Original Article

Bull Emerg Trauma 2023;11(1):19-25.

Bulletin of Emergency And Trauma

Evaluation of the Spiral Chest CT Scan Findings in Patients with Multiple Trauma

Ramin Ebrahimian[1,2], Zoubin Souri[3], Alireza Feizkhah[4,5], Mohammadreza Mobayen[4], Habib Eslami Kenarsari[1], Mojdeh Esmailzadeh[4], Mohsen Ghorbani[1], Soroush Mirhedayati[1], Parissa Bagheri Toolaroud[4,6]

[1]Clinical Research Development Unit of Poursina Hospital, Guilan University of Medical Sciences, Rasht, Iran
[2]Department of Surgery, Faculty of Medicine, Guilan University of Medical Sciences, Rasht, Iran
[3]Department of Radiology, Faculty of Medicine, Guilan University of Medical Sciences, Rasht, Iran
[4]Burn and Regenerative Medicine Research Center, Guilan University of Medical Sciences, Rasht, Iran
[5]Department of Medical Physics, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
[6]Health Information Management Research Center, Kashan University of Medical Sciences, Kashan, Iran

***Corresponding author:** Parissa Bagheri Toolaroud*
Address: Health Information Management Research Center, Kashan University of Medical Sciences, Postal code: 87159-73449, Kashan, Iran. **Tel:** +98-911-2812842, +98-31-55589373; **Fax:** +98-31-55548883;
e-mail: parissabagheri@yahoo.com

Received: December 13, 2022
Revised: December 22, 2023
Accepted: December 25, 2023

ABSTRACT

Objective: To evaluate the spiral chest computed tomography (CT) scan findings in patients with multiple trauma during the COVID-19 pandemic.
Methods: This retrospective study was performed on multiple trauma patients admitted to a tertiary hospital in the north of Iran in 2020. All patients with multiple trauma who had undergone a chest spiral CT were included in this study. Furthermore, the data analysis was performed through descriptive and analytical statistics using SPSS software.
Results: A total of 600 patients were included over the study period. The mean age of patients was 48.2±20.3 years. Of the total, 496 (65.3%) patients had blunt chest injuries, and 104 (34.7%) had penetrating chest injuries. Falling was the most common mechanical cause of chest trauma in 270 patients (45%). Surgical interventions were performed in 110 (18.3%) patients. A total of 276 (46%) patients had chest injuries identified by CT scans. Many patients (15.6%) had ground-glass lung opacity in the CT scan reports. Lung consolidation, pneumothorax, lung contusion, hemothorax, and rib fractures were the most common.
Conclusion: Due to the high frequency of typical findings in spiral CT scan examinations, obtaining a reliable history of trauma severity, injury mechanism, and a detailed physical examination is recommended before prescribing a CT scan for patients.

Keywords: Multiple trauma; Tomography; Spiral Computed; Emergency medicine; COVID-19.

Please cite this paper as:
Ebrahimian R, Souri Z, Feizkhah AR, Mobayen MR, Eslami Kenarsari H, Esmailzadeh M, Ghorbani M, Mirhedayati S, Bagheri Toolaroud P. Evaluation of the Spiral Chest CT Scan Findings in Patients with Multiple Trauma. *Bull Emerg Trauma*. 2023;11(1):19-25. doi: 10.30476/BEAT.2023.97214.1402.

Introduction

Trauma is one of the leading causes of life-threatening injuries worldwide. Blunt trauma is one of the most commonly reported causes [1]. According to the Institute for Health Metrics and Evaluation (IHME), multiple trauma causes acute disability to approximately 50 million people worldwide annually, and 5.8 million people die from this injury. Notably, this number represents 10% of worldwide deaths [2]. In addition, the mortality rate from multiple trauma in developed countries is less than 10%, and more than 90% occur in less developed countries [3].

In multiple trauma patients, thoracic injuries account for 25% of mortality, making them a prevalent cause of death. Acute chest trauma usually occurs in accidents and mechanical injuries [4]. Regarding mechanical injuries, penetration and blunt trauma are the two forms of injuries. It is readily plausible that blunt injuries are significant since they account for 70% of all chest traumas [5]. Furthermore, 15% of all trauma cases worldwide are caused by blunt chest injuries [6]. Determining the mortality rate can be difficult in blunt chest trauma, possibly due to pulmonary and non-pulmonary [7].

Acute chest trauma may occur with rib fractures, hemothorax, Pneumothorax, hemopneumothorax, and pleural injuries. Moreover, this can be accompanied by severe injuries to other regions, such as the head, abdomen, extremities, and the heart [4,8]. Different treatment approaches are required for different chest injuries. Since a prompt diagnosis of different types of chest injuries is life-saving, multi-slice CT scans (MSCT) and reconstructive imaging techniques have been most helpful in diagnostic approaches [9]. The increasing use of chest CT scans leads to improved diagnostic approaches for patients who are clinically asymptomatic and in multiple trauma with dangerous mechanisms [10]. Incidental chest imaging findings are another advantage, as they may require immediate medical attention [11]. Therefore, this study aims to evaluate spiral chest CT scan findings in patients with multiple trauma referred to the emergency department of Poursina Hospital in Rasht, Guilan, during the COVID-19 pandemic in 2020.

Materials and Methods

Data Source and Design

This retrospective study was conducted at the Poursina Trauma Center in North of Iran. All patients with multiple trauma injuries (ISS: Injury Severity Score≥16) who had undergone a chest spiral CT scan were included in this study. Patients without radiographic assessments and CT scans were excluded from the study. The ISS is a score that attempts to standardize the severity of injuries sustained during a trauma. The ISS is calculated by taking the sum of the squares of the highest AIS from each of the three most severely injured body regions to achieve a score that ranges from 3 (least) to 75 (most) injured; its system is established in https://www.mdcalc.com/calc/1239/injury-severity-score-iss [12].

The research's statistical population includes all multiple trauma patients referred to Porsina Hospital, Rasht, from January 2020 to January 2021, for whom a spiral chest CT scan was performed. Data were collected retrospectively by census method from patients' records in Hospital Information System (HIS) who met the inclusion criteria. According to the hospital information system, the number of people referred in this time period was about 600. The sample size was determined using Krejcie and Morgan's methodology [13]. However, to achieve more accurate results, all 600 records were evaluated.

A researcher-made checklist was used to collect the data. Data collected included demographic information (age, gender), clinical findings (length of stay, anatomic region, Glasgow Coma Scale (GCS), surgical intervention, trauma type (penetrating, blunt), cause of trauma (falling, violence and strife, vehicle collisions type (car-car accident (CCA), motor-car accident (MCA), and pedestrian-car accident (PCA)), and Spiral chest CT scan findings. The radiologic findings included completely normal, Pneumothorax, hemothorax, pneumohemothorax, Pneumomediastinum, mediastinal hematoma, rib fracture, heart injury, tracheal rupture, diaphragmatic rupture, esophageal rupture, clavicle fracture, lung opacity, sternal fracture, and scapula fracture. Chest CT scans were performed using a 16-slice multi-detector computed tomography (MDCT) HiSpeed Dual Hitachi scanner.

Statistical Analysis

There was no missing data. Continuous variables are presented as means, and standard deviation (SD) and categorical variables are presented as numbers and percentages. Statistics analysis was conducted using the SPSS software package (version 24.0, SPSS Inc., Chicago, IL, USA).

Results

A total of 600 patients with a mean age of 48.21 (SD=20.26) years were studied. Most of the patients (296) were in the age group between 20 to 49 years (49.3%), while 22 patients (3.7%) were under 20 years old. A total of 430 patients (71.6%) were male, and 170 (28.4%) were female. Trauma mechanisms were categorized as: falling for 270 patients (45%), violence and strife for 86 patients (14.4%), MCA for 46 patients (10.6%), CCA for 118 patients (19.6%), and PCA for 62 patients (10.4%). The type of injury in 496 patients (65.3%) was blunt trauma, and in 104 patients (34.7%) was penetrating trauma. This study considered 15 as normal LOC, 13-14 as mild

decreased LOC, 8-12 as moderate decreased LOC, and GCS score less than eight as severe decreased LOC. Most patients (80.3%) had normal LOC, and ten patients (1.7%) had severely decreased LOC at admission (Table 1).

Figure 1 shows the frequency of spiral chest CT scan findings in multiple trauma patients. A total of 326 patients (54%) had normal chest CT scans. In 174 cases (29%), infectious lung consolidation was reported. Differentiation between infectious and non-infectious lung consolidation was based on a history of physical examination, symptoms of COVID-19 infection, and RT-PCR test results. Infectious lung consolidation (29%) and Pneumothorax (19.3%) had the highest frequencies among the others. No cardiac injury, diaphragmatic rupture, trachea, and esophagus ruptures were reported.

The highest frequency of Pneumothorax, hemothorax, pneumohemothorax, rib fracture, and Clavicle fracture was reported in the 20-49 age group. The highest consolidation frequency was reported in the 50-69 age group (Table 2). Pneumothorax, hemothorax, pneumohemothorax, rib fractures, and lung contusion were most reported in vehicle collisions. All four cases of mediastinal hematoma were due to falling.

Table 1. Basic demographics and clinical information in multiple trauma patients (n=600)

Demographic Variables		**n (%)**
Age	<20	22 (3.7)
	20-49	296 (49.3)
	50-69	180 (30)
	>70	102 (17)
	Mean (SD)	48.21 (20.26)
Sex	Male	430 (71.6)
	Female	170(28.4)
GCS	15	482 (80.3)
	13-14	66 (11)
	8-12	42 (7)
	<8	10 (1.7)
Mechanisms of injury	Falling	270 (45.0)
	Violence and Strife	86 (14.4)
	MCA	64 (10.6)
	CCA	118(19.6)
	PCA	62 (10.4)
Trauma type	Blunt trauma	496 (65.3)
	Penetrating trauma	104 (34.7)
Surgical intervention	Yes	110 (18.3)
	No	490 (81.7)

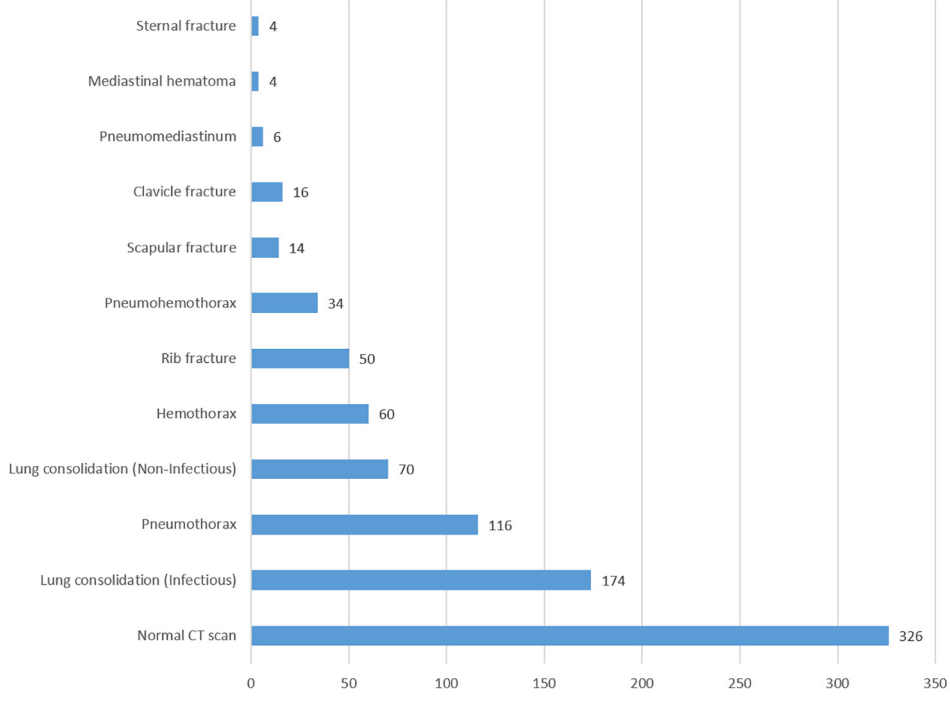

Fig. 1. Distribution of spiral Chest CT scan findings in patients

Table 2. The frequency of Chest CT scan findings based on age, sex, level of consciousness, type, cause of trauma, and surgical intervention.

Variables	Age				Sex		GCS				Trauma type		Cause					Intervention	
	<20	20-49	50-69	>70	Male	Female	Normal	Mild	Moderate	Severe	Blunt	penetration	Fall	Assault	MCA	PCA	CCA	Yes	No
Pneumothorax	4 (3.45)	68 (58.62)	28 (24.14)	16 (13.79)	82 (70.69)	34 (29.31)	68 (58.62)	26 (22.41)	16 (13.79)	6 (5.17)	88 (75.86)	28 (24.14)	44 (37.93)	18 (15.52)	10 (8.62)	6 (5.17)	38 (32.76)	86 (74.14)	30 (25.86)
Hemothorax	0 (0)	34 (56.67)	18 (30.00)	8 (13.33)	36 (60.00)	24 (40.00)	40 (66.67)	12 (20.00)	6 (10.00)	2 (3.33)	42 (70.00)	18 (30.00)	24 (40.00)	6 (10.00)	6 (10.00)	6 (10.00)	18 (30.00)	44 (73.33)	16 (26.67)
Pneumohemothorax	0 (0)	24 (70.59)	8 (23.53)	2 (5.88)	18 (52.94)	16 (47.06)	18 (52.94)	12 (35.29)	2 (5.88)	2 (5.88)	24 (70.59)	10 (29.41)	12 (35.29)	2 (5.88)	2 (5.88)	0 (0)	18 (52.94)	30 (88.24)	4 (11.76)
Pneumomediastinum	2 (33.33)	0 (0)	4 (66.67)	0 (0)	2 (33.33)	4 (66.67)	6 (100.00)	0 (0)	0 (0)	0 (0)	6 (100.00)	0 (0)	4 (66.67)	0 (0)	0 (0)	2 (33.33)	0 (0)	0 (0)	6 (100.00)
Mediastinal hematoma	0 (0)	0 (0)	2 (50.00)	2 (50.00)	2 (50.00)	2 (50.00)	4 (100.00)	0 (0)	0 (0)	0 (0)	4 (100.00)	0 (0)	4 (100.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (100.00)
Rib fracture	0 (0)	30 (60.00)	10 (20.00)	10 (20.00)	36 (72.00)	14 (28.00)	8 (16.00)	26 (52.00)	10 (20.00)	6 (6.00)	32 (64.00)	18 (36.00)	14 (28.00)	4 (8.00)	6 (12.00)	8 (16.00)	18 (36.00)	30 (60.0)	20 (40.0)
Clavicle fracture	0 (0)	10 (62.50)	6 (37.50)	0 (0)	16 (100.00)	0 ()	8 (50.00)	2 (12.50)	2 (12.50)	4 (25.00)	12 (75.00)	4 (25.00)	4 (25.00)	2 (12.50)	4 (25.00)	2 (12.50)	4 (25.00)	10 (62.5)	6 (37.5)
Sternal fracture	0 (0)	2 (50.00)	2 (50.00)	0 (0)	4 (100.00)	0 (0)	2 (50.00)	0 (0)	2 (50.00)	0 (0)	4 (100)	0 (0)	2 (50.0)	0 (0)	0 (0)	2 (50)	0 (0)	0 (0)	4 (100.00)
Scapular fracture	0 (0)	4 (28.57)	4 (28.57)	6 (42.86)	8 (57.14)	6 (42.86)	14 (100.00)	0 (0)	0 (0)	0 (0)	12 (85.71)	2 (14.29)	8 (57.14)	2 (14.29)	2 (14.29)	0 (0)	2 (14.29)	6 (42.86)	8 (57.14)
Lung consolidation	4 (1.64)	110 (45.08)	86 (35.25)	44 (18.03)	172 (70.49)	72 (29.51)	188 (77.05)	28 (11.48)	22 (9.02)	6 (2.46)	210 (86.07)	34 (13.93)	124 (50.82)	24 (9.84)	18 (7.38)	24 (9.84)	54 (22.13)	84 (34.43)	160 (65.57)

Table 2 shows that Pneumothorax, hemothorax, pneumohemothorax, rib fractures, clavicle fractures, and lung contusions were most reported in penetrating trauma. The frequency of normal chest CT scans was almost equal in both penetrating and blunt trauma.

Pneumomediastinum, mediastinal hematoma, and sternal fractures were also most reported in this group of patients, but other chest CT scan findings had more frequency in patients who needed thoracic surgical intervention. Spiral CT scan findings, including Pneumothorax, hemothorax, pneumohemothorax, rib fractures, clavicle fractures, and lung contusion, were reported with the highest frequency in patients with severely decreased LOC.

Discussion

The use of chest CT scans as an effective diagnostic approach for acute chest trauma is increasing in patients with or without clinical and radiographic signs. Therefore, the study aimed to determine and evaluate the effectiveness of this action and its proper management according to the results obtained from spiral chest CT scan findings in patients with multiple trauma.

In the present study, more than half of the patients had normal chest CT scan findings. A Study conducted by Musavi *et al*., in Kashan showed that 74% of patients had normal CT scans, and abnormal CT scan reports had 38% more positive findings than simple chest radiography, which led to a change in the course of treatment [14]. The highest prevalence of abnormality was related to lung consolidation (including ground glass lung opacity (which is expected considering the COVID-19 pandemic. Abdolrahimzadehfard *et al*., study investigated that in CT scan findings of trauma patients during the corona era and before and based on RSNA criteria, most cases related to ground-glass opacities (GGOs) with (73.1%)) were observed [15]. That should be noted that Brink *et al*., showed that 51% of patients had normal chest CT scans [16].

According to data obtained, the most frequent cause of trauma in patients was related to falling with 45%. On the other hand, the mechanism of PCA (pedestrian-car accident) with 10.4% had the lowest frequency. In contrast to our study, a study on US American College reported that the CCA (car-car accident) mechanism had the highest frequency with 45.3%, and the lowest frequency related to the MCA (motor-car accident) and PCA mechanisms, each was 11.8 percent. Falling as a trauma mechanism accounted for 19.3% of the cases studied [17]. Based on the evidence, there is a significant difference in the frequency of the falling mechanism compared to other studies, which can be because of the specific geographical conditions of the region, like cultural and construction issues. In addition, since the primary source of income is from gardening and agriculture, a high rate of falling from the tree should be noted.

The present study reported the highest prevalence of Pneumothorax, Hemothorax, Pneumomediastinum, Scapular fracture, and lung consolidation due to falling. Moreover, blunt trauma was 65.3%, and penetrating trauma was 34.7% of cases. These results were consistent with findings from a previous study conducted in Pakistan that reported a prevalence of 63.3% for blunt trauma and 36.6% for penetrating trauma [18]. In the present study, the prevalence of Pneumothorax, hemothorax, pneumohemothorax, rib fracture, clavicle fracture, and lung consolidation were higher in patients with penetrating trauma, and the frequency of normal chest CT scans was reported to be equal in patients with penetrating and blunt trauma. Therefore, the frequency of normal chest CT scans was significant only considering CT scan findings due to traumatic injuries and excluding lung consolidations, which could be in the context of the COVID-19 pandemic. Our results suggest that necessary criteria should be taken to select the suitable diagnostic approaches; proper consideration of simple chest radiography based on suspected injuries and physical examination, observing, and monitoring the patient can be a solution to avoid unnecessary diagnostic measures or overtreatment of nonsignificant injuries. The choice to undertake routine CT scans at a trauma center should be decided with caution, taking into account the risks and benefits. Considering the high rate of unnecessary chest CT scans, it is recommended to consult with relevant specialists and implement standard guidelines at different levels to prevent unnecessary chest CT prescriptions, harm to patients, and prevent unnecessary costs. Also, it is recommended that complete information on the patient's clinical history, detailed physical examination, the severity of the trauma, and the mechanism of injury should be collected in a prospective study of the study population. Then the relationship of these factors with a finding obtained from CT scan results should be investigated to prevent unnecessary CT scans by identifying and analyzing high-risk factors related to abnormal results. In addition, further research should be conducted to assess the types of incidental findings and how to accurately create a protocol to report incidental findings. Failure to report can lead to negligence and a late diagnosis of a potentially life-threatening illness.

There are several limitations to present study. This is a retrospective study; hence, different results can be obtained because of the differences in our patient population as well as depending on various risk factors. Thus, the results may not be applicable to all hospitals. Another of the study's limitations is the single-center research environment, which suggests that more samples should be examined in future studies.

According to the high frequency of normal chest

CT scans, this diagnostic approach is unnecessary in many cases. It might result from unreliable patient history, inaccurate history taking in the emergency room, or failure to consider criteria for performing chest CT scans. The availability and reliability of this diagnostic tool may also have been a factor for this high statistic. The results obtained in this study highlights that frequency of falling as the mechanism of trauma was almost as twice of other studies. Therefore, due to the region's geographical status, we recommend that local officials consider actions to inform and educate people to prevent these accidents. This investigation also shows that 40.6% of patients had lung consolidation (29% ground glass lung opacity), which led to further evaluations for COVID-19 infection and isolation of the patients.

Declaration

Ethics approval and consent to participate: This research was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1399.483). Patient informed consent was not acquired due to the use of previously gathered data from the hospital information system; nevertheless, the names of patients were not gathered from the database for ethical reasons.

Consent for publication: None of the authors declared.

Conflict of interests: Each author has made substantial contributions to the conception and design of the study or acquisition of data or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content. Each author has seen and approved the contents of the submitted manuscript. None of the authors has any personal or financial conflicts of interest.

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Authors' contributions: RE, MM and ZS contributed to the concept and design of the study. AF, AK and ME, contributed to the field data collection. PB and HE conducted the analysis and PB drafted the first version of the manuscript. MG and SM provided a critical review of the article. All authors reviewed and approved the final manuscript.

Acknowledgment: This study was part of a MD thesis supported by Guilan University of medical sciences. In addition, we thank the Clinical Research Development Unit of Poursina Hospital for their assistance in this project.

References

1. Debus F, Lefering R, Lechler P, Schwarting T, Bockmann B, Strasser E, Mand C, Ruchholtz S, Frink M; TraumaRegister DGU. Association of an In-House Blood Bank with Therapy and Outcome in Severely Injured Patients: An Analysis of 18,573 Patients from the TraumaRegister DGU®. *PLoS One*. 2016;**11**(11):e0148736.
2. Lendrum RA, Lockey DJ. Trauma system development. *Anaesthesia*. 2013;**68** Suppl 1:30-9.
3. Sakran JV, Greer SE, Werlin E, McCunn M. Care of the injured worldwide: trauma still the neglected disease of modern society. *Scand J Trauma Resusc Emerg Med*. 2012;**20**:64.
4. Lang P, Kulla M, Kerwagen F, Lefering R, Friemert B, Palm HG; TraumaRegister DGU. The role of whole-body computed tomography in the diagnosis of thoracic injuries in severely injured patients - a retrospective multi-centre study based on the trauma registry of the German trauma society (TraumaRegister DGU®). *Scand J Trauma Resusc Emerg Med*. 2017;**25**(1):82.
5. Harrison M. Traumatic pneumothorax: a review of current practices. *Br J Hosp Med (Lond)*. 2014;**75**(3):132-5.
6. Demirhan R, Onan B, Oz K, Halezeroglu S. Comprehensive analysis of 4205 patients with chest trauma: a 10-year experience. *Interact Cardiovasc Thorac Surg*. 2009;**9**(3):450-3.
7. Trauma EAftSo. Pain management in blunt thoracic trauma. BTT) An Evidence-Based Outcome Evaluation 2nd Review-2003.
8. Dogrul BN, Kiliccalan I, Asci ES, Peker SC. Blunt trauma related chest wall and pulmonary injuries: An overview. *Chin J Traumatol*. 2020;**23**(3):125-138.
9. Awais M, Salam B, Nadeem N, Rehman A, Baloch NU. Diagnostic Accuracy of Computed Tomography Scout Film and Chest X-ray for Detection of Rib Fractures in Patients with Chest Trauma: A Cross-sectional Study. *Cureus*. 2019;**11**(1):e3875.
10. Kim SJ, Bista AB, Min YG, Kim EY, Park KJ, Kang DK, et al. Usefulness of low dose chest CT for initial evaluation of blunt chest trauma. *Medicine (Baltimore)*. 2017;**96**(2):e5888.
11. Fakler JK, Ozkurtul O, Josten C. Retrospective analysis of incidental non-trauma associated findings in severely injured patients identified by whole-body spiral CT scans. *Patient Saf Surg*. 2014;**8**:36.
12. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;**14**(3):187-96.
13. Krejcie RV, Morgan DW. Determining sample size for research activities. *Educational and psychological measurement*. 1970;**30**(3):607-10.
14. Moussavi N, Davoodabadi AH, Atoof F, Razi SE, Behnampour M, Talari HR. Routine Chest Computed Tomography and Patient Outcome in Blunt Trauma. *Arch Trauma Res*. 2015;**4**(2):e25299.
15. Abdolrahimzadeh Fard H, Mahmudi-Azer S, Abdulzahraa Yaqoob Q, Sabetian G, Iranpour P, Shayan Z, et al. Comparison of chest CT scan findings between COVID-19 and pulmonary contusion in trauma patients based on RSNA criteria: Established novel criteria for trauma victims. *Chin J Traumatol*. 2022;**25**(3):170-176.
16. Brink M, Deunk J, Dekker HM,

Edwards MJ, Kool DR, van Vugt AB, et al. Criteria for the selective use of chest computed tomography in blunt trauma patients. *Eur Radiol*. 2010;**20**(4):818-28.

17. Langdorf MI, Medak AJ, Hendey GW, Nishijima DK, Mower WR, Raja AS, 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.

18. Mazcuri M, Ahmad T, Abid A, Thapaliya P, Ali M, Ali N. Pattern and Outcome of Thoracic Injuries in a Busy Tertiary Care Unit. *Cureus*. 2020;**12**(10):e11181.