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Investigating the predictive power of clinical findings and examinations in the diagnosis of thorax bone fractures in patients with chest trauma; a retrospective cross-sectional study

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Abstract

Introduction: The diagnosis of thoracic bone fractures in patients with chest trauma is a critical area of study, particularly in emergency medicine. Clinical findings and examinations play a significant role in accurately diagnosing these injuries, which can lead to improved patient outcomes.

Objectives: This investigation focuses on the predictive power of various clinical indicators and examination techniques used in diagnosing thorax bone fractures among patients referred to Taleghani hospital in Kermanshah, Iran, from April 2022 to November 2024.

Patients and Methods: This retrospective cross-sectional study was conducted to assess the predictive power of clinical findings and examinations in diagnosing thorax bone fractures among patients with chest trauma at Taleghani hospital from April 2022 to November 2024. Data were collected from clinical documents, including demographic information, clinical findings, and imaging studies (X-rays, ultrasounds, and CT scans), focusing on patients aged 18 and older. Logistic regression was conducted to evaluate the correlations between clinical indicators and bone fracture diagnoses.

Results: The study included 997 chest trauma patients with a mean age of 43.02 ± 16.7 years, of whom 114 (11.4%) were found to have thoracic bone fractures. Age was identified as an independent predictor for thorax bone fracture, with an OR of 1.02, and hemothorax and pneumothorax demonstrated a strong association, with an OR of 6.25 and 5.40. Similarly, patients with a pain score ≥ 5 were found to be 5.18 times more likely to experience bone fractures compared to less than five. Additionally, pulmonary sound loss (OR = 3.86), pulmonary contusion (OR = 5.28), and subcutaneous crepitation (OR = 3.49) were notable predictors of fractures.

Conclusion: In conclusion, age, hemothorax, pneumothorax, a pain score of 5 or higher, along with pulmonary sound loss, pulmonary contusion, and subcutaneous crepitation are significant predictors of thorax bone fractures and enhance the predictive model for identifying at-risk patients in chest trauma cases.

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Introduction

Chest trauma, also known as thoracic trauma, is one of the most common causes of morbidity and mortality (1), which refers to any physical injury affecting the chest area, including the ribs, sternal fractures, and other organs surrounded by the chest cage (2,3). This type of trauma is a significant cause of morbidity and mortality, accounting for approximately 20-25% of all trauma-related deaths (3). Chest injuries can be classified as either blunt or penetrating, with blunt injuries being more common, typically resulting from motor vehicle collisions or falls (1,2). The most critical conditions arising from chest trauma include pneumothorax, hemothorax, rib fractures, and cardiac injuries (4). Diagnosis often involves imaging techniques such as X-rays or computed tomography (CT), scans, while management may range from supportive care to surgical interventions depending on the severity of the injuries (1). Immediate recognition and treatment of life-threatening conditions are crucial for improving patient outcomes, as many fatalities occur within the

Key point

In this retrospective cross-sectional study, we found that factors such as age, presence of hemothorax and pneumothorax, pain scores of five or above, diminished pulmonary sounds, pulmonary contusions, and subcutaneous crepitation serve as important indicators for thorax bone fractures. Incorporating these variables improves the accuracy of predicting patients at risk in cases of chest trauma. Recognizing these key predictors can help healthcare providers promptly identify and prioritize chest trauma patients who are more likely to have thorax bone fractures, facilitating earlier intervention and potentially improving clinical outcomes.

first hour's post-injury (5).

Physical examination and clinical findings in chest trauma are critical for early diagnosis and managing injuries effectively. Common physical examination signs include pain, tachypnea, dyspnea, and pale mucous membranes, which indicate emergency conditions (6,7). In cases of blunt trauma, findings such as rib fractures, hemothorax, and pneumothorax are prevalent, with rib fractures being particularly common among older adults, often leading to complications like pneumonia or acute respiratory distress syndrome (8,9). Imaging studies, particularly CT scan, complement physical examinations by revealing internal injuries that may not be apparent upon initial assessment (9). Overall, a thorough physical examination combined with appropriate imaging is essential for optimal management of thoracic trauma (10).

Thoracic bone fractures, particularly of the ribs, sternum, and scapula, are significantly correlated with pain, pneumothorax, and hemothorax due to their anatomical proximity to vital structures within the thoracic cavity. Rib fractures are common in blunt chest trauma and can lead to severe pain that compromises respiratory mechanics, often resulting in shallow breathing and an increased risk of complications such as pneumonia (11,12). Some studies reported that the incidence of pneumothorax is notably higher in patients with rib fractures, especially when the lower ribs are involved, as these can puncture the pleura and allow air to enter the pleural space (13). Additionally, hemothorax frequently accompanies rib fractures due to injury to intercostal vessels or lung parenchyma, leading to blood accumulation in the pleural cavity (14). Scapula fractures also correlate with high rates of intrathoracic injuries, including rib fractures and both pneumothorax and hemothorax, further complicating patient outcomes (15,16). Thus, effective management of bone thoracic fractures requires careful monitoring for these associated complications.

The diagnosis of thoracic bone fractures in patients with chest trauma is a critical aspect of emergency medicine, as timely and accurate identification of these injuries can significantly influence treatment outcomes. Clinical findings and examinations play a pivotal role in this diagnostic process, yet there is a need for systematic evaluation of their predictive power. This study aims to investigate the correlation between various demographic characteristics, clinical indicators, physical examination findings, and the diagnosis of thorax bone fractures among patients referred to Taleghani hospital in Kermanshah, Iran, from April 2022 to November 2024. By establishing the predictive value of clinical findings, this study seeks to enhance diagnostic accuracy and improve patient management strategies in cases of chest trauma, ultimately contributing to better health outcomes in this vulnerable population.

Objectives

The objective of this study is to evaluate the correlation between clinical findings and examinations with thorax bone fracture diagnosis among patients with chest trauma referred to Taleghani Hospital in Kermanshah, Iran, during the period from April 2022 to November 2024. Specifically, the study aims to identify which demographic characteristics, such as age and gender, and clinical indicators, such as pain score, hemothorax, pneumothorax, subcutaneous crepitation, pulmonary sound loss, and pulmonary contusion are most predictive of thorax bone fractures when compared to imaging results from chest CT scan.

Patients and Methods

Study design and participants

This study is a retrospective cross-sectional design aimed to investigate the predictive power of clinical findings and examinations in diagnosing thorax bone fractures among patients with chest trauma referred to Taleghani hospital in Kermanshah, Iran, from April 2022 to November 2024.

Inclusion and exclusion criteria

Participants included adults aged 18 years and older who present with symptoms of chest trauma, such as chest pain, dyspnea, report of falling, car accident, or direct trauma to the chest, and who have undergone both clinical assessments and imaging studies (X-ray, ultrasound, and CT scan) for suspected fractures. Exclusion criteria will consist of individuals with a history of previous thoracic surgery or chronic disease that may impact the results of bone fracture, patients with incomplete clinical documents, or those who did not undergo appropriate imaging.

Data collection

Data collection for this study involved a systematic approach, including collecting demographic, clinical, and imaging data from chest trauma patients' clinical documents referred to Taleghani Hospital. Clinical assessments included patients' demographic characteristics (age and gender), and physical examinations focusing on symptoms such as chest pain using the visual analog scale (VAS) and lung auscultation to check lung sounds. Imaging studies, including X-rays and ultrasounds

for seek hemothorax, pneumothorax, subcutaneous crepitation, and pulmonary contusion. The chest CT scan report was evaluated to confirm the presence of thorax bone fractures.

Outcome measurement

The primary outcome of this study is to establish the correlation between clinical findings and examinations with the diagnosis of thorax bone fractures in patients with chest trauma referred to Taleghani hospital. The secondary outcomes involve identifying specific demographic characteristics, clinical indicators, and physical examinations that are independent predictors of the presence of thorax bone fractures.

Statistical analysis

Data were analyzed using the Statistical Package for Social Science (SPSS) version 27 (IBM Corp, USA). The statistical analysis for this study included both descriptive and analytical statistics to evaluate the correlation between clinical findings and examinations with the diagnosis of thorax bone fractures in patients with chest trauma. Descriptive statistics encompass means, standard deviations, and frequency distributions to present patient demographics and clinical characteristics. Analytical statistics involved chi-square test to assess associations between categorical variables and independent T-test to examine correlations between quantitative variables with the presence of thorax bone fractures. Additionally, univariate and multivariate logistic regression analysis were employed to identify demographic characteristics, clinical indicators, and physical examination findings that served as independent predictors of thorax bone fractures. A *P* value of less than 0.05 was deemed statistically significant.

Results

In this study, 997 chest trauma patients with a mean age of 43.02 ± 16.7 years were included. Out of the studied population, 114 (11.4%) patients exhibited thoracic bone fractures as identified through chest CT scans. The study population consisted of a majority of males, with females comprising a smaller proportion. Most patients showed no hemothorax disorder, while a small percentage did. Similarly, the vast majority did not have pneumothorax. When assessing pain scores, a significant portion reported scores of five or higher. Most individuals exhibited no pulmonary sound loss, and a small population showed signs of subcutaneous crepitation. The majority also did not have pulmonary contusion. Among those with thoracic bone fractures, rib fractures were the most common type, followed by fewer cases of sternum and scapula fractures (Table 1).

The results examining patients' frequency distribution of demographic and clinical data based on thorax bone fracture outcomes demonstrated that, although gender distribution showed a higher percentage of males than females experienced fractures, this difference was not statistically significant. The presence of hemothorax was significantly associated with fractures, as a notable proportion of patients with hemothorax had fractures compared to those without hemothorax. Similarly, pneumothorax also demonstrated a significant correlation, with a larger percentage of patients suffering from fractures among those with pneumothorax. Pain scores indicated that patients experiencing higher levels of pain were more likely to have fractures, contrasting with those reporting lower pain levels. Additionally, the absence of pulmonary sound loss was associated with a higher percentage of patients without fractures, while those with sound loss had a greater occurrence of fractures. Subcutaneous crepitation followed a similar trend, indicating that patients without this symptom had fewer fractures than those who did. The presence of pulmonary contusion was also significantly linked to fracture occurrence, with a higher percentage of patients having fractures among those with contusions. Lastly, age differences revealed that older patients tended to have a higher occurrence of fractures compared to younger individuals (Table 2).

In the analysis of thorax bone fractures, the univariate logistic regression, conducted under unadjusted conditions for confounders, revealed significant correlations with various clinical factors. Specifically, age

Table 1. Demographic characteristics and clinical findings of studied patients

Variable	Sub-variable	Frequency	Percent
Gender	Male	708	71
	Female	289	29
Hemothorax	No	964	96.7
	Yes	33	3.3
Pneumothorax	No	969	97.2
	Yes	28	2.8
Pain score	< 5	289	29
	≥ 5	708	71
Pulmonary sound loss	No	971	97.4
	Yes	26	2.6
Subcutaneous crepitation	No	978	98.1
	Yes	19	1.9
Pulmonary contusion	No	961	96.4
	Yes	36	3.6
Thorax bone fracture type	Rib	89	78.2
	Sternum	11	9.6
	Scapula	14	12.2
Thorax bone fracture	No	883	88.6
	Yes	114	11.4

Variable	Mean	SD	Min	Max
Age (year)	43.02	16.7	9	96

SD; Standard deviation, Min; Maximum, Max; Maximum.

Table 2. Frequency distribution of patients' demographic characteristics and clinical findings according to thorax bone fracture outcome (Yes/No)

Variable		Thorax Bone Fracture				*P* value
		No (n= 883)		Yes (n= 114)		
		Number	%	Number	%	
Gender	Male (n= 708)	628	88.4	82	11.6	0.819*
	Female (n= 289)	257	88.9	32	11.1	
Hemothorax	No (n= 964)	872	90.5	92	9.5	<0.001*
	Yes (n= 33)	11	33.3	22	66.7	
Pneumothorax	No (n= 969)	874	90.2	95	9.8	<0.001*
	Yes (n= 28)	9	32.1	19	67.9	
Pain score	< 5 (n= 289)	284	98.3	5	1.7	<0.001*
	≥ 5 (n= 708)	599	84.6	109	15.4	
Pulmonary sound loss	No (n= 971)	874	90	97	10	<0.001*
	Yes (n= 26)	9	34.6	17	65.4	
Subcutaneous crepitation	No (n= 978)	875	89.5	103	10.5	<0.001*
	Yes (n= 19)	8	42.1	11	57.9	
Pulmonary contusion	No (n= 961)	866	90.1	95	9.9	<0.001*
	Yes (n= 36)	17	47.2	19	52.8	
Variable		**Mean**	**SD**	**Mean**	**SD**	***P* value**
Age (year)		4174	16.51	52.95	15.22	<0.001**

SD: Standard deviation. *Chi-square, **Independent T-test.

was associated with fracture occurrence, indicated by an odds ratio (OR) of 1.03, suggesting that for each additional year of age, the likelihood of sustaining a fracture increases by 3%. Additionally, hemothorax and pneumothorax were strongly linked to fractures, with ORs of 18.95 and 19.42, respectively. Pain scores also demonstrated a significant relationship with fractures, yielding an OR of 10.33. Furthermore, pulmonary sound loss, subcutaneous crepitation, and pulmonary contusion were significantly correlated with fracture occurrence, exhibiting OR of 17.01, 11.68, and 10.18, respectively (Table 3).

When adjusting for confounders using multivariate logistic regression, several variables emerged as significant and independent predictors of thorax bone fracture occurrence. Age was identified as an independent predictor, with an OR of 1.02, indicating that each additional year of age increases the odds of fractures by 2%. Hemothorax demonstrated a particularly strong association, with an OR of 6.25, suggesting that patients with hemothorax are over six times more likely to experience fractures compared to those without. Similarly, pneumothorax was associated with a high risk, reflected in an OR of 5.40. Pain score also served as a significant predictor; specifically, patients with a pain score ≥ 5 were found to be 5.18 times more likely to experience bone fractures compared to less than five. Additionally, pulmonary sound loss (OR = 3.86) and subcutaneous crepitation (OR = 3.49) were notable predictors of fractures. Finally, pulmonary contusion was shown to have a strong association with an OR of 5.28, establishing it as an independent risk factor for thorax bone fractures (Table 4).

Discussion

The results indicated that hemothorax and pneumothorax

Table 3. The correlation between clinical findings and examinations with thorax bone fractures using univariate logistic regression (unadjusted)

Variable		Thorax bone fractures			
		P value	OR	95% CI	
				Lower	Upper
Age (y)		<0.001	1.03	1.02	1.05
Hemothorax	No		Ref (1)		
	Yes	<0.001	18.95	8.91	40.33
Pneumothorax	No		Ref (1)		
	Yes	<0.001	19.42	8.54	44.13
Pain score	< 5		Ref (1)		
	≥ 5	<0.001	10.33	4.17	25.61
Pulmonary sound loss	No		Ref (1)		
	Yes	<0.001	17.01	7.38	39.21
Subcutaneous crepitation	No		Ref (1)		
	Yes	<0.001	11.68	4.59	29.70
Pulmonary contusion	No		Ref (1)		
	Yes	<0.001	10.18	5.12	20.26

OR: Odds ratio; CI: Confidence interval; Ref: Reference.

Table 4. The predictive power of clinical findings and examinations for predicting thorax bone fractures using multivariate logistic regression (adjusted)

Variable		Thorax bone fractures			
		P value	OR	95% CI	
				Lower	Upper
Age (y)		<0.001	1.02	1.01	1.04
Hemothorax	No			Ref (1)	
	Yes	<0.001	6.25	2.54	15.38
Pneumothorax	No			Ref (1)	
	Yes	0.003	5.40	1.78	16.39
Pain score	< 5			Ref (1)	
	≥ 5	<0.001	5.18	2.04	13.15
Pulmonary sound loss	No			Ref (1)	
	Yes	0.022	3.86	1.21	12.25
Subcutaneous crepitation	No			Ref (1)	
	Yes	0.038	3.49	1.07	11.38
Pulmonary contusion	No			Ref (1)	
	Yes	<0.001	5.28	2.28	12.22

OR: Odds ratio; CI: Confidence interval; Ref: Reference.

are independent predictors for thorax bone fracture diagnosis, with OR of 6.25 and 5.40 respectively, which is in line with previous studies that emphasize the significance of these complications in blunt chest trauma. For instance, a study highlighted that pleural complications like hemothorax and pneumothorax are prevalent in patients with rib fractures, complicating treatment and increasing hospitalization duration (13). Additionally, other research has shown that rib fractures often correlate with underlying complications such as hemothorax and pneumothorax, reinforcing their role as critical indicators in trauma assessments (17,18). Kozanlı and Güler in their study reported that pneumothorax, and hemothorax (16). Overall, the current results substantiate earlier findings that suggest a strong association between these pleural complications and thoracic injuries, underscoring their importance in clinical decision-making for trauma patients.

Our study highlights that pain significantly contributes to the diagnosis of thorax bone fractures, with patients reporting a pain score of 5 or higher being 5.18 times more likely to have such fractures compared to those with lower scores. This finding is consistent with previous research that underscores the role of pain as a critical indicator in diagnosing fractures. For instance, studies have demonstrated that higher pain intensity correlates with an increased likelihood of fracture presence, particularly in trauma cases (19). Moreover, pain assessment has been shown to enhance diagnostic accuracy and treatment planning in bone fractures (20). Overall, the current results reinforce the importance of pain evaluation in clinical assessments for thorax bone fractures, suggesting that effective pain management and accurate pain scoring could improve diagnostic outcomes and patient care in trauma settings.

The present study findings indicated that pulmonary sound loss (OR = 3.86), subcutaneous crepitation (OR = 3.49), and pulmonary contusion (OR = 5.28) are significant predictors of thorax bone fractures. This aligns with previous studies that have identified similar predictors in trauma patients; a study by Ball et al showed that subcutaneous emphysema and pulmonary contusions are frequently associated with rib fractures, highlighting their role as critical indicators in diagnosing thoracic injuries (21). Additionally, Kozanlı and Güler reported a statistically significant difference in the frequency distribution of pneumothorax and hemothorax between patients with and without scapula fractures; their study found that patients with scapula fractures exhibited a higher incidence of both pneumothorax and hemothorax, highlighting the association between scapular injuries and thoracic complications (16). Overall, these findings reinforce the critical role of these clinical indicators in predicting thorax bone fractures in trauma patients, highlighting the need for further investigation to refine clinical assessment protocols and improve patient outcomes.

The finding that age is an independent predictor of thorax bone fractures, with an OR of 1.02, suggests that each additional year of age increases the likelihood of sustaining fractures in the ribs, scapula, and sternum by 2%. This aligns with previous research consistently highlighting the relationship between aging and increased fracture risk across various skeletal sites. The study by Larsson et al emphasizes the role of age in rib fracture risk, noting a significant decrease in failure strain for rib cortical bone as individuals age. This decrease in structural integrity contributes to higher fracture susceptibility, supporting our finding that age is a critical factor in thoracic injuries (22). The study by Corrales et al illustrated how age-related changes in thoracic geometry can exacerbate injury risks during impacts and how increased thoracic kyphosis alters rib angles and increases shear stress on ribs, leading to a higher incidence of

fractures in older populations (23). The identification of age as an independent predictor of thorax bone fractures underscores the need for heightened awareness among healthcare providers regarding the vulnerability of older patients to such injuries. This study complements existing literature by reinforcing the significance of aging in fracture risk assessment and highlights the necessity for tailored clinical approaches to improve outcomes for this demographic.

The results of this study confirm that hemothorax and pneumothorax are significant independent predictors of thorax bone fractures, aligning with previous research that emphasizes the prevalence of these complications in blunt chest trauma. The association between pleural complications and rib fractures complicates treatment and extends hospitalization, highlighting the critical need for thorough assessments in trauma cases. Additionally, the findings underscore the importance of pain as a key diagnostic indicator for thorax bone fractures, with higher pain scores correlating with an increased likelihood of fracture presence. This reinforces the necessity of effective pain management and accurate pain evaluation in clinical settings. Furthermore, the study identifies pulmonary sound loss, subcutaneous crepitation, and pulmonary contusion as vital clinical indicators, consistent with earlier studies that have linked these symptoms to thoracic injuries. Lastly, age emerges as an important factor in fracture risk, with older individuals exhibiting a greater susceptibility to thoracic injuries due to age-related changes in bone integrity and thoracic geometry. These findings highlight the need for enhanced clinical protocols that consider these predictors to improve diagnostic accuracy and patient outcomes in trauma care.

Conclusion

In conclusion, the findings of this study highlight several significant and independent predictors of thorax bone fractures among chest trauma patients. Age was identified as a critical factor, with each additional year increasing fracture odds by 2%. Hemothorax and pneumothorax were strongly associated with fractures, with odds ratios of 6.25 and 5.40, respectively, indicating a marked increase in fracture risk for patients presenting with these conditions. Additionally, a pain score of 5 or higher significantly correlated with fracture occurrence, as did pulmonary sound loss and subcutaneous crepitation. Notably, pulmonary contusion emerged as another strong predictor, further emphasizing the complex interplay of clinical indicators in assessing fracture risk. These results underscore the importance of thorough clinical evaluations in identifying at-risk patients and guiding timely interventions in trauma care settings.

Limitations of the study

This study has several limitations that should be considered when interpreting the findings. First, its retrospective design may introduce biases related to data collection, as it relies on existing clinical records that could be incomplete or inconsistently documented. The generalizability of the results may also be limited, as the study population is drawn from a single institution, which may not reflect broader patient demographics or clinical practices. Additionally, the reliance on subjective clinical assessments, such as pain scores and lung auscultation, could lead to variability in how different clinicians record and interpret these indicators. Furthermore, while efforts were made to adjust for confounding variables using logistic regression, unmeasured factors may still influence the relationship between clinical findings and fracture diagnoses.

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Authors' contribution

Conceptualization: Mohammad Reza Rezaei and Bareza Rezaei.
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Validation: Shahrouz Tabrizi and Mohammad Reza Farnia.
Writing–original draft: All authors.
Writing–reviewing and editing: All authors.

Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

While preparing this work, the authors utilized AI (Perplexity.ai and Grammarly.com) to refine grammar points and language style. Subsequently, they thoroughly reviewed and edited the content as necessary, assuming full responsibility for the publication's content.

Ethical issues

The research was conducted in accordance with the principles outlined in the Declaration of Helsinki. Informed written consent was obtained from all participants. This study was conducted at Taleghani Hospital and is derived from the thesis work of Maryam Shiravand (Thesis #50004930), approved by the ethics committee of Kermanshah University of Medical Sciences, Kermanshah, Iran, under the ethical code (IR.KUMS.MED.REC.1403.347; https://ethics.research.ac.ir/EthicsProposalView.php?id=521490) and approval date on January 5, 2025. Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

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