sci Int*. 2013;233(1):90-8.
5. Esmailian M, Zargarbashi EH, Masoumi B, Karami M. Accuracy of ultrasonography in confirmation of adequate reduction of distal radius fractures. *Emergency*. 2013;1(1):7-10.
6. Brenner DJ. Medical imaging in the 21st century—getting the best bang for the rad. *N Engl J Med*. 2010;362(10):943-5.
7. Lee J, Kirschner J, Pawa S, Wiener DE, Newman DH, Shah K. Computed tomography use in the adult emergency department of an academic urban hospital from 2001 to 2007. *Ann Emerg Med*. 2010;56(6):591-6.
8. Holmes JF, Wisner DH, McGahan JP, Mower WR, Kuppermann N. Clinical prediction rules for identifying adults at very low risk for intra-abdominal injuries after blunt trauma. *Ann Emerg Med*. 2009;54(4):575-84.
9. Rodriguez RM, Anglin D, Langdorf MI, et al. NEXUS chest: validation of a decision instrument for selective chest imaging in blunt trauma. *JAMA Surg*. 2013;148(10):940-6.
10. Gentry Wilkerson R, Stone MB. Sensitivity of bedside ultrasound and supine anteroposterior chest radiographs for the identification of pneumothorax after blunt trauma. *Acad Emerg Med*. 2010;17(1):11-7.
11. Xirouchaki N, Magkanas E, Vaporidi K, et al. Lung ultrasound in critically ill patients: comparison with bedside chest radiography. *Intensive Care Med*. 2011;37(9):1488-93.
12. Cardinale L, Volpicelli G, Lamorte A, Martino J, Veltri A. Revisiting signs, strengths and weaknesses of Standard Chest Radiography in patients of Acute Dyspnea in the Emergency Department. *J Thorac Dis*. 2012;4(4):398-407.
13. Ebrahimi A, Yousefifard M, Kazemi HM, et al. Diagnostic Accuracy of Chest Ultrasonography versus Chest Radiography for Identification of Pneumothorax: A Systematic Review and Meta-Analysis. *Tanaffos*. 2014;13(4):29-37.
14. Rodriguez RM, Hendey GW, Marek G, Dery RA, Bjoring A. A pilot study to derive clinical variables for selective chest radiography in blunt trauma patients. *Ann Emerg Med*. 2006;47(5):415-8.
15. Sears BW, Luchette FA, Esposito TJ, et al. Old fashion clinical judgment in the era of protocols: is mandatory chest X-ray necessary in injured patients? *J Trauma*. 2005;59(2):324-32.
16. Safari S, Baratloo A, Negida AS, Taheri MS, Hashemi B, Selkisari SH. Comparing the Interpretation of Traumatic Chest X-Ray by Emergency Medicine Specialists and Radiologists. *Arch Trauma Res*. 2014;3(4):e22189.
17. Michalke JA. An overview of emergency ultrasound in the United States. *World J Emerg Med*. 2012;3(2):85-90.
18. Poletti PA, Kinkel K, Vermeulen B, Irmay F, Unger P-F, Terrier F. Blunt Abdominal Trauma: Should US Be Used to Detect Both Free Fluid and Organ Injuries? *Radiology*. 2003;227(1):95-103.
19. Soldati G, Testa A, Pignataro G, et al. The ultrasonographic deep sulcus sign in traumatic pneumothorax. *Ultrasound Med Biol*. 2006;32(8):1157-63.
20. Shojaei M, Faridaalae G, Yousefifard M, et al. New scoring system for intra-abdominal injury diagnosis after blunt trauma. *Chin J Traumatol*. 2014;17(1):19-24.
21. Heydari F, Esmailian M, Dehghanniri M. Diagnostic Accuracy of Ultrasonography in the Initial Evaluation of Patients with Penetrating Chest Trauma. *Emergency*. 2014;2(2):81-4.
22. Hyacinthe A-C, Broux C, Francony G, et al. Diagnostic accuracy of ultrasonography in the acute assessment of common thoracic lesions after trauma. *Chest*. 2012;141(5):1177-83.
23. Soldati G, Testa A, Sher S, Pignataro G, La Sala M, Silveri NG. Occult traumatic pneumothorax: diagnostic accuracy of lung ultrasonography in the emergency department. *Chest*. 2008;133(1):204-11.
24. Roberts DJ, Niven DJ, James MT, Ball CG, Kirkpatrick AW. Thoracic ultrasonography versus chest radiography for detection of pneumothoraces: challenges in deriving and interpreting summary diagnostic accuracy estimates. *Crit Care*. 2014;18:416.
25. Liu Y-c, Liu J-h, Fang ZA, et al. Modified shock index and mortality rate of emergency patients. *World J Emerg Med*. 2012;3(2):114-7.

