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Investigating the accuracy of portable ultrasonography in diagnosis of traumatic thoracic lesions compared to CT scan

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ABSTRACT

Background and Objective: This study investigated the accuracy of portable ultrasonography in the diagnosis of traumatic thoracic lesions (hemothorax, pneumothorax, contusions and fractures) compared to Computed Tomography scan (CT-scan).

Materials and Methods: This descriptive-analytical cross-sectional study was carried out on 50 patients with thoracic trauma to assess the diagnostic value of portable ultrasonography compared to CT scan. First, ultrasonography of the lungs and CT scan of the chest were performed. Then, the sensitivity, specificity, and positive and negative predictive values were investigated to examine the accuracy and precision of ultrasonography compared to CT scan.

Results: In this study, the sensitivity, specificity, and positive and negative predictive values of ultrasonography for detecting thoracic lesions and complications following trauma were 56.82%, 100.0%, 100%, and 91.52%, respectively, with a diagnostic accuracy of 92.37%.

Conclusion: The findings of the present study suggested that in the initial evaluation of patients with traumatic thoracic injuries, ultrasonography, in addition to being an accessible, simple, low-cost and feasible method for all patients, has a high diagnostic value, especially in diagnosing pneumothorax and sternum fracture.

Keywords: thoracic trauma, pneumothorax, FAST (Focused Assessment with Sonography in Trauma) exam, chest CT scan, hemothorax, rib fracture, sternal fracture, pulmonary contusion

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INTRODUCTION

Currently, trauma is the main cause of mortality, hospitalization and disability in all age groups. For this reason, much research is being done on victims of trauma. Non-penetrating injury to the chest is the cause of mortality in 10%-15% of patients hospitalized due to trauma worldwide. A statistical analysis in the United States revealed that injuries to the thoracic region were the cause of 25% of trauma-related deaths. The mortality rate in traumatic thoracic injury is high. Age of over 50 years, penetrating injury, bilateral thoracic injury, injuries associated with thoracic injury, and the need for mechanical ventilation were identified as possible risk factors for mortality in patients with thoracic injuries [1]. The most important thoracic injuries include rib fractures, pneumothorax, hemothorax, and aortic rupture, and there are different ways to diagnose them. Rapid diagnosis of thoracic trauma injuries can reduce mortality and the related burden. Among the available procedures, thoracic radiography is used as a primary diagnostic tool in these cases. This technique is cheap and non-invasive, and can acceptably show cases such as obvious rib fractures, hemothorax and pneumothorax. Studies report the low diagnostic performance of thoracic radiography (pneumothorax 62%, hemothorax 70.3%, and rib fracture 73.4%) in identifying internal injuries of the thoracic region [2].

Also, it cannot be performed in critically-ill patients due to concerns about spinal cord injuries, hemodynamic instability, and reduced level of consciousness. The next modality is ultrasonography, which is performed along with FAST (Focused Assessment With Sonography in Trauma). Lung ultrasonography is a reliable, dynamic, FAST, and non-invasive method that can be performed at the patient's bedside, and it has significant value in emergency in diagnosing pneumothorax. However, this tool is largely dependent on the experience and expertise of the operator. The diagnostic value of ultrasonography to find mediastinal lesions depends on the mediastinal compartment. In the evaluation of supra-aortic, pericardial and paratracheal areas, ultrasonography has a sensitivity of 89%-100% and accuracy almost equal to CT scan. Nonetheless, ultrasonography has only 69%-81% sensitivity in the aortopulmonary window and subcarinal areas [3].

Nowadays, there are different criteria to reduce the amount of x-rays and increase the sensitivity of examinations, one of which is (National Emergency X-Radiography Utilization Study) NEXUS Criteria for Thoracic Trauma. According to this criterion, CT scan is the gold standard for diagnosing thoracic

trauma. Although this diagnostic tool is very accurate in detecting injuries inside the thoracic region, patients who undergo a CT scan receive a high dose of radiation [4]. Presently, diagnostic measures for thoracic trauma include CT-scan, CXR (Chest X-ray), and ultrasonography. As it is well-known, some patients suspected of pneumothorax are unstable and cannot be referred to CT-scan and CXR, while thoracic ultrasonography can be used as a quick, accessible, simple and bedside method to diagnose thoracic lesions caused by trauma. Thus, this study investigated the accuracy of portable ultrasonography in diagnosing thoracic trauma lesions (hemothorax, pneumothorax, contusions, and fractures) compared to CT scan in patients referred to the emergency wards of Shahid Rahnemoon Hospital And Shahid Sadoughi Hospital In Yazd.

METHODOLOGY

This descriptive-analytical study was carried out using a cross-sectional method to assess the diagnostic value of portable ultrasonography compared to CT scan.

Inclusion criteria

All thoracic trauma patients (penetrating and non-penetrating) referring to the emergency wards of Shahid Rahnemoon Hospital and Shahid Sadoughi Hospital in Yazd within 6 months in 2021 who were indicated for chest CT scan according to the NEXUS criteria, were included in the study.

Exclusion criteria

These included: patients whose lesions were diagnosed before ultrasonography, needing an urgent thoracic tube, hemodynamic instability, pregnant women, patients transferred to the operating room earlier than CT scan and ultrasonography, and lack of consent for ultrasonography.

The statistical population included patients with thoracic trauma referred to the emergency room of Shahid Rahnemoon Hospital and Shahid Sadoughi Hospital in Yazd with a sample volume of at least 50 cases. This study used non-random sequential sampling.

NEXUS criteria for thoracic CT scan in patients with blunt thoracic trauma included: abnormal thoracic X-ray, rapid deceleration mechanism, distracting painful injury, thoracic wall tenderness, sternal tenderness, thoracic spine tenderness, and scapular tenderness. To collect data, a researcher-made questionnaire was used including two parts of demographic information (age and gender) and information related to thoracic trauma (type of trauma, mechanism of trauma, and pathological findings of CT scan). The content validity of the questionnaire was confirmed by faculty clinicians of Emergency Medicine Ward. Thoracic ultrasonography was performed with a high-frequency linear probe (7.5 MHz) and a low-frequency probe (3.5 MHz) of the Sonosite device by an emergency medicine specialist trained in sonography of trauma patients. Ultrasonography was performed without knowing the results of the chest x-ray and CT scan. Subsequently, the ultrasonography results were compared with the CT scan findings and interpreted by the radiologist. The obtained results were tabulated and its sensitivity, specificity, and positive and negative predictive values were calculated.

RESULT

The study was conducted on 50 patients. According to method design, unstable hemodynamic patients(n=31), Pregnant patients (n=2), Tension pneumothorax (n=3) were excluded from the study (Figure 1).

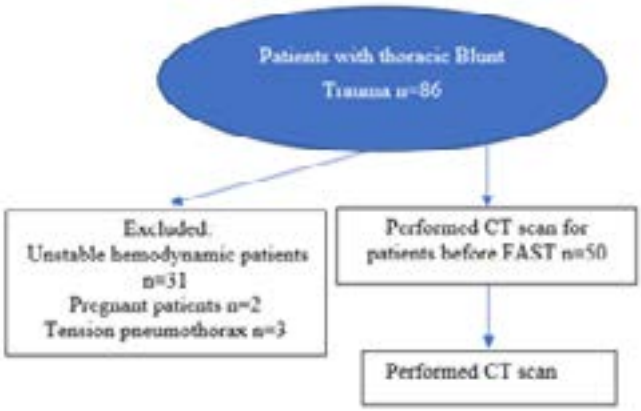

Fig. 1. Flow chart of thoracic trauma patients during the study period

The mean age of the patients was 33.8 years ± 1.6 years with a range of 4 years-85 years. Of these, 43 (86%) were male and 7 (14%) were female. The present study showed that the mechanism of trauma was falls in 30% of the cases and accidents in 70% of the cases (Table 1).

Tab. 1. Determination of demographic variables and mechanism of trauma in the study

			Frequency	%
Variable	Gender	Male	43	86
		Female	7	14
	Trauma mechanism	Fall	0	30
		Accident	0	70

The sensitivity, specificity, PPV and NPV of bedside ultrasonography by an emergency medicine specialist in the diagnosis of pneumothorax compared to CT scan was 70%, 100%, 100% and 93.2% respectively, and accuracy was 94.0% (Table 2).

Tab. 2. Determining the diagnostic value of bedside ultrasonography by an emergency medicine specialist in the diagnosis of pneumothorax compared to CT scan

Negative CT scan	Positive CT scan	Pneumothorax
0	7	Positive ultrasonography
40	3	Negative ultrasonography
Statistic	**Value**	**95% CI**
Sensitivity	70.00%	34.75% to 93.33%
Specificity	100.00%	91.19% to 100.00%
Disease prevalence	20.00%	10.03% to 33.72%
Positive predictive value	100.00%	59.04% to 100.00%
Negative predictive value	93.02%	83.80% to 97.17%
Accuracy	94.00%	83.45% to 98.75%

The sensitivity, specificity, PPV and NPV of bedside ultrasonography by an emergency medicine specialist in the diagnosis of hemothorax compared to CT scan was 37.5%, 100%, 100% and 89.13%, and the accuracy was 89.8% (Table 3).

Tab. 3. Determining the diagnostic value of bedside ultrasonography by an emergency medicine specialist in the diagnosis of hemothorax compared to CT scan

Negative CT scan	Positive CT scan	Hemothorax
0	3	Positive ultrasonography
41	5	Negative ultrasonography
Statistic	**Value**	**95% CI**
Sensitivity	37.50%	8.52% to 75.51%
Specificity	100.00%	91.40% to 100.00%
Disease prevalence	16.33%	7.32% to 29.66%
Positive predictive value	100.00%	29.24% to 100.00%
Negative predictive value	89.13%	82.74% to 93.34%
Accuracy	89.80%	77.77% to 96.60%

The sensitivity, specificity, PPV and NPV of bedside ultrasonography by an emergency medicine specialist in the diagnosis of rib fracture compared to CT scan was 65.0%, 100%, 100%, 81.8%, and the accuracy was 86.0% (Table 4).

Tab. 4. Determining the diagnostic value of bedside ultrasonography by an emergency medicine specialist in the diagnosis of rib fracture compared to CT scan

Negative CT scan	Positive CT scan	Rib fracture diagnosis
13	0	Positive ultrasonography
7	30	Negative ultrasonography
Statistic	**Value**	**95% CI**
Sensitivity	65.00%	40.78% to 84.61%
Specificity	100.00%	88.43% to 100.00%
Disease prevalence	40.00%	26.41% to 54.82%
Positive predictive value	100.00%	75.29% to 100.00%
Negative predictive value	81.08%	70.22% to 88.62%
Accuracy	86.00%	73.26% to 94.18%

The sensitivity, specificity, PPV and NPV of bedside ultrasonography by an emergency medicine specialist in the diagnosis of sternum fracture compared to CT scan Was 100%, 100%, 100% and 100%, and the accuracy was 100% (Table 5).

Tab. 5. Determining the diagnostic value of bedside ultrasonography by an emergency medicine specialist in the diagnosis of sternum fracture compared to CT scan

Negative CT scan	Positive CT scan	Sternum fracture diagnosis
2	0	Positive ultrasonography
0	48	Negative ultrasonography
Statistic	**Value**	**95% CI**
Sensitivity	100.00%	15.81% to 100.00%
Specificity	100.00%	92.60% to 100.00%
Disease prevalence	4.00%	0.49% to 13.71%

Positive predictive value	100.00%	15.81% to 100.00%
Negative predictive value	100.00%	92.60% to 100.00%
Accuracy	100.00%	92.89% to 100.00%

The sensitivity, specificity, PPV and NPV of bedside ultrasonography by an emergency medicine specialist in the diagnosis of pulmonary contusion compared to CT scan was 0.0%, 100%, 92.0% and 92.0% and the accuracy was 100% (Table 6).

Tab. 6. Determining the diagnostic value of bedside ultrasonography by an emergency medicine specialist in the diagnosis of pulmonary contusion compared to CT scan

Negative CT scan	Positive CT scan	Pulmonary Contusion Diagnosis
0	0	Positive ultrasonography
4	46	Negative ultrasonography
Statistic	**Value**	**95% CI**
Sensitivity	0.00%	0.00% to 60.24%
Specificity	100.00%	92.29% to 100.00%
Disease prevalence	8.00%	2.22% to 19.23%
Positive predictive value	0	0
Negative predictive value	92.00%	92.00% to 92.00%
Accuracy	92.00%	80.77% to 97.78%

The general sensitivity, specificity, PPV and NPV of bedside ultrasonography by an emergency medicine specialist in diagnosing complications caused by thoracic trauma was 56.8%, 100%, 100%, 91.52% and the accuracy was 92.37% (Table 7).

Tab. 7. Determining the general diagnostic value of bedside ultrasonography by an emergency medicine specialist in diagnosing complications caused by thoracic trauma

Statistic	Value	95% CI
Sensitivity	56.82%	41.03% to 71.65%
Specificity	100.00%	98.22% to 100.00%
Disease prevalence	17.67%	13.14% to 22.99%
Positive predictive value	100.00%	86.28% to 100.00%
Negative predictive value	91.52%	88.49% to 93.81%
Accuracy	92.37%	88.34% to 95.34%

DISCUSSION

The present study was a descriptive-analytical study that used a descriptive-cross-sectional method and evaluation of the diagnostic methods with the aim of examining the accuracy of portable ultrasonography in the diagnosis of thoracic traumata compared to CT scan in the emergency ward of teaching hospitals of Shahid Sadoughi University of Medical Sciences, Yazd, central Iran. Accidents were the most common cause of trauma in this study, and the most engaged age group were those in the second and third decades of life and they occurred more in men than women. In this study, the sensitivity, specificity, and positive and negative predictive value of ultrasonography for detecting thoracic traumata and complications following trauma were 56.82%, 100.0%, 100%, and 91.52%, respectively, with a diagnostic accuracy of 92.37%. In the present study, the highest diagnostic value of ultrasonography pertained to the diagnosis of pneumothorax and sternum fracture. In cases of localized and small pneumothorax, especially in the back of the thorax, small hematomata, fractures with low displacement, especially in the back of the thoracic region, ultrasonography was less able to find the lesion. This issue may be due to operator-dependent nature of the procedure. The study by Vafaei et al., conducted in Shahid Beheshti University of Medical Sciences, examined 152 patients with thoracic trauma and showed that the sensitivity and specificity of ultrasonography were 68.8% and 92.3% in the diagnosis of lung contusion, 83.6% and 97.9% in the diagnosis of pneumothorax, and 75.9% and 95.9% in the diagnosis of hemothorax. This was almost consistent with the present study [5]. The study by Helmy et al. suggested that the sensitivity and specificity of ultrasonography were 97.5% and 90% in the diagnosis of lung contusion, and its positive and negative predictive values were 97.5% and 90%, respectively, which was higher than that in Mashayekhian's study [6]. In another study, they mentioned 58.1% sensitivity, 100% specificity, 100% positive predictive value, and 86.3% negative predictive value for ultrasonography in the diagnosis of lung cancer [7]. To assess rib fractures, lung CT scan and thoracic x-ray are easier modalities, because in ultrasonography, each rib must be evaluated alone, which is time-consuming for the doctor/operator; it can also be painful for the patient due to the contact of the probe with the fracture area. Yet, CT scan does not have these problems. In this regard, in a study, the diagnostic accuracy of sonography was 80% with a sensitivity of 91.2% and a specificity of 72.7% for the diagnosis of any rib fracture [8]. Regarding the assessment of pneumothorax, especially the compressive type(tension pneumothorax), it is necessary to evaluate it at bedside due to its emergency nature, and if necessary, it should be treated quickly. Fortunately, in this context, the sensitivity and specificity of the bedside ultrasonography are reported as 70% and 100%, respectively. Of course, there are limitations in the use of ultrasonography. Pneumomediastinum,

subcutaneous emphysema, pulmonary empyema, and pleural adhesions by destroying normal artifacts and sliding pleural layers cause false positive ultrasonography results. Finally, the small size of pneumothorax, localized pneumothorax, the low quality of the ultrasonography device and its probe, and operator-dependent nature of the procedure can produce false negative results [2].

CONCLUSION

The results of the present study indicated that compared to CT scan, which is the gold standard for diagnosing thoracic traumata complications in multiple traumata patients, ultrasonography has a good diagnostic value with good diagnostic accuracy: Due to its availability, radiation-free nature, easy use at patient's bedside, and applicability for all patients as a suitable method in determining the treatment modality of patients with thoracic trauma in the emergency room in the initial treatment, especially in the diagnosis of pneumothorax, it is a very suitable diagnostic modality with high diagnostic value.

AUTHORSHIP

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- Drafting the work and reviewing it critically for important intellectual content: Faeze Zeinali.
- Final approval of the version to be published: Ali Raee.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. Yimam AE, Mustofa SY, Aytolign HA. Mortality rate and factors associated with death in traumatic chest injury patients: A retrospective study. Int J Surg Open. 2021;37:100420.
2. Jivani HB, Joshi P, Dsouza J. Beyond the surface: exploring chest trauma with conventional radiography and CT. Cureus. 2023;15:1-11.
3. Spering C, Brauns SD, Lefering R, Bouillon B, Dobroniak CC, et al. Diagnostic value of chest radiography in the early management of severely injured patients with mediastinal vascular injury. Eur J Trauma Emerg Surg. 2022;48:4223-4231.
4. Ahmadzadeh K, Abbasi M, Yousefifard M, Safari S. Value of NEXUS chest rules in assessment of traumatic chest injuries; a systematic review and a meta-analysis. Am J Emerg Med. 2023;65:53-58.
5. 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;4:29-33.
6. Helmy S, Beshay B, Hady MA, Mansour A. Role of chest ultrasonography in the diagnosis of lung contusion. Egypt J Chest Dis Tuberc. 2015;64:469-475.
7. Jahanshir A, Moghari SM, Ahmadi A, Moghadam PZ, Bahreini M. Value of point-of-care ultrasonography compared with computed tomography scan in detecting potential life-threatening conditions in blunt chest trauma patients. Ultrasound J. 2020;12:1-10.
8. Çelik A, Akoglu H, Omercikoglu S, Bugdayci O, Karacabey S, et al. The diagnostic accuracy of ultrasonography for the diagnosis of rib fractures in patients presenting to emergency department with blunt chest trauma. J Emerg Med. 2021;60:90-97.