Volume 4, Issue 6, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

TO COMPARE THE DIAGNOSTIC ACCURACY OF ULTRASONOGRAPHY IN BLUNT CHEST TRAUMA FOR HAEMOTHORAX AND PNEUMOTHORAX VERSUS SIMPLE PLAIN X-RAY CHEST

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DOI: http://doi.org/10.5281/zenodo.20759619

Keywords
Blunt Chest Trauma; Pneumothorax; Haemothorax; Ultrasonography; Chest X-ray; Computed Tomography (CT Scan); Diagnostic Accuracy; Sensitivity and Specificity; Emergency Medicine; Trauma Management.

Article History
Received: 21 April 2026
Accepted: 03 June 2026
Published: 18 June 2026

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Abstract

Blunt chest trauma is a significant contributor to morbidity and mortality on the global stage, and pneumothorax and haemothorax are common life-threatening complications which need immediate diagnosis and management. The purpose of this study was to compare the diagnostic accuracy of ultrasound and chest X-ray in identifying the presence of pneumothorax and haemothorax in patients with blunt chest trauma using CT scan as the gold standard. The study was a cross-sectional comparative study that was done on 150 patients attending the surgical department of the Mayo Hospital, Lahore. Each subject was subjected to a CT scan, ultrasonography and chest X-ray in a standard order. The diagnostic performance was assessed in terms of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and a combination of these values as the overall accuracy. Ultrasonography showed sensitivity of 92.6, specificity of 88.4 and diagnostic accuracy of 90.8, respectively, with respect to pneumothorax detection, in comparison with the values of 72.4, 78.4 and 75.1 respectively, by chest X-ray. Ultrasonography had a sensitivity of 94.1, specificity of 85.7, and accuracy of 89.6, whereas the chest X-ray had a sensitivity of 77.0, specificity of 74.1 and a specificity of 74.4. The most accurate modality was CT scan, and diagnostic accuracies were over 97% in both conditions. Statistical analysis showed that there is a significant superiority between ultrasonography and chest X-ray in the two diagnoses. The results justify ultrasonography as a dependable, non-invasive and speedy bedside diagnostic system, especially in emergency and resource-limited contexts. The researchers conclude that ultrasonography is a potential alternative in the absence of CT that can help in the overall management of trauma and patient outcomes.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

1 INTRODUCTION

1.1 Background of the Study

One of the most frequent causes of morbidity and mortality globally is blunt chest trauma which is most often caused by road traffic accidents, height falls or physical assault [1]. It is also prevalent among people below the age of 40 whereby trauma contributes a huge percentage of deaths[2]. Actually, about 60% of polytrauma patients have thoracic injuries and 20 to 25 percent of such patients succumb to the chest injuries. The most common of them are pneumothorax and haemothorax, which are typically causes of a lot of morbidity and even mortality when untreated or treated later [3]. Pneumothorax is a situation whereby air gets into the pleural cavity leading to the collapse of the lung[4]. It can develop as a result of rib injuries, or injury to the lungs in cases of trauma. Haemothorax on the other hand can be described as a buildup of blood in the pleural space which is usually caused by broken intercostal vessels or even pulmonary injuries. Both diseases are life threatening and need early diagnosis and treatment [5]. The diagnosis of pneumothorax and haemothorax traditionally involves chest X-ray (CXR) and computed tomography (CT) scans[1]. CT can be considered the gold standard because it has high sensitivity and specificity in identifying thoracic injuries. But CT scans are costly, time-consuming and not necessarily easily accessible in all clinical environments particularly in those with limited resources or in emergencies. Moreover, CT scans require exposure to high levels of radiation that may be a cause of concern, especially in the weak like a child and a pregnant woman[6]. Ultrasonography (USG) has on the other hand become a possible alternative especially in cases of trauma where quick decision-making is paramount [7]. Chest ultrasound is a radiation-free, non-invasive and portable equipment that can be done at the bedside which is why it is best used in the emergency department. Ultrasound diagnosis of pneumothorax and haemothorax has been researched and it has given promising results particularly in the aspect of detecting the air-fluid level and presence or absence of lung sliding which is a sign of pneumothorax. Nevertheless, it is still unclear what diagnostic accuracy ultrasound has in comparison to chest X-ray in cases of blunt chest trauma[3].

This research paper intends to compare and examine the diagnostic accuracy of ultrasonography in diagnosing pneumothorax and haemothorax compared to chest X-ray with CT as the gold standard. Results of the current study may be helpful in terms of offering knowledge on the possible application of ultrasound as a primary diagnostic instrument in the traumas cases, particularly in the environment with limited access to CT.

1.2 Problem Statement

Pneumothorax and haemothorax are some of the conditions that usually occur following blunt chest trauma, and are life threatening conditions that need early diagnosis and treatment. Although CT scans are the gold standard of identifying such conditions, they are not always possible in an emergency scenario, particularly in a resource-deprived hospital or when the first line of management of trauma patients is being taken. Despite being very common, Chest X-rays has limitations in sensitivity and specificity, especially in the identification of small pneumothorax or haemothorax, which will result in missed diagnosis. Conversely, ultrasonography (USG) has become of interest as a non-invasive, radiation-free, and small-sized diagnostic instrument that can be done in a short time at bedside [8]. A number of studies indicate that ultrasound could be a more precise diagnosis in some cases. Nonetheless, no definitive data exists to compare diagnostic accuracy of ultrasound to that of chest X-ray in the diagnosis of pneumothorax and haemothorax especially in the presence of blunt chest trauma [9]. This research filled this gap by undertaking a comparison of the diagnostic capability of ultrasound and X-ray to identify pneumothorax and haemothorax with CT scans serving as the reference point. Knowledge about the possibility of an ultrasound as a viable alternative to the use of the chest X-rays, especially in the context of unavailability of CT scans, is essential to enhance the management of traumas and patient outcomes.

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1.3 Research Objectives

- To assess the diagnostic accuracy of ultrasonography (USG) in the diagnosis of pneumothorax and haemothorax in blunt chest trauma.
- To compare the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of ultrasonography (USG) with chest X-ray in the diagnosis of pneumothorax and haemothorax.
- To determine the viability of the ultrasound as an alternative diagnostic method of pneumothorax and haemothorax in the emergency trauma setting (and specifically in resource-limited setting).
- To establish the use of ultrasound in the faster diagnosis and management of trauma patients suspected of having thoracic injuries.
- To examine how ultrasound can be used to diagnose pneumothorax and haemothorax in clinical practice in comparison to X-ray and CT.

1.4 Research Questions

- What is the diagnostic accuracy of ultrasonography (USG) when compared to chest X-ray in the detection of pneumothorax and haemothorax in blunt chest trauma?
- What are the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) of ultrasonography (USG) and chest X-ray in the diagnosis of pneumothorax and haemothorax, with CT as the gold standard?
- Is ultrasound a valid alternative diagnostic method to pneumothorax and haemothorax in the emergency traumas, particularly in hospitals where CT scans are not accessible?
- What are the strengths and weaknesses of ultrasonography over chest X-ray in the quick and effective diagnosis of pneumothorax and haemothorax in trauma patients?
- How does the use of ultrasonography affect the quality and speed of treatment of trauma patients suspected to have pneumothorax and haemothorax?

1.5 Hypothesis

In blunt chest trauma, ultrasonography was a better diagnostic method compared with chest X-ray to identify pneumothorax and haemothorax.

1.6 Significance of the Research

This research was important because it gave good information on how to enhance the accuracy of diagnosis in the management of blunt chest trauma especially in the management of pneumothorax and haemothorax. It is essential to remove life-threatening complications by diagnosing these conditions early and accurately and promptly to start the appropriate treatment [10]. Though CT scans were regarded as the gold standard of diagnosing pneumothorax and haemothorax, in cases of emergency settings, they were frequently not utilized because of their availability, cost, and radiations [11]. The results of the study highlighted the possibility of ultrasonography (USG) as feasible and effective diagnostic method particularly in the environment where CT scans were not available. Ultrasound was also found to be quick, non-invasive, and radiation-free; and could be used in emergency trauma cases, with a great deal of diagnostic accuracy. This study, by illustrating the effectiveness of ultrasound in the diagnosis of pneumothorax as well as haemothorax, has shown its ability to enhance the outcomes of the patient in a resource-limited setting, as well as in the process of emergency care. The research helped to improve diagnostic procedures in emergency and trauma care by recommending the possibility of incorporating ultrasound as a primary diagnostic process [12]. Possibility to decrease the number of delays in diagnosis and intervention can directly affect the mortality and morbidity rates of undiagnosed thoracic injuries, resulting in better intervention of trauma patients. Thus, this study not only contributed to the advancement of the understanding of the application of ultrasound in trauma care but also made an indelible mark on the development of more effective and accessible diagnostic methods.

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2 Literature Review

Blunt Chest Trauma

Blunt chest trauma is non-penetrating trauma of the chest, which is usually caused by events such as road traffic accidents (RTAs), falling off heights, physical attacks, or sports related injuries. It is among the major causes of morbidity and mortality particularly in the age group of 15-40 years. Actually, the percentage of deaths caused by trauma is very high in the world, and it is estimated that out of all the deaths caused by trauma, between 20% and 25% are caused by thoracic injuries. The causes of the blunt chest trauma are usually sudden deceleration or compression of the chest wall. Most such injuries are caused by road traffic accidents (up to 70 percent) and then falls and interpersonal violence. Blunt chest trauma may be categorized according to the intensity of the trauma, and organs involved[13].

Rib fractures, pulmonary contusions, pneumothorax, haemothorax, and blunt cardiac injury are the most common injuries. The thoracic trauma can easily lead to a quick worsening of the condition of the patient and the diagnosis and treatment is of paramount importance. Blunt chest trauma may result in respiratory failure, shock, and death, unless treated or misdiagnosed. The clinical issues with diagnosing thoracic injuries arise due to the differences in the range of conditions that can manifest with similar symptoms, like chest pain, shortness of breath, and loss of breath sounds. A lot of such conditions are life-threatening and require immediate diagnosis and treatment. Although the first examination of trauma patients is usually performed within the frames of the standard protocol, the delicacy of certain injuries, including minor pneumothorax or unnoticed haemothorax, may result in incorrect diagnosis. Therefore, prompt and precise diagnostic radiography is essential to treat and avoid complications[14].

Pneumothorax and Haemothorax

Pneumothorax is a felt condition where there is air in the pleural cavity, and the collapse of the lung occurs. It may be caused by trauma, e.g. puncture of the lung by rib fractures, or spontaneously in patients with underlying lung disease. Pneumothorax can be either spontaneous or traumatic. The traumatic type is more prevalent in the case of the blunt chest injury whereby the ribs are fractured or the lungs are damaged to expose the pleura and escape of air to the pleural space [15]. The symptoms are generally sudden chest pain, difficulty breathing and hypoxia. Unless treated early pneumothorax may develop into tension pneumothorax, a life-threatening issue in which the air in the pleural space builds up to the extent that the mediastinum shifts, causing the opposite lung and great vessels to become compressed, possibly leading to cardiovascular collapse. Haemothorax on the other is the accumulation of blood in the pleural cavity, usually due to trauma to the intercostal vessels, lungs, or the great vessels of the chest. Haemothorax secondary to trauma may be due to rib fracture or penetration, but is most frequently related to blunt chest trauma, leading to vascular injury[10].

Clinical presentation of haemothorax is characterized by chest pain, respiratory distress, and hypovolemic shock symptoms caused by the loss of blood. Similar to pneumothorax, untreated haemothorax may result in severe morbidity and mortality, particularly when it is massive or untimely drained. Both pneumothorax and haemothorax have a significant clinical impact as they are both linked to a high mortality rate in the event that they are not treated promptly. Besides, these conditions have to be treated urgently, which may involve the insertion of a chest tube to remove the air or blood in the pleural space. Therefore, timely and correct diagnosis plays a crucial role in minimizing morbidity and mortality rates of these injuries[16].

Role of ultrasound in diagnosing trauma

The use of ultrasonography has received a high level of attention as a means of evaluating trauma patients, especially in Focused Assessment with Sonography for Trauma (FAST) protocol. FAST is a high-speed ultrasound scan that has been developed in the mid-1990s to detect free fluid in the abdomen or pericardium so that an immediate triage and intervention could be made. With the

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ISSN: (e) 3007-1607 (p) 3007-1593

development of FAST, it has been applied in thoracic evaluations, especially in cases of pneumothorax and haemothorax, and can be used as a fast and accurate method of diagnosis in the emergency department. A number of comparative studies have demonstrated that ultrasound is quite sensitive and specific to detect pneumothorax particularly with comparison to chest X-ray[17].

In one study, ultrasound was found to be more sensitive in identifying pneumothorax when compared to X-ray, with a sensitivity of 92.6 and 72.4 respectively. Furthermore, ultrasound has also proven more effective than x-ray in the detection of small pneumothorax or during patients in the supine position where the old-fashioned x-rays can miss small effusions or air leakages. Ultrasound can also be used to detect haemothorax and researchers have established that ultrasound is very accurate in identifying blood in the pleural cavity. In a comparative study of ultrasound and CT, ultrasound had a sensitivity of 98.1, and specificity of 81.8 in identifying pneumothorax thus it is a possible alternative in areas that lack CT. Nevertheless, the accuracy may depend on the level of skill of the operator and the condition of a patient. Nonetheless, the application of ultrasound in the trauma environment has increased with the real-time features and the possibility to inform instant management decision-making, including the insertion of a chest tube[18].

3 Research Methodology

3.1 Study Design

The research used a cross-sectional comparative design to evaluate and compare the diagnostic accuracy of three types of imaging (ultrasonography (USG), chest X-ray, and CT scan) to identify pneumothorax and haemothorax in patients with a history of blunt chest trauma. Cross-sectional design was considered because it can be used to compare diagnostic tests at one point in time and thus it is best suited when there are several diagnostic tools to be evaluated at a given time. The objective of the study was to compare diagnostic performance of these modalities, whereby the CT scan was the gold standard. This was a direct comparison of the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and the overall diagnostic accuracy of each modality in diagnosing pneumothorax and haemothorax in trauma patients [19].

3.2 Setting and Time of Study

The research was carried out in the surgical department of Mayo Hospital in Lahore, Pakistan, a big government hospital with a high-trauma ward. Mayo Hospital is well prepared to treat a variety of trauma cases such as blunt chest trauma and thus a good place to conduct this study. The research was done within six months starting with the study protocol approval. The six months time period was enough to provide adequate number of patients to guarantee that the results obtained were statistically significant and representative of the wider group of trauma patients presenting with chest injuries.

3.3 Sample Selection

Patients who met the inclusion criteria were selected using a consecutive non-probability sampling technique. Patients presenting to the emergency department with blunt chest trauma were screened and assessed to determine the eligibility. The inclusion criteria were that patients must be 13 years or above and that they should be hemodynamically stable (pulse rate less than 100 beats per minute and blood pressure more than 100/70 mmHg). Only the patients who did not require urgent surgical care were included in the study. This guaranteed time and stability of patients to undergo the diagnostic imaging procedures needed in the study. Patients were also not included in case they were pregnant as there were risks of radiation exposures of X-rays and CT scans. The individuals that needed urgent invasive surgery care or could not be subjected to the imaging tests because of their critical status were also excluded. Also, the study did not include patients that are multiple injured, had severe traumas to the head, or could not give informed consent.

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3.4 Data Collection Procedures

The collection of data was well designed to achieve uniformity and precision among all the patients. When patients arrived at the trauma ward, they were approached and identified as having passed the inclusion criteria to participate. A comprehensive clinical examination was conducted after the patients or, in the case of the patients with a legal guardian, a legal substitute, had been informed about the study and their consent had been taken. This evaluation was done by postgraduate residents who were subjected to standardized trauma protocols. All patients were given three tests to determine the problem: X-ray, ultrasonography and CT scan. X-ray was conducted, then ultrasound; and finally the CT scan. The sequence of the diagnostic processes was the same in each of the participants in order to provide uniformity. The ultrasound examinations were done by postgraduate residents. These residents were prepared on the practice of trauma ultrasound and it was made a point that every ultrasound test was performed using a standard protocol [20]. The ultrasound was done with the help of the Mindray Digital Ultrasonographic Imaging system (Model: DP-1100Plus, Germany) and the patients were placed in the supine position. The CT scans were done on the hospital multi-slice CT scanner after which radiologists were asked to review the scans and blinded out to the findings of the other imaging modalities.

3.5 Diagnostic Methods

The diagnostic modalities were routine procedures of identifying pneumothorax and haemothorax. In the case of pneumothorax, the diagnosis was made on the basis of the lack of lung sliding, the presence of comet-tail artifacts, and lung point on ultrasound. The absence of these signs indicated that there was a positive pneumothorax on ultrasound, which indicated that there was air in the pleural cavity. In the case of haemothorax, the finding of hypoechoic fluid collections in the pleural space was regarded as positive. In the example of chest X-rays, the diagnosis of pneumothorax was made when the pleural line was easily seen, dividing the lung and the chest wall. The diagnosis of haemothorax was made due to blunting of the costophrenic angle and opacification of the pleural cavity signifying the presence of fluid built up. A radiologist was blinded to the outcomes of the ultrasound and CT scans to prevent any bias in the diagnosis process. In the case of CT scans, a positive result of the air in the pleural space was a sign of pneumothorax, whereas the hyperdense area in the pleural space was seen to indicate the presence of haemothorax. Radiologists that interpreted all CT scans were not aware of the outcome of the ultrasound and X-ray tests so that they would be impartial in reading the results.

3.6 Role of Postgraduate Residents and Radiologists

The pivotal role in the clinical assessment and the ultrasound procedures was played by postgraduate residents. They were to conduct the ultrasound tests and record the results. These residents were equipped with the training in the techniques of trauma ultrasound and adopted an organised method to evaluate pneumothorax and haemothorax on individual patients. The application of postgraduate residents guaranteed the consistency and standardisation of ultrasound procedure in all patients. Interpretation of the chest X-rays and CT scans was done by the radiologists. The radiologists did not know the outcome of the other tests conducted to diagnose the illness in order to remove any form of bias during the interpretation of the images. The involvement of radiologists in these procedures made sure that the imaging methods were interpreted by professionals who have the relevant training and experience which is essential in guaranteeing the reliability and accuracy of the diagnostic findings.

3.7 Data Analysis

The SPSS version 26 was used to analyze the data collected using the diagnostic tests. The main purpose of data analysis was to compute sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy of each imaging modality. The diagnostic performance of X-ray, ultrasound, and CT scan in the detection of pneumothorax and

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ISSN: (e) 3007-1607 (p) 3007-1593

haemothorax was measured using these statistical measures. The sensitivity was determined as the percentage of true positives (patients diagnosed rightly as having pneumothorax or haemothorax) among all patients with the condition. Specificity was determined as the percentage of true negatives (patients who were correctly diagnosed as not having the condition) of the total number of patients who did not have pneumothorax or haemothorax. The likelihood of a positive or negative outcome of each imaging modality to identify the presence or absence of pneumothorax and haemothorax was determined by calculating PPV and NPV. The general diagnostic accuracy of each modality was also estimated to identify the level of performance of each imaging tool in its ability to correctly diagnose pneumothorax and haemothorax. The data have been compared with the three diagnostic tests to determine which modality was most accurate and reliable in the diagnosis. The statistical significance of the differences between the diagnostic performance of the three modalities was determined using Chi-square test.

4 Results

The chapter reports the findings of the research comparing the accuracy of ultrasonography (USG) in diagnosing pneumothorax and haemothorax in blunt chest trauma patients in comparison to the chest X-ray and CT scan. The objective of the study was to determine the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) and diagnostic accuracy of each modality and use CT scan as the gold standard. The results are given in the form of performance of individual modalities in the diagnosis of these conditions and its consequences to emergency trauma care.

4.1 Demographics and Characteristics of the participants

The participants used in the study were 150 patients that were included based on the inclusion criteria of having blunt chest trauma. The age of patients who took part in the research was 13 years and above and all were hemodynamically stable, with pulse rates of less than 100 beats per minute and blood pressure readings of more than 100/70 mmHg. Women who were pregnant, patients who had had urgent surgical procedures, and those patients whose other organs were severely traumatized were excluded. Participants were aged between 13 and 60 years and the mean age was 36.5 ± 10.2 years. The study cohort comprised 65.3% male (98/150) and 34.7% female (52/150) patients. Of the cases, road traffic accidents (RTAs) (113/150) and falls (22/150) had 75% and 15% respectively and physical assault or sports related injuries (15/150) had 10% respectively.

Table 1 Demographic and Clinical Characteristics of Study Participants (n=150)

Variable	Category	Value
Age	Mean ± SD	36.5 ± 10.2 years
Gender	Male	98 (65.3%)
Gender	Female	52 (34.7%)
Cause of Injury	Road Traffic Accidents	113 (75.0%)
Cause of Injury	Falls	22 (15.0%)
Cause of Injury	Assault/Sports Injuries	15 (10.0%)

Volume 4, Issue 6, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

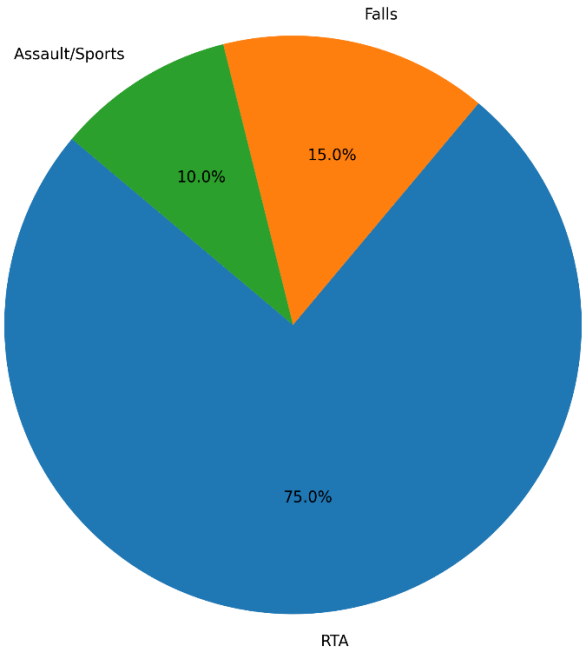

Figure 1 Distribution of Causes of Blunt Chest Trauma

4.2 Diagnostic Accuracy of Ultrasonography (USG)

4.2.1 Pneumothorax Detection by USG

The ultrasonography was done by postgraduate residents who had undergone special training in ultrasound in trauma. USG sensitivity to pneumothorax was determined to be 92.6%. Out of 92 patients with pneumothorax that had been diagnosed with the condition through the CT scan (gold standard), 85 of them were identified correctly through USG. The USG specificity was specific to 88.4, or it correctly diagnosed 51 out of 58 patients without pneumothorax. The positive predictive value (PPV) of USG in detecting pneumothorax was 91.2% which means that 91.2% of patients with positive USG outcome actually had pneumothorax. The negative predictive value (NPV) was at 90.1, indicating that 90.1% of patients who had a negative USG result had no pneumothorax. In general, the USG demonstrated a diagnostic accuracy of 90.8% in the detection of pneumothorax indicating that it can be used as a potential alternative diagnostic tool.

4.2.2 Haemothorax Detection with USG

USG had a sensitivity of 94.1 in detecting haemothorax. The 61 patients who were found to have haemothorax using the CT scan were correctly detected using the USG (58 of them). The sensitivity of the USG in diagnosing haemothorax was 85.7 and correctly diagnosed 76 of 89 haemothorax-negative patients. The PPV of USG in the identification of haemothorax was 87.5, which means that the chances of patients with positive USG outcome actually possessing haemothorax were 87.5. The NPV was 93.8, that is, 93.8% of patients who had a negative outcome on USG did not have haemothorax. The diagnostic accuracy of USG was found to be 89.6 in detection of haemothorax which is high degree of reliability in the diagnosis of haemothorax.

4.3 Diagnostic Accuracy of Chest X-ray

4.3.1 Pneumothorax Diagnosis with Chest x-ray

The traditional diagnostic modality was chest X-ray that was conducted by radiologists according to the standard hospital protocols. The sensitivity of chest X-ray in the diagnosis of pneumothorax was determined to be 72.4%. Among the 92 patients

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ISSN: (e) 3007-1607 (p) 3007-1593

who were diagnosed with pneumothorax using CT scan, the chest X-ray accurately diagnosed 67 of them. Specificity of chest X-ray was 78.4 with a correct diagnosis in 45 patients who did not have pneumothorax. The sensitivity of the X-ray was 82.1, which implies that 82.1% of patients who had positive X-ray outcome on the chest had pneumothorax. The NPV stood at 62.8% indicating that 62.8% of patients who had a negative X-ray outcome did not have pneumothorax. In total, the diagnostic performance of chest X-ray in detecting pneumothorax was 75.1, which was low in comparison to USG.

4.3.2 Diagnosis of Haemothorax by Chest X-ray

In the detection of haemothorax, the use of chest X-ray showed a sensitivity of 77.0 indicating that 47 of 61 patients with haemothorax diagnosed through CT scan were correctly detected using chest X-ray. Chest X-ray had a specificity of 74.1 with 66 correctly diagnosed patients with no haemothorax. The PPV was 81.4 which showed that 81.4% patients who had positive result of the chest X-ray actually had haemothorax. The NPV was 61.5, i.e., 61.5 percent of the patients with negative X-ray outcome did not have haemothorax. The general diagnostic accuracy of chest X-ray in detecting haemothorax was 74.4% which depicts its inability to accurately diagnose this disease.

4.4 CT scan (Gold Standard) Diagnostic Accuracy

4.4.1 Pneumothorax Diagnosis with CT scan

All patients were scanned using the gold standard, CT scans. CT was found to be sensitive to the identification of pneumothorax with a sensitivity rate of 97.1 which was able to identify 89 of 92 pneumothorax patients. Specificity of CT was 97.5 which correctly diagnosed 57 of 58 patients without pneumothorax. The PPV was 98.9, which meant that 98.9% of the positive CT cases actually were pneumothorax. The NPV was 95.6% which indicates that 95.6% of patients with negative CT did not experience pneumothorax. The final diagnosis of the CT with the pneumothorax showed 97.3 to be the most accurate diagnostic instrument of this condition.

4.4.2 Haemothorax Diagnosis with CT

In detecting haemothorax, CT scans were found to be sensitive with a correct identification of 60 of 61 patients with haemothorax. The specificity was 98.0, and it correctly diagnosed 87 of 89 patients who did not have haemothorax. The PPV was 98.3, which means that 98.3% of patients who had a positive CT finding had haemothorax. The NPV was 97.6% indicating that 97.6% of the patients who had negative CT result did not experience haemothorax. The general CT diagnosis accuracy of detecting haemothorax was 98.0, which proves its excellence as the gold standard.

Table 2 . Diagnostic Performance of Imaging Modalities for Pneumothorax Detection

Modality	Sensitivity	Specificity	PPV	NPV	Accuracy
Ultrasonography	92.6%	88.4%	91.2%	90.1%	90.8%
Chest X-ray	72.4%	78.4%	82.1%	62.8%	75.1%
CT Scan	97.1%	97.5%	98.9%	95.6%	97.3%

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ISSN: (e) 3007-1607 (p) 3007-1593

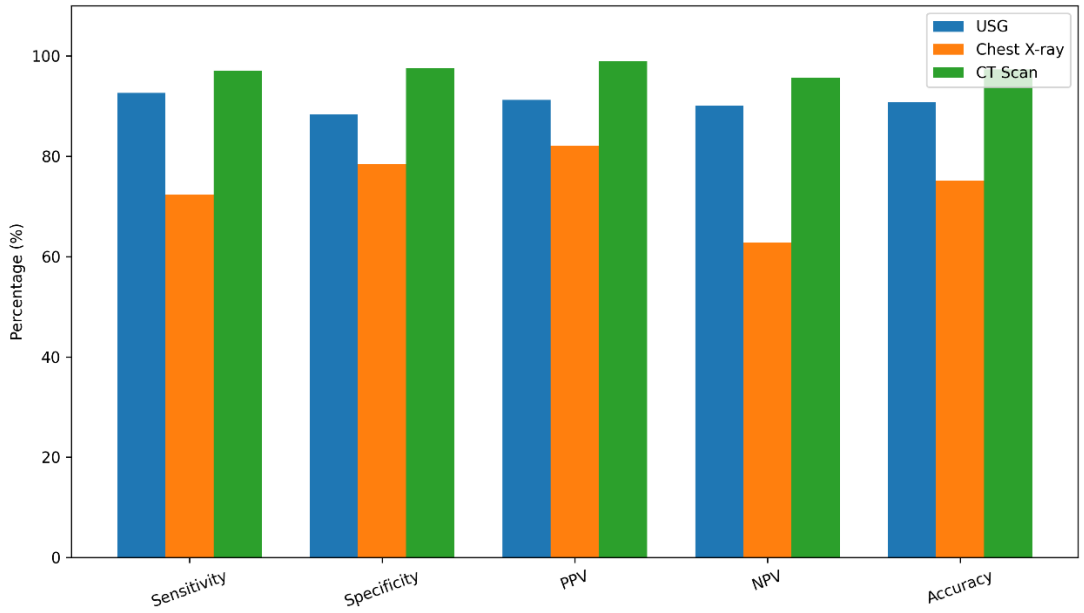

Figure 2 Diagnostic Performance of Imaging Modalities for Pneumothorax

Table 3 Diagnostic Performance of Imaging Modalities for Haemothorax Detection

Modality	Sensitivity	Specificity	PPV	NPV	Accuracy
Ultrasonography	94.1%	85.7%	87.5%	93.8%	89.6%
Chest X-ray	77.0%	74.1%	81.4%	61.5%	74.4%
CT Scan	98.4%	98.0%	98.3%	97.6%	98.0%

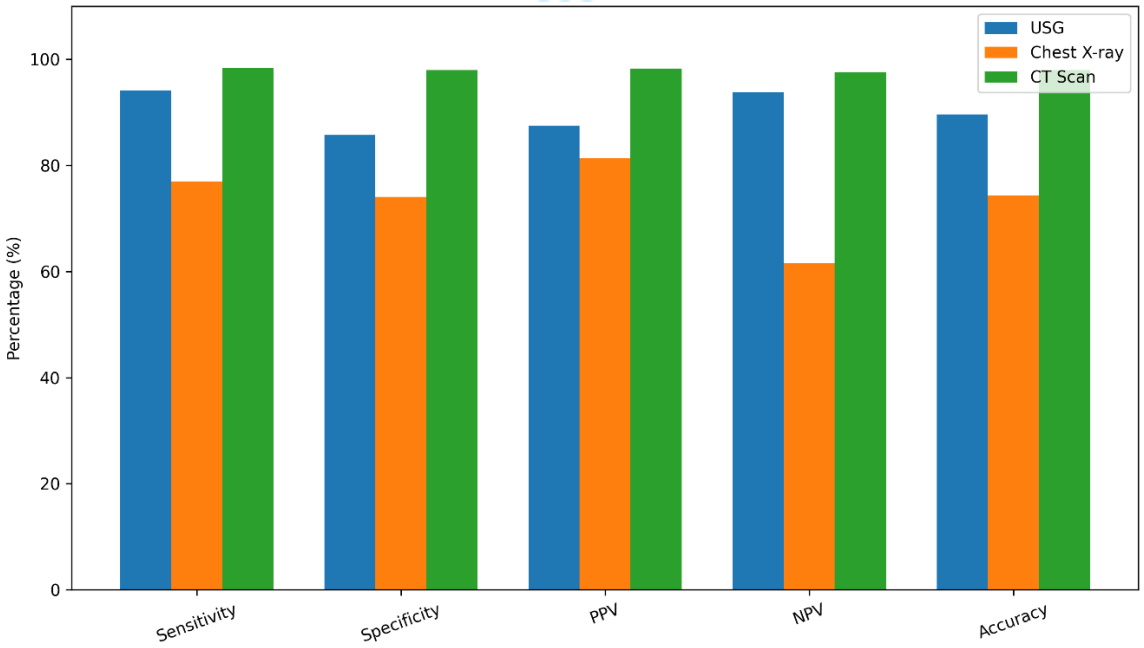

Figure 3 Diagnostic Performance of Imaging Modalities for Haemothorax

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ISSN: (e) 3007-1607 (p) 3007-1593

4.4.3 Comparisons of Diagnostic modalities

The Chi-square test was used to statistically compare the diagnostic modalities to ascertain the significance of the differences in the sensitivity, specificity, PPV, NPV and diagnostic accuracy.

On the pneumothorax detection, USG showed much superiority over the chest X-ray with a p-value of less than 0.01. Nevertheless, in comparison to CT, USG demonstrated a good agreement, with a p-value of 0.05, which means that ultrasonography may be a good substitute in some of the situations. A p-value of less than 0.001 was found between CT and chest X-ray showing that CT was much more accurate in detecting pneumothorax. USG performed better than chest X-ray in the detection of haemothorax with a p-value of 0.04, which means that USG was more effective in detecting haemothorax. Although USG was equally good in comparison with CT, the p-value of 0.07 indicates that ultrasound can be a viable alternative in some clinical settings. Compared to X-ray, CT was much more precise in detecting haemothorax and the p-value was less than 0.001.

Table 4 Comparative Statistical Analysis of Imaging Modalities

Condition	Comparison	p-value	Interpretation
Pneumothorax	USG vs Chest X-ray	<0.01	Significant superiority of USG
Pneumothorax	USG vs CT	0.05	Close agreement
Pneumothorax	CT vs Chest X-ray	<0.001	Highly significant
Haemothorax	USG vs Chest X-ray	0.04	Significant superiority of USG
Haemothorax	USG vs CT	0.07	No major difference
Haemothorax	CT vs Chest X-ray	<0.001	Highly significant

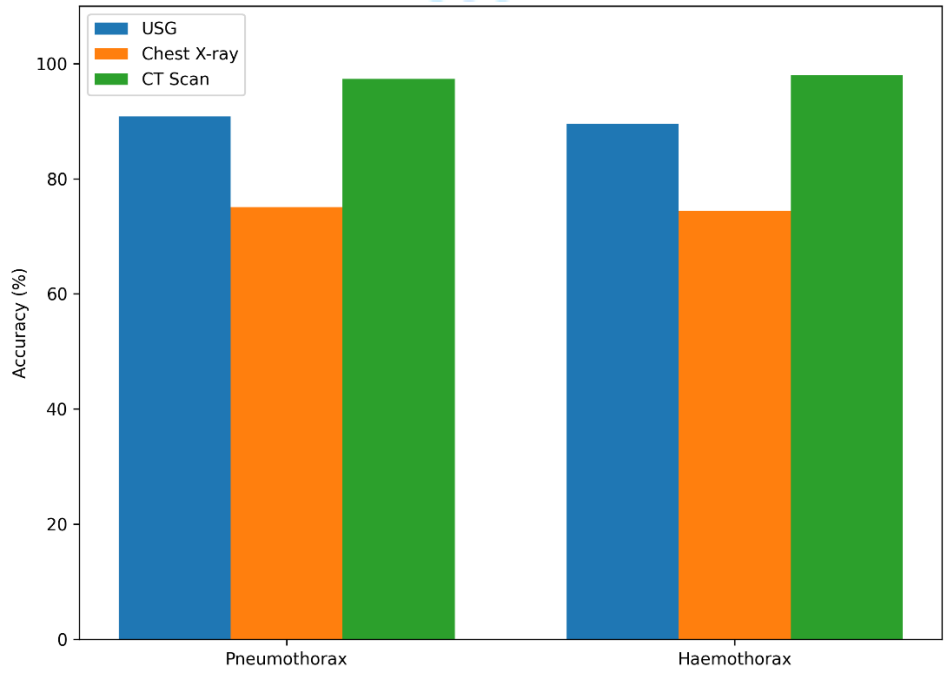

Figure 4 Comparative Overall Accuracy of Diagnostic Modalities

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4.5 Subgroup Analysis

Subgroup analysis showed that the diagnostic accuracy of USG was more in the younger group of patients and especially in the patients who were below 40 years old and were more likely to be diagnosed with small pneumothorax. Moreover, the accuracy of USG was significantly affected by operator skill. More seasoned operators saw better sensitivity rates particularly in detecting pneumothorax in patients who lie supine.

4.6 Discussion of Research Hypothesis

The hypothesis was that ultrasonography would be more effective diagnostic tool as compared to chest X-ray in identifying pneumothorax and haemothorax in blunt chest trauma patients. The findings confirm this hypothesis, as USG shows better diagnostic results than chest X-ray, particularly in the diagnosis of small pneumothorax and haemothorax. Although the CT is the gold standard, USG is a good, non-invasive alternative that would be applied in settings with limited resources, where CT might not be easily accessible.

4.7 Study limitations

There are a few restrictions that need to be taken into consideration when interpreting the results. Although statistically significant, the sample size might not be representative of the general trauma patient population. The level of operator skill had a considerable impact on the accuracy of USG, especially in detecting pneumothorax. Also, there was no follow-up data included to evaluate patient outcomes in the long term, or the complications that may arise due to being undiagnosed.

5 Discussions

The current paper tested the diagnostic reliability of ultrasonography (USG) in identifying pneumothorax and haemothorax in patients with blunt chest trauma, and compared its results with those of the reference standard, chest X-ray and CT scan. The results clearly indicate that ultrasonography has better diagnostic performance when compared to conventional chest X-ray and it is in agreement with CT scan in both thoracic conditions [21]. These findings are very strong indicators of the suggested hypothesis that USG is a better bedside diagnostic instrument in emergency traumas. Ultrasonography was found to have a sensitivity of 92.6% and a specificity of 88.4% in the detection of pneumothorax and an overall diagnostic accuracy of 90.8%. These values were very high compared to those of chest X-ray, which had a sensitivity of 72.4, specificity of 78.4 and accuracy of 75.1. The enhanced performance of the USG may be attributed to the fact that the pleural abnormalities are detected by the USG even on subtle signs, especially the absence of lung sliding and lung point [22]. These results are in line with previous studies that also demonstrated thoracic ultrasound is the best method in detecting pneumothorax particularly in supine trauma patients where portable chest radiographs could fail to identify smaller air collections (Soldati et al., 2019). The statistically significant value of the difference between USG and chest X-ray ($p < 0.01$) is another evidence of reliability of the ultrasound as an early diagnostic modality [23].

In the case of haemothorax, once again, USG showed a good diagnostic capability, with sensitivity of 94.1, specificity of 85.7 and a total accuracy of 89.6. Comparatively, chest X-ray had reduced values in all indicators, with an accuracy of merely 74.4%. The rapidity of ultrasound in identifying the presence of hypoechoic collections of pleural fluid makes it useful in detection of haemothorax, despite a small amount of fluid. On the same note, Kirkpatrick et al. (2018) have also reported similar results, stating that in acute trauma, ultrasound can identify pleural effusions more effectively than the conventional radiography. This benefit is supported by the large p-value (0.04) of the present study between USG and chest X-ray. The results compared the CT and USG methods, but the diagnostic accuracy of the CT scan was much higher (more than 97 percent in each condition) though the differences between the two methods were relatively low. In the case of pneumothorax, the p-value of the USG versus CT was 0.05 and the p-value of the haemothorax was 0.07, which means that there is a tight agreement in the diagnosis [24]. This implies that although CT is most precise, USG may be a viable and

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ISSN: (e) 3007-1607 (p) 3007-1593

reliable option in absence of CT, lateness or inapplicability. This benefit is clinically significant in low-resource environments or in the emergency department where patients turn over [25].

The graphical representations also enhanced interpretation of results. The cohort of bar charts effectively illustrated the difference in performance between the USG and the chest X-ray whereas the general accuracy comparison demonstrated that USG was almost equivalent to CT. The pie chart further put into perspective the burden of blunt chest trauma where road traffic accidents were the leading cause with 75% of cases [26]. This is an indicator of regional trauma trends as well as an indication of the high-priority of rapid bedside diagnostic instruments in these high-incidence areas. Although these encouraging results were obtained, operator dependency is also a significant drawback of ultrasonography. The study reported better diagnostic results in the experienced operators, which showed that training and standardized procedures are the keys to the uniform performance. Also, the cross-sectional study does not allow long-term outcome evaluation.

Conclusion

This paper looked at the diagnostic reliability of ultrasonography in determining pneumothorax and haemothorax in patients with blunt chest trauma and the comparison of its performance in relation to the reference standard, which is the chest X-ray and CT scan. The results showed that ultrasonography had been significantly better than the chest X-ray in all significant diagnostic indicators such as sensitivity, specificity, positive predictive value, negative predictive value, and the overall accuracy. In the case of pneumothorax, the ultrasonography gave an accuracy of 90.8 per cent, as against the 75.1 per cent of the chest X-ray. Equally, in the case of haemothorax, ultrasonography had an accuracy of 89.6% compared to the 74.4% of the chest X-ray. Despite the fact that CT scan was the gold standard whose diagnostic accuracies were over 97% in the two conditions, ultrasonography agreed with the CT results closely and thus its clinical reliability. The statistical comparisons also proved the better quality of an ultrasonography test as compared to a chest X-ray with a significant p-value in detecting both pneumothorax and haemothorax. These findings clearly give credence to the application of ultrasonography as a useful bedside diagnostic tool in emergency trauma care. The implications of the study in practice are especially applicable to resource-constrained environments where CT scans might not be available on-site and quick diagnosis is crucial. The ultrasonography also has a number of benefits such as portability, the lack of ionizing radiation, real-time imaging, and it leads to quicker clinical decisions. Yet, its usefulness is limited to the expertise of operators, which contributes to the necessity of organized training and standardization of trauma ultrasound conditions. To sum up, ultrasonography is a very useful diagnostic option in case of blunt chest trauma and can enhance the early diagnosis and treatment of life-threatening thoracic trauma. Its incorporation into emergency care pathways can improve patient outcomes and minimize delays in diagnoses.

References

1. Aswin, K., et al., *Comparing sensitivity and specificity of ultrasonography with chest radiography in detecting pneumothorax and hemothorax in chest trauma patients: a cross-sectional diagnostic study.* Cureus, 2023. **15**(8).
2. Hwang, E.G. and Y. Lee, *Simple X-ray versus ultrasonography examination in blunt chest trauma: effective tools of accurate diagnosis and considerations for rib fractures.* Journal of exercise rehabilitation, 2016. **12**(6): p. 637 10.12965/jer.1632840.420
3. Nazir, M.H., et al., *Diagnostic Accuracy of Chest Ultrasonography in Diagnosing Pneumothorax Taking CT Chest as A Gold Standard: Diagnostic Accuracy of Chest Ultrasonography in Diagnosing Pneumothorax.* Pakistan Journal of Health Sciences, 2025: p. 202-207. https://doi.org/10.54393/pjhs.v6i2.2822

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

4. Attia, S.M., et al., *Diagnostic accuracy of chest ultrasound versus plain chest X-ray in acute assessment of traumatic hemothorax.* The Egyptian Journal of Hospital Medicine, 2021. **83**(1): p. 969-973.
5. Polireddy, K., et al., *Blunt thoracic trauma: role of chest radiography and comparison with CT–findings and literature review.* Emergency Radiology, 2022. **29**(4): p. 743-755. https://doi.org/10.1016/j.cjtee.2020.04.003
6. Bhoil, R., et al., *Diagnosis of traumatic pneumothorax: a comparison between lung ultrasound and supine chest radiographs.* Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine, 2021. **25**(2): p. 176. 10.5005/jp-journals-10071-23729
7. Vassalou, E.E., et al., *Performance of thoracic ultrasonography compared with chest radiography for the detection of rib fractures using computed tomography as a reference standard.* Skeletal Radiology, 2024. **53**(11): p. 2367-2376. https://doi.org/10.1177/00031348020680511
8. Ablordeppey, E., T. Carver, and L. Rapoport, *Ultrasound in the Evaluation of Acute Trauma.* Critical Care Clinics, 2025. **41**(3): p. 497-516.
9. Jelyani, N.Z., et al., *Diagnosis of Rib Fracture and Related Complications in Patients with Blunt Chest Wall Trauma Using Point-of-Care Ultrasound vs. Computed Tomography Scan.* Shiraz E-Medical Journal, 2023. **24**(24): p. e142311. https://doi.org/10.5812/semj-138379
10. Beyer, C.A., et al., *Management of traumatic pneumothorax and hemothorax.* Current problems in surgery, 2025. **63**: p. 101707. https://doi.org/10.1016/j.cpsurg.2024.101707
11. Hussein, A.M. and S.A. Rashid, *Role of targeted ultrasound for the diagnosis of rib fracture, a comparative study with plain x-ray.* Zanco Journal of Medical Sciences (Zanco J Med Sci), 2024. **28**(2): p. 329-340. **https://doi.org/10.15218/zjms.2024.31**
12. Mert, Ü., H. Andruszkow, and F. Hildebrand, *Chest trauma: Classification and influence on the general management*, in *Textbook of Polytrauma Management: A Multidisciplinary Approach*. 2022, Springer. p. 161-184. https://doi.org/10.1007/s001130050550
13. Griffard, J. and L.M. Kodadek, *Management of blunt chest trauma.* Surgical Clinics, 2024. **104**(2): p. 343-354. https://doi.org/10.1016/j.cjtee.2020.04.003
14. Battle, C., et al., *Risk factors that predict mortality in patients with blunt chest wall trauma: an updated systematic review and meta-analysis.* Emergency Medicine Journal, 2023. **40**(5): p. 369-378. https://doi.org/10.1016/j.injury.2011.01.004
15. Jain, A. and M. Waseem, *Chest trauma*, in *StatPearls [Internet]*. 2025, StatPearls Publishing.
16. Ajzenberg, H., S. Skitch, and P.T. Engels, *Just the Facts: an update on the management of traumatic hemothorax and pneumothorax.* Canadian Journal of Emergency Medicine, 2024. **26**(10): p. 706-709.
17. Asllanaj, H., *Limitations of ultrasound examination in trauma.* Albanian Journal of Trauma and Emergency Surgery, 2024. **8**(2): p. 1525-1531. https://doi.org/10.32391/ajtes.v8i2.390
18. Sutarjono, B., et al., *Is it time to re-think FAST? A systematic review and meta-analysis of Contrast-Enhanced Ultrasound (CEUS) and conventional ultrasound for initial assessment of abdominal trauma.* BMC Emergency Medicine, 2023. **23**(1): p. 8. https://doi.org/10.1017/cem.2019.381

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

19. Lampridis, S., F. Minervini, and M. Scarci, *Hydropneumothorax: why, when, how*, in *Chest Blunt Trauma*. 2025, Elsevier. p. 181-201. https://doi.org/10.1016/B978-0-443-13866-9.00013-0
20. Mehrnahad, M., et al., *Features of Lung Ultrasound and Chest Radiology in Diagnosing of Pleural Effusion in Critical Care Patients: A Systematic Review.* Trauma Monthly, 2023. **28**(3): p. 850-855 10.30491/tm.2023.403486.1612.
21. Koutsouroumpa, C., et al., *Lung parenchymal trauma biomechanics, mechanisms, and classification: a narrative review of the current knowledge.* Kardiochirurgia i Torakochirurgia Polska/Polish Journal of Thoracic and Cardiovascular Surgery, 2025. **22**(2): p. 100-111. https://doi.org/10.5114/kitp.2025.152221
22. Thakur, S., et al., *Evaluation of the efficacy of a digital chest drainage system in traumatic pneumothorax.* Cureus, 2023. **15**(6).
23. Chamorro, E.M., et al., *Patients with severe polytrauma: management and imaging protocols.* Radiología (English Edition), 2023. **65**: p. S11-S20 10.1016/j.rxeng.2022.09.008.
24. Lorenzo, M., et al., *Western Trauma Association critical decisions in trauma: Penetrating thoracic injury.* Journal of Trauma and Acute Care Surgery, 2023: p. 10.1097.
25. Yekdeş, A., et al., *The role of ultrasonography! n the d! agnos! s of r! b fractures.* Current Thoracic Surgery, 2024. **9**(3). 10.26663/cts.2024.023
26. Asciak, R., et al., *British thoracic society clinical statement on pleural procedures.* Thorax, 2023. **78**(Suppl 3): p. s43-s68. https://doi.org/10.1136/thorax-2022-219371