

Research Article

Radiological Evaluation of Chest Trauma Using Multidetector Computed Tomography

Dr Sabastian Antony X^{1*}, Dr Akbar Shah S²

¹Assistant Professor in Department of Radio-Diagnosis, Dhanalakshmi Srinivasan Institute of Medical Sciences, Perambalur, Tamil Nadu, India.

²Associate Professor in Department of Radio-Diagnosis, Dhanalakshmi Srinivasan Institute of Medical Sciences, Perambalur, Tamil Nadu, India

*Corresponding Author

Sabastian Antony X

Article History

Received: 03.04.2026

Revised: 23.04.2026

Accepted: 13.05.2026

Published: 28.05.2026

Citations:

Antony, S. X., & Shah, A. S. Radiological evaluation of chest trauma using multidetector computed tomography. J Surg Radiol, V5 (5) 231-237

Abstract: **Introduction:** Chest trauma is a major cause of morbidity and mortality worldwide, with road traffic accidents and falls being the predominant etiologies. Rapid and accurate diagnosis of intrathoracic injuries is essential for timely intervention. While chest radiography remains the initial screening tool, it has well recognized limitations in detecting subtle and life threatening injuries. **Objective:** To evaluate the spectrum of chest injuries in trauma patients using multidetector computed tomography (MDCT) and to compare its diagnostic yield with that of concurrent chest radiography. **Methods:** This prospective observational study was conducted at Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital between 1st August 2025 and 25th February 2026. Forty hemodynamically stable adult patients with chest trauma who underwent MDCT were included. Clinical data, chest radiographs, and MDCT findings were recorded. Descriptive statistics and chi square tests were applied, with MDCT serving as the reference standard. **Results:** The mean age of the study population was 38.2 ± 14.7 years, with a male predominance (80%). Road traffic accidents accounted for 62.5% of injuries. MDCT detected rib fractures in 85% of patients, pulmonary contusions in 55%, hemothorax in 50%, pneumothorax in 35%, and pneumomediastinum in 7.5%. A significant association was found between an increasing number of rib fractures and the occurrence of pulmonary complications ($p < 0.05$). Chest radiography missed 23.5% of rib fractures, 54.5% of pulmonary contusions, and all occult pneumothoraces, demonstrating a markedly lower sensitivity. **Conclusion:** MDCT reveals a wide and often clinically occult spectrum of thoracic injuries that are frequently underestimated by chest radiography. Its routine use in the evaluation of chest trauma can lead to prompt, appropriate management and potentially reduce trauma related mortality and morbidity.

Keywords: Chest trauma, multidetector computed tomography, pulmonary contusion, rib fractures, pneumothorax, hemothorax.

INTRODUCTION

Thoracic trauma is a significant global health burden, contributing to approximately 25% of all trauma-related deaths and acting as a major co-factor in another 25% of fatalities [1,2]. The chest houses vital structures heart, great vessels, lungs, tracheobronchial tree, and diaphragm making it particularly vulnerable to both blunt and penetrating forces. Blunt trauma, predominantly resulting from road traffic accidents, falls from height, and physical assaults, accounts for the vast majority of chest injuries in civilian practice [3,4]. The immediate and delayed consequences of such injuries, including respiratory failure, exsanguination, and sepsis, demand rapid and precise diagnosis. In low- and middle-income countries like India, where motor vehicle collisions are escalating due to rapid urbanization and inconsistent road safety measures, the incidence of chest trauma continues to rise steeply [5]. Early identification of the full extent of injury is therefore critical, not only to guide surgical and intensive care interventions but also to predict outcomes and allocate limited healthcare resources effectively.

Conventional chest radiography has traditionally been the first-line imaging modality in the initial assessment of trauma patients, valued for its speed, portability, and widespread availability. It can readily depict large pneumothoraces, massive hemothoraces, and displaced rib fractures. However, numerous studies have demonstrated that supine anteroposterior chest radiographs, often obtained under suboptimal conditions in the emergency department, fail to detect a substantial number of clinically significant injuries [6,7]. Occult pneumothorax, small to moderate hemothorax, pulmonary contusions, diaphragmatic rupture, and mediastinal injuries are frequently missed. It is reported that up to 50% of pulmonary contusions and 30-50% of pneumothoraces are not visible on the initial chest radiograph [7,8]. Furthermore, the presence of overlying soft tissues, patient rotation, and poor inspiration compromises the sensitivity for rib fractures, sternal fractures, and scapular fractures. The diagnostic inadequacy of plain radiography may lead to delayed treatment, unexpected deterioration, and preventable complications.

Multidetector computed tomography has revolutionized the imaging of chest trauma by overcoming the inherent limitations of projectional radiography. Modern MDCT scanners, with sub-millimeter isotropic resolution, enable rapid acquisition of volumetric data during a single breath-hold, minimizing motion artifacts in even poorly cooperative trauma patients [9]. The raw data can be reconstructed into high-quality multiplanar reformations in coronal, sagittal, and oblique planes, as well as three-dimensional volume-rendered images that provide a surgeon's-eye view of complex fractures. This capability greatly enhances the detection of subtle injuries such as non-displaced rib fractures, tiny pneumothoraces, small hemothoraces, and parenchymal lacerations that are invisible on radiographs [10,11].

Additionally, MDCT with intravenous contrast allows simultaneous assessment of the thoracic aorta, pulmonary vasculature, and diaphragmatic integrity, offering a "one-stop-shop" evaluation that can dramatically shorten the time to definitive management. The superior sensitivity of MDCT has been reported in multiple prospective series, with up to 45% of trauma patients having injuries detected on CT that were not apparent on chest radiography, prompting a change in management in 20-30% of cases [6,12].

Given the high burden of chest trauma and the limited published data from rural tertiary care centres in India, there is a compelling need to document the radiological spectrum of thoracic injuries as visualized by MDCT in this setting. The present study was therefore designed to prospectively evaluate consecutive patients presenting with chest trauma to Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital, using a 128-slice MDCT system. By systematically analyzing injury patterns, frequency, and correlation with plain radiography, the study aimed to provide local evidence that could inform imaging protocols and improve trauma care pathways.

OBJECTIVE

The primary objective of this study was to evaluate the full spectrum of traumatic chest injuries using multidetector computed tomography in patients presenting to the emergency department with blunt or penetrating chest trauma. The study sought to determine the frequency and distribution of various intrathoracic and chest wall injuries, including rib fractures, pulmonary contusions, pneumothorax, hemothorax, mediastinal injuries, and diaphragmatic ruptures, as detected by MDCT.

The secondary objective was to compare the diagnostic yield of MDCT with that of the initial digital chest radiograph performed in the same patient cohort. By using MDCT as the reference standard, the sensitivity of chest radiography for each injury category was calculated. The study further aimed to analyze the association between the number of fractured ribs and the

occurrence of significant pulmonary complications, and to highlight the added value of MDCT in altering clinical decision-making in a resource-constrained Indian teaching hospital.

MATERIALS AND METHODS

This was a prospective, single-centre, observational study carried out in the Department of Radiodiagnosis at Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital, a tertiary care rural teaching hospital in Tamil Nadu, India. The study period extended from 1st August 2025 to 25th February 2026. A total of 40 patients who sustained chest trauma and were referred for MDCT imaging of the thorax were enrolled after obtaining written informed consent. The sample size was determined by the number of eligible patients presenting during the seven-month study window, following a convenience sampling method. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study (Approval No. DSI/EC/2025/12).

Patients aged 18 years and above of either sex, with a history of acute blunt or penetrating chest trauma, who were hemodynamically stable (systolic blood pressure >90 mmHg, heart rate <120 beats/minute, and respiratory rate <30/minute without mechanical ventilation), and who underwent MDCT within 24 hours of presentation were included. Patients with hemodynamic instability requiring immediate surgical intervention, pregnant or lactating women, individuals with known allergy to iodinated contrast media, those with serum creatinine >1.5 mg/dL or estimated glomerular filtration rate <60 mL/min/1.73m², and patients with previous thoracic surgery that altered normal anatomy were excluded. Critically ill patients in whom breath-hold was impossible and those who did not consent were also excluded.

All patients initially underwent a digital anteroposterior supine chest radiograph in the emergency department. Subsequently, MDCT of the thorax was performed on a 128-slice scanner (Siemens Somatom Definition AS+, Siemens Healthineers, Germany). A scout topogram was obtained to plan scan coverage from the thoracic inlet to the adrenal glands. Non-ionic iodinated contrast (Iohexol, 350 mg iodine/mL) was administered at a dose of 1.5 mL/kg body weight via a pressure injector at 3.5 mL/sec, followed by a 30 mL saline chaser, through an 18-gauge antecubital intravenous line. Imaging was acquired in the arterial phase using bolus tracking with a region of interest in the descending thoracic aorta (threshold 100 Hounsfield units). Scan parameters were: 120 kVp, automated tube current modulation (CareDose 4D), collimation 128 × 0.6 mm, pitch 0.9, rotation time 0.5 seconds. Raw data were reconstructed into 1 mm axial slices with 0.7 mm increment, and coronal and sagittal multiplanar reformations were generated. All

images were transferred to a dedicated workstation (Syngo.via, Siemens) and independently interpreted by a radiologist with more than five years of experience in emergency radiology, blinded to the initial chest radiograph report at the time of reporting. The chest radiograph was separately reported by an emergency physician and later reviewed by the same radiologist for the purpose of comparison.

Data collection included demographic details, mechanism of injury, clinical examination findings, chest radiograph interpretation, and MDCT findings. The following variables were systematically recorded: presence and number of rib fractures (and whether flail segment was present), pulmonary contusion (none, mild <20% lobar volume, severe $\geq 20\%$), pneumothorax (and whether it was occult), hemothorax, hemopneumothorax, subcutaneous emphysema, pneumomediastinum, tracheobronchial injury, aortic or

great vessel injury, cardiac contusion, diaphragmatic rupture, and associated fractures of clavicle, scapula, or sternum. Data were entered into Microsoft Excel 2019 and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Categorical variables were expressed as frequencies and percentages, and continuous variables as mean $\pm$ standard deviation. The Chi-square test was used to assess the association between the number of rib fractures (categorized as ≤ 2 , 3-5, >5) and the occurrence of pulmonary contusion, pneumothorax, and hemothorax. The sensitivity of chest radiography for each injury was calculated using MDCT as the gold standard. A two-tailed p value <0.05 was considered statistically significant.

RESULTS

Forty patients with chest trauma were studied. The mean age was 38.2 ± 14.7 years (range 19–68 years). Males outnumbered females, comprising 32 (80%) of the cohort, while 8 (20%) were females. The most common mechanism of injury was road traffic accident, seen in 25 patients (62.5%), followed by fall from height in 10 (25%), physical assault in 3 (7.5%), and industrial mishaps in 2 (5%). The demographic profile and injury mechanisms are detailed in Table 1 and Table 2.

MDCT revealed a wide spectrum of thoracic injuries, frequently multiple in the same patient. Rib fractures were the most prevalent injury, identified in 34 patients (85%), with a mean of 3.1 ± 2.4 fractured ribs per patient. Flail chest (≥ 3 consecutive rib fractures with paradoxical movement) was present in 7 patients (17.5%). Pulmonary contusions were observed in 22 patients (55%); of these, 12 (54.5%) were classified as mild and 10 (45.5%) as severe. Hemothorax was detected in 20 patients (50%), pneumothorax in 14 (35%), and combined hemopneumothorax in 10 (25%). Among the pneumothoraces, 5 (35.7%) were occult, i.e., not evident on the supine chest radiograph but clearly visible on MDCT. Subcutaneous emphysema accompanied 16 patients (40%), pneumomediastinum occurred in 3 (7.5%), and diaphragmatic rupture was identified in 2 (5%). One patient (2.5%) sustained a contained traumatic aortic injury of the isthmus. Skeletal injuries beyond the ribs included clavicle fractures in 5 (12.5%), scapular fractures in 4 (10%), and sternal fractures in 3 (7.5%). The distribution of all MDCT-detected injuries is summarized in Table 3.

When patients were stratified by the number of fractured ribs, a statistically significant association was found with the presence of pulmonary complications. Among those with ≤ 2 rib fractures ($n=12$), pulmonary contusion was seen in 4 (33.3%), pneumothorax in 2 (16.7%), and hemothorax in 3 (25%). In the 3-5 rib fracture group ($n=18$), contusion rose to 10 (55.6%), pneumothorax to 6 (33.3%), and hemothorax to 10 (55.6%). In the >5 rib fractures group ($n=10$), contusion was present in 8 (80%), pneumothorax in 6 (60%), and hemothorax in 7 (70%). The chi-square test yielded $p=0.04$ for contusion, $p=0.03$ for pneumothorax, and $p=0.04$ for hemothorax, indicating a significant trend toward higher complication rates with increasing rib fracture count (Table 4).

Comparison of chest radiography with the gold-standard MDCT demonstrated marked under-detection of injuries by the plain film. Chest radiography identified rib fractures in 26 of 34 patients (sensitivity 76.5%), missing 8 fractures that were often posterior or non-displaced. Sensitivity for pulmonary contusion was merely 45.5% (10/22), and for pneumothorax 57.1% (8/14), failing to detect all 5 occult pneumothoraces. Hemothorax was detected in 12 of 20 patients (sensitivity 60%), and pneumomediastinum in 1 of 3 (33.3%). Neither the aortic injury nor one of the two diaphragmatic ruptures was apparent on chest radiography. Overall, 18 of the 40 patients (45%) had at least one injury detected only on MDCT that was missed on the admission chest radiograph. These comparative data are presented in Table 5.

Table 1: Demographic Characteristics of the Study Population (n=40)

Parameter	Value
Age (years), Mean $\pm$ SD	38.2 $\pm$ 14.7
Age Range (years)	19 – 68
Sex, n (%)	
Male	32 (80%)
Female	8 (20%)
Male:Female ratio	4:1

Table 2: Mechanism of Injury (n=40)

Mechanism	n (%)
Road Traffic Accident	25 (62.5%)
Fall from Height	10 (25.0%)
Assault	3 (7.5%)
Industrial Mishap	2 (5.0%)
Total	40 (100%)

Table 3: Spectrum of Thoracic Injuries Detected by MDCT (n=40)

Injury	n (%)*
Rib Fractures	34 (85.0%)
Pulmonary Contusion	22 (55.0%)
Mild (<20% lobe)	12 (30.0%)
Severe ($\geq$ 20% lobe)	10 (25.0%)
Hemothorax	20 (50.0%)
Pneumothorax	14 (35.0%)
Occult Pneumothorax	5 (12.5%)
Hemopneumothorax	10 (25.0%)
Subcutaneous Emphysema	16 (40.0%)
Pneumomediastinum	3 (7.5%)
Diaphragmatic Rupture	2 (5.0%)
Traumatic Aortic Injury	1 (2.5%)
Clavicle Fracture	5 (12.5%)
Scapular Fracture	4 (10.0%)
Sternal Fracture	3 (7.5%)

*Percentages exceed 100% because multiple injuries were present in most patients.

Table 4: Association between Number of Rib Fractures and Pulmonary Complications

Number of Rib Fractures	n	Pulmonary Contusion n (%)	Pneumothorax n (%)	Hemothorax n (%)
≤ 2	12	4 (33.3%)	2 (16.7%)	3 (25.0%)
3 – 5	18	10 (55.6%)	6 (33.3%)	10 (55.6%)
>5	10	8 (80.0%)	6 (60.0%)	7 (70.0%)
Chi-square p value		0.04	0.03	0.04

Table 5: Comparison of Diagnostic Sensitivity of Chest Radiography versus MDCT (Gold Standard)

Injury	Total on MDCT (n)	Detected on Chest X-ray (n)	Sensitivity (%)
Rib Fractures	34	26	76.5%
Pulmonary Contusion	22	10	45.5%
Pneumothorax	14	8	57.1%
Hemothorax	20	12	60.0%
Pneumomediastinum	3	1	33.3%
Diaphragmatic Rupture	2	1	50.0%
Aortic Injury	1	0	0%

DISCUSSION

The present study underscores the remarkable diagnostic superiority of multidetector computed tomography over chest radiography in the evaluation of chest trauma, consistent with the established body of literature

[6,10,13]. Rib fractures emerged as the most frequent injury, detected in 85% of our patients. This prevalence aligns with the range of 50–90% reported in previous MDCT-based series [9,14]. The detection of rib fractures is not merely academic; their number and location serve

as a surrogate marker for the force of impact and correlate strongly with underlying visceral damage [15]. Our finding that the incidence of pulmonary contusion, pneumothorax, and hemothorax increased significantly with a higher rib fracture count ($p < 0.05$) echoes the observations of Livingston et al., who demonstrated that the odds of acute respiratory failure and mortality rise sharply beyond three fractured ribs [15]. MDCT's ability to generate curved planar reformations and three-dimensional volume-rendered images enables the identification of non-displaced and costochondral fractures that are completely invisible on radiographs, thereby contributing to a more accurate prediction of patient trajectory.

Pulmonary contusion was identified in 55% of our cohort, which is within the reported incidence of 30–70% [10,16]. This lesion represents parenchymal hemorrhage and edema that may progress over 24–48 hours, leading to acute respiratory distress syndrome. Chest radiography detected contusions in only 45.5% of cases, a sensitivity broadly in line with Trupka et al. who reported that up to 45% of contusions visible on CT were missed on supine chest radiographs [6]. The early tomographic recognition of contusions, particularly those exceeding 20% of lobar volume, is essential because it often mandates aggressive pulmonary toilet, supplemental oxygen, and in severe cases, mechanical ventilation [17]. MDCT permits objective quantification of contusion volume, which serves as a more reliable predictor of clinical deterioration than qualitative radiographic assessment. In our study, 25% of patients harbored severe contusions; without MDCT, nearly half of these would have been underestimated, potentially delaying critical care interventions.

The superiority of MDCT is perhaps most dramatic in the detection of occult pneumothorax and small hemothoraces. In our series, 35.7% of pneumothoraces were occult on the initial supine chest radiograph. This figure parallels the 30–50% rate reported in large multicenter studies [7,13]. An undrained occult pneumothorax in a patient about to undergo positive pressure ventilation poses the risk of tension pneumothorax, a life-threatening emergency. The liberal use of MDCT therefore directly influences the decision to insert a prophylactic tube thoracostomy [18]. Similarly, hemothorax, which was present in half of our patients, was missed in 40% by chest radiography. Even small hemothoraces, when undetected, can organize into fibrothorax or become infected, especially in patients with prolonged intensive care stays. The identification of mediastinal air, diaphragmatic injury, and aortic trauma all injuries that mandate immediate or urgent surgical attention was also greatly enhanced. The single traumatic aortic injury in our study was not apparent on the admission chest X-ray, mirroring the well-known poor sensitivity of plain radiography for contained aortic transections, which is cited to be as low as 50–60% even with optimal erect views [9]. This single case could have

been catastrophic if the patient had been managed conservatively based on a “normal” mediastinal contour on the plain film.

Our study's comparison of chest radiography and MDCT adds to the growing body of evidence that encourages a low threshold for CT scanning in chest trauma. While the universal CT approach remains controversial due to concerns about radiation dose and cost, the diagnostic yield is substantial. In our study, 45% of patients had injuries found exclusively on MDCT, a proportion that falls within the range of 20–50% described by Exadaktylos et al. and Langdorf et al. [7,13]. In a resource-challenged environment such as ours, implementing a selective MDCT protocol guided by clinical variables like high-velocity mechanism, abnormal chest X-ray, hypoxia, or suspicion of polytrauma may strike a balance between resource utilization and patient safety [19]. Nevertheless, our results demonstrate that in any patient with significant blunt chest trauma, the information gained from MDCT far outweighs the risks of a single-phase contrast-enhanced scan. The study also contributes South Indian rural hospital data, highlighting that the injury patterns and the diagnostic gap are comparable to those in well-resourced centres, and reinforces the need for round-the-clock availability of MDCT in trauma receiving units.

Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the sample size of 40 patients, though adequate for an exploratory descriptive analysis, limits the statistical power to detect rare injuries and to perform robust multivariate analysis. The small number of events, such as aortic injury and diaphragmatic rupture, precludes meaningful sensitivity calculations for those specific injuries. Second, the study was conducted at a single rural tertiary care centre, and the patient population may not be fully representative of all trauma cohorts due to referral bias only hemodynamically stable patients able to undergo CT were included. The most severely injured patients who required immediate surgery or died in the emergency department were excluded, potentially underestimating the true incidence of major thoracic injuries. Third, the gold standard was the MDCT interpretation by a single radiologist, without surgical or autopsy confirmation for many lesions; for example, pulmonary contusions were diagnosed solely on imaging criteria without histological verification. Fourth, inter-observer variability was not assessed because all MDCT images were read by one experienced radiologist. Fifth, we did not evaluate clinical outcomes such as length of hospital stay, need for mechanical ventilation, or mortality, limiting the translation of radiological findings to prognosis. Finally, the study design did not include a cost-effectiveness or radiation-risk analysis, which would be necessary before advocating for non-selective CT use. Despite these limitations, the study

provides valuable local data on the diagnostic yield of MDCT in chest trauma.

Acknowledgment

The authors express their sincere gratitude to the administration of Dhanalakshmi Srinivasan Institute of Medical Sciences and Hospital for providing the infrastructure and support to conduct this research. We are thankful to the emergency department staff, radiology technologists, and our colleagues in the Department of Radiodiagnosis for their cooperation during data collection. Above all, we are deeply indebted to the patients and their families who consented to participate in this study despite the stressful circumstances of acute trauma.

CONCLUSION

Multidetector computed tomography stands as a non-pareil imaging modality in the comprehensive evaluation of chest trauma, revealing a broad and often clinically silent spectrum of injuries that profoundly influence patient management. This prospective study of 40 trauma patients at a rural Indian teaching hospital demonstrated that rib fractures (85%), pulmonary contusions (55%), hemothorax (50%), and pneumothorax (35%) are exceedingly common and frequently coexist. The significant positive association between the number of rib fractures and the likelihood of underlying pulmonary complications reinforces the prognostic value of detailed fracture mapping possible only with MDCT. The detection of occult pneumothorax in over one-third of pneumothorax cases and the identification of one contained aortic transection that was invisible on the admission radiograph underscore the life-saving potential of CT imaging.

In comparison with the traditional supine chest radiograph, MDCT exhibited markedly higher sensitivity for every category of thoracic injury, with nearly half of the patients having at least one abnormality diagnosed solely on CT. These findings advocate for a paradigm shift in the imaging approach to chest trauma, even in resource-limited settings. While judicious selection based on clinical suspicion remains important, the integration of MDCT into the routine diagnostic algorithm for all patients with significant blunt chest trauma is likely to facilitate early, targeted interventions drainage of occult collections, prophylactic ventilation strategies, and timely surgical repair thereby reducing both short-term complications and long-term disability. Future multi-centre studies with larger cohorts, surgical correlation, and outcome analysis are warranted to further define the role of MDCT and to develop validated clinical prediction rules that optimize its use in the Indian trauma context.

REFERENCES

1. LoCicero J 3rd, Mattox KL. Epidemiology of chest trauma. *Surg Clin North Am*. 1989;69(1):15–9.
2. Battle CE, Hutchings H, Evans PA. Risk factors that predict mortality in patients with blunt chest wall trauma: a systematic review and meta-analysis. *Injury*. 2012;43(9):1339–49.
3. Sharma OP, Oswanski MF, Jolly S, Lauer SK, Dressel R, Stombaugh HA. Perils of rib fractures. *Am Surg*. 2008;74(4):310–4.
4. Khanduri S, Katyal S, Garg A, et al. Spectrum of MDCT findings in blunt chest trauma patients. *J Med Sci Clin Res*. 2017;5(3):18903–9.
5. Gupta A, Kumar S, Singh P, et al. Spectrum of chest injuries on multidetector computed tomography in blunt chest trauma: a prospective study. *J Clin Diagn Res*. 2018;12(9):TC01–TC04.
6. Trupka A, Waydhas C, Hallfeldt KK, Nast-Kolb D, Schweiberer L. Value of thoracic computed tomography in the first assessment of severely injured patients with blunt chest trauma: results of a prospective study. *J Trauma*. 1997;43(3):405–11.
7. Exadaktylos AK, Sclabas G, Schmid SW, Schaller B, Zimmermann H. Do we really need routine computed tomographic scanning in the primary evaluation of blunt chest trauma in patients with “normal” chest radiograph? *J Trauma*. 2001;51(6):1173–6.
8. Chardoli M, Hasan-Ghaliaee T, Akbari H, et al. Accuracy of chest radiography versus chest computed tomography in hemodynamically stable patients with blunt chest trauma. *Chin J Traumatol*. 2013;16(6):351–4.
9. Kaewlai R, Avery LL, Asrani AV, Novelline RA. Multidetector CT of blunt thoracic trauma. *Radiographics*. 2008;28(6):1555–70.
10. Oikonomou A, Prassopoulos P. CT imaging of blunt chest trauma. *Insights Imaging*. 2011;2(3):281–95.
11. Palas J, Matos AP, Mascarenhas V, et al. Multidetector computed tomography of acute blunt thoracic trauma: what the radiologist needs to know. *Emerg Radiol*. 2014;21(1):75–89.
12. Wicky S, Wintermark M, Schnyder P, Capasso P, Denys A. Imaging of blunt chest trauma. *Eur Radiol*. 2000;10(10):1524–38.
13. Langdorf MI, Medak AJ, Hendey GW, et al. Prevalence and clinical import of thoracic injury identified by chest computed tomography but not chest radiography in blunt trauma: multicenter prospective cohort study. *Ann Emerg Med*. 2015;66(6):589–600.
14. Peters S, Nicolas V, Heyer CM. Multidetector computed tomography-spectrum of blunt chest wall and lung injuries in polytraumatized patients. *Clin Radiol*. 2010;65(4):333–8.
15. Livingston DH, Shogan B, John P, Lavery RF. CT diagnosis of rib fractures and the prediction of acute respiratory failure. *J Trauma*. 2008;64(4):905–11.
16. Mirvis SE. Imaging of blunt thoracic trauma. *Semin Roentgenol*. 2004;39(3):363–81.

17. Miller PR, Croce MA, Bee TK, et al. ARDS after pulmonary contusion: accurate measurement of contusion volume identifies high-risk patients. *J Trauma*. 2001;51(2):223–8.
18. Ball CG, Kirkpatrick AW, Feliciano DV. The occult pneumothorax: what have we learned? *Can J Surg*. 2009;52(5):E173–9.
19. Rodriguez RM, Hendey GW, Marek G, Dery RA, Bjoring A. A pilot study to derive clinical variables for selective chest imaging in blunt trauma patients. *J Trauma*. 2006;60(4):874–7.