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Original Article

CT as a first-line modality in elderly patients with stable blunt chest trauma

Alexander Becker [a, b, *], Tamar Dola [a], Yuri Berlin [a, b], Dan Hershko [a, b]

[a] Department of Surgery A, Emek Medical Center, Afula, 18101, Israel
[b] Faculty of Medicine, Technion–Israel Institute of Technology, Haifa, 31096, Israel

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ABSTRACT

Purpose: Blunt thoracic injuries are common among elderly patients and may be a common cause of morbidity and death from blunt trauma injuries. We aimed to examine the impact of chest CT on the diagnosis and change of management plan in elderly patients with stable blunt chest trauma. We hypothesized that chest CT may play an important role in providing optimal management to this subgroup of trauma patients.

Methods: A retrospective analysis was performed on all the admitted adult blunt trauma patients between January 2014 and December 2018. Stable blunt chest trauma patients with abbreviated injury severity (AIS) < 3 for extra-thoracic injuries confirmed with chest X-ray (CXR) and chest CT on admission or during hospitalization were included in the study. The AIS is an international scale for grading the severity of anatomic injury following blunt trauma. Primary outcome variables were occult injuries, change in management, need for surgical procedures, missed injuries, readmission rate, intensive care unit (ICU) and length of hospital stay.

Results: There are 473 patients with blunt chest trauma included in the study. The study patients were divided into two groups according to the age range: group 1: 289 patients were included and aged 18–64 years; group 2: 184 patients were included and aged 65–99 years . Elderly patients in group 2 more often required ICU admission (11.4% *vs.* 5.2%), had a longer length of ICU stay (days) (median 11 *vs.* 6, $p = 0.01$), and the length of hospital stay (days) (median 14 vs. 6, $p = 0.04$). Injuries identified on chest CT has led to a change of management in 4.4% of young patients in group 1 and in 10.9% of elderly patients in group 2 with initially normal CXR. Chest CT resulted in a change of management in 12.8% of young patients in group 1 and in 25.7% of elderly patients in group 2 with initially abnormal CXR.

Conclusion: Chest CT led to a change of management in a substantial proportion of elderly patients. Therefore, we recommend chest CT as a first-line imaging modality in patients aged over 65 years with isolated blunt chest trauma.

Introduction

Geriatric trauma has been increasingly recognized as a problem for trauma centers around the world. The patients aged over 65 years old account for 20%–25% of all trauma patients admitted to trauma centers.[1,2] These patients commonly have associated comorbidities that significantly increase the risk of severe disability and death compared to young patients with similar injury severity scores.[3] Thus, special attention should be paid on the diagnosis and treatment of the elderly which may be different from the general guidelines for young patients. Blunt thoracic injuries are common among elderly patients and may be a common cause of morbidity and death from blunt trauma injuries.[4] It was shown that even low-grade injuries such as minor rib fractures and pulmonary contusion may be associated with increased mortality in elderly patients. For example, a 20% increase in mortality rates due to lung complications was observed as well as a 10% increase in mortality risk for each additional rib fractures.[5,6] In another study, a 2-fold increase in mortality rate was observed among 956 patients older than 65 years with blunt chest trauma compared to patients younger than 65 years (14% *vs.* 6%).[7] However, it was also shown that when timely optimal diagnostic work-up is initiated along with urgent directed treatment, the outcome differences between elderly patient and young patients may decrease significantly.[8] Therefore, early

* Corresponding author. Department of Surgery A, Emek Medical Center, Afula, 18101, Israel
E-mail address: becker_al@clalit.org.il (A. Becker).
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diagnosis of the full extent of chest injury in elderly trauma patients is of great importance.

The common practice used for the diagnostic work-up of patients that have severe blunt trauma is chest CT. However, its use in stable patients is still a matter of debate and hence the work-up may be determined by chest X-ray (CXR) only in some developing countries.

Numerous studies have shown inferior diagnostic accuracy of CXR compared to chest CT in the evaluation of other blunt thoracic traumas.[9,10] It has been shown that CXR misses up to 50% of rib fractures and pulmonary injuries that may be identified by CT.[9] In the elderly population, this may be due to interpretation difficulties associated aging chest wall deformities and inability to maintain upright position. Such missed injuries may have negative impact on morbidity and mortality rates. It is therefore important to define the optimal diagnostic work-up for elderly patients with hemodynamically stable blunt chest trauma.

In this study, we aimed to examine the impact of chest CT on the diagnosis of additional occult and missed thoracic injuries (CT-positive, CXR-negative) and the contribution of CT on change of management plans in elderly patients with stable blunt chest trauma. Based on the reported low diagnostic accuracy of CXR, we hypothesized that chest CT may play an important role in providing optimal management to this subgroup of trauma patients.

Methods

We performed a retrospective analysis on all adult blunt trauma patients admitted to Emek Medical Center, a regional level-II trauma center, between January 2014 and December 2018. Stable blunt chest trauma patients with abbreviated injury score (AIS) < 3 for extra-thoracic injuries that were evaluated with CXR and chest CT on admission to the emergency room or during hospitalization were included in the study.

The AIS is an international scale for grading the severity of anatomic injury following blunt trauma. Each separate injury is assigned to 1 of 6 fixed degrees in the AIS. The AIS classifies individual injuries by body region as follows: AIS 1-minor, AIS 2-serious, AIS 4-severe, AIS 5-critical, and AIS 6-maximal (currently untreatable). With regards to severity, patients with mild injuries have an AIS < 3, and those with severe trauma an AIS >3.

Unstable patients with systolic blood pressure (SBP) <90 mmHg, patients that died in the emergency department, and patients transferred to other facilities were excluded from the study. Similarly, patients with multiple injuries, and patients that had only one of the imaging studies were excluded from the study.

All patients were assessed for demographics, mechanism of injury, recurrent admissions, injury severity score (ISS), hospital length of stay, intensive care unit (ICU) length of stay, surgical interventions, and mortality.

Final radiographic diagnoses were recorded by CXR and chest CT including rib fractures, spinal fractures, sternum fractures, hemothorax, pneumothorax, pulmonary contusion, and vascular injuries.

Injuries identified on chest CT that were not diagnosed on CXR were defined as occult injuries. Injuries that were not identified during the assessment at admission and diagnosed in tertiary survey (>24h) were defined as missed injuries.

Change in management was defined as need for further diagnostic evaluation, surgical procedures, and hospitalization.

CXR and chest CT were performed on the basis of high suspicion for thoracic injury at the discretion of emergency room physician or attending physician after admission.

The study patients were divided into two groups according to the age range, patients aged 18-64 years were in the group 1; patients aged 65-99 years were in the group 2. Blunt chest trauma of patients between the ages of 18-64 years old (group 1) were compared with their counterparts aged $\geq$ 65 years old (group 2). Primary outcome variables were occult injuries, change in management, need for surgical procedures, missed injuries, readmission rate, and ICU and hospital length of stay.

Statistical analysis was performed using SAS statistical software Version 9.2 (SAS Institute Inc., Cary, NC). Statistical tests performed included Chi-square tests. All non-categorical data are shown as median (range) value. A p value less than 0.05 was considered statistically significant.

This study was approved by the Institutional Review Board.

Results

Among 7048 admitted blunt trauma patients during the study period, 1105 had blunt chest trauma and 473 met the inclusion criteria. Mean age of patients enrolled to the study was 54 years and ranged 18–99 years. There were 245 (51.8%) male patients and 228 (48.2%) female patients in this study. The median ISS was 8 (range 1-24) (Table 1).

There were 289 patients (61.1%) with the age range of 18-64 years, median 38 years included in group 1; and 184 (38.9%) with the age range of 65-99 years and median 72 years included in group 2. Of the 184 aged patients in group 2, 35 patients (19.0%) were older than 75 years.

The most common mechanisms of injury in both groups were fall from height and motor vehicle accidents. Patients did not different significantly between the two groups with respect to ISS (12 *vs.* 14; $p = 0.17$). Ten patients (3.5%) in group 1 and 12 patients (6.5%) in group 2 had AIS $\geq$ 3.

Elderly patients more often required ICU admission (11.4% *vs.* 5.2%), and had significantly longer ICU length of stay (11 *vs.* 6, $p = 0.04$) and hospital length of stay (14 *vs.* 6, $p = 0.01$) compared to young patients in group 1 (Table 1). Similarly, elderly patients had higher readmission rates than younger group of patients (6.5% *vs.* 1.4%, $p = 0.003$). There was no mortality reported in group 1. Death occurred in 4 of 184 (2.2%) in group 2.

Patients with normal CXR at admission

In group 1, all the 289 patients underwent CXR and chest CT and 203 (70.2%) of them had a normal CXR. Among them, 25 (12.3%) had abnormal chest CT. Occult injuries included rib fractures in 12 patients, flail chest in 2, scapular fractures in 4, sternum fractures in 4, and thoracic spine fractures in 2. Eight patients were diagnosed with pulmonary contusion, 6 with pneumothorax, and 4 with hemothorax. Occult injuries identified by chest CT required a change in management in 9 of 203 (4.4%) patients: serial CXR to follow occult pneumothorax and hemothorax in 8 patients, admitted to ICU in 2. There was no change in management that required surgical intervention observed in this subgroup.

In group 2, all the 184 elderly patients underwent CXR and chest CT, and 110 (59.8%) patients had normal CXR on admission. Among them, 33 (30.0%) had an abnormal chest CT, which was significantly higher than the rate observed in the group 1 (30.0% *vs.* 12.3%, $p = 0.04$). Occult injuries identified on chest CT included ribs fractures in 33 patients, fractures of sternum in 7, thoracic spine fractures in 6, fractures of scapular in 5. Seventeen patients were diagnosed with pulmonary contusion, 8 with pneumothorax, 7 with hemothorax, and 4 with mediastinal hematomas. Chest CT in these patients resulted in a change in management plan in 12 out of 110 (10.9%) patients: chest drain insertion in 6 patients for hemopneumothorax, serial CXR to follow occult pneumothorax and hemothorax in 11 patients, chest CT to rule out aortic and esophageal injuries in 4. Thus, the rate of change in management plan

Table 1
Demographics of the study patients.

Variables	Total	Group 1	Group 2	*p* value
Patients	473 (100.00)	289 (61.1)	184 (38.9)	
Age, median (range) (years)	54 (18-99)	38 (18-64)	72 (65-99)	
Gender				
Male	245 (51.8)			
Female	228 (48.2)			
Mechanism of injury				
Fall	239 (50.5)	127 (43.9)	112 (60.9)	0.04
Motor vehicle accident	185 (39.1)	121 (41.9)	64 (34.8)	0.3
Collision with a hard object	21 (4.4)	21 (7.3)	–	
Assault	20 (4.2)	20 (6.9)	–	
Other	8 (1.7)	–	8 (4.3)	
ISS	8 (1-24)			
1-8	292 (61.7)	196 (67.8)	96 (52.2)	0.09
9-14	145 (30.7)	70 (24.2)	75 (40.8)	< 0.05
16-24	36 (7.6)	23 (8.0)	13 (7.1)	0.7
Chest AIS				
1-2	445 (94.1)	279 (96.5)	176 (93.5)	0.17
≥3	26 (5.5)	10 (3.5)	12 (6.5)	0.01
Length of stay (days)				
Hospital	6 (2-29)	6 (2-21)	14 (4-29)	0.01
ICU	4 (2-18)	6 (2-14)	11 (2-26)	0.04
Mortality	4 (0.8)	–	4 (2.2)	

Data are presented as median (range) or *n* (%).
ISS: injury severity score; ICU: intensive care unit; AIS: abbreviated injury scale.

following CT was significantly higher in elderly patients compared to young patients (10.9% *vs.* 4.4%, $p = 0.04$). Three patients received CT scans for further evaluation of spine fractures. Seven patients were admitted to ICU.

Patients with abnormal CXR at admission

In group 1, 86 patients had an abnormal CXR and all of them also had an abnormal chest CT. Of those, 43 patients were diagnosed with additional rib fractures, 3 with flail chest, and 7 had thoracic spine fractures, 7 diagnosed with fractures of scapula, and 6 with fractures of sternum. And 12 patients were diagnosed with pulmonary contusion, 11 with occult pneumothorax, 6 with hemothorax, and 2 with mediastinal hematoma. The additional findings on chest CT resulted in changed management in 11 (12.8%) patients, including chest drain insertion in 6, CT spine in 5, echocardiography in 5, additional CT angiography in 4, and angiography in 1. Seven patients required ICU admission.

In group 2, 74 (40.2%) patients had abnormal initial CXR. All of them had abnormal chest CT as well. All patients had additional rib fractures; 4 had thoracic spine fractures, 4 diagnosed with fractures of scapula, 3 with fractures of sternum. In addition, 15 patients were diagnosed with pulmonary contusion, 8 with occult hemopneumothorax. These chest CT findings resulted in changed management in 19/74 (25.7%) patients, including chest drain insertion in 5, CT spine in 5, and serial CXR in 9. Thus, the change in management plan in elderly patients with initial abnormal CXR was higher than in the young age group (25.7% *vs.* 12.8%). Nine patients required ICU admission. No case of great vessels or diaphragm injury was reported in studied patients.

Overall, there were 313 (66.2%) patients had initial normal CXR, 203 of them in group1 and 110 in group2.) Among the 313 patients with initial normal CXR, 58 (18.5%) patients had occult or missed injuries identified by CT, 25 of them in group 1 (young patients) and 33 of them in group 2 (elderly patients) ($p = 0.04$). In 10.7% of all patients, management plans were changed due to occult or missed injuries identified by CT, which was significantly greater for elderly patients (20/289 (6.96%) *vs.* 31/184 (16.98%), $p = 0.002$). Changed management rate was also significant between the 2 groups of patients with a normal CXR compared to abnormal CXR (4.4% *vs.* 12.7% for group 1, $p = 0.01$; 10.9% *vs.* 25.7% for group 2, $p = 0.02$). These results were summarized in Table 2 and Figs. 1 and 2.

Discussion

Previous studies have shown that chest CT provide a higher sensitivity and specificity rates than that of CXR for the diagnosis of blunt thoracic trauma.[11–13] Specifically, the diagnostic accuracy of chest CT is significantly higher compare to CXR in the evaluation of rib, sternum fractures, pulmonary contusion, pneumothorax and hemothorax.[14,15] Similar to these studies, we observed significant disparities between CXR and CT. Limited diagnostic sensitivity of the conventional chest radiography and high accuracy of chest CT in visualizing chest injuries with a significant superiority in detecting chest wall injuries, pulmonary contusion, pneumothorax, and hemothorax, were the main reasons for these disparities. In our study CXR missed injuries that were detected by CT, most notably rib fractures (45 patients), pulmonary contusion (25 patients), sternal fractures (11 patients), and thoracic spine fractures (8 patients).

Patient who presented with normal CXR but abnormal CT typically had undiagnosed chest wall injuries, such as rib fractures, sternal fractures, and pulmonary contusion.

Nevertheless, despite its superiority, the routine use of chest CT in patients with stable thoracic trauma is a matter of debate. In some studies, the benefit and change in treatment following CT was minimal since it led to an increase in the diagnosis of mainly minor thoracic injuries.[11,14,16–18] For example, Plurad et al.[14] studied 2326 chest CT examinations performed in general trauma population with blunt chest trauma. Although the number of occult findings increased, the number of patients who needed treatment for these injuries was small. Similarly, Marts et al.[11] reported 170 stable patients with blunt thoracic trauma who were evaluated with CXR and subsequently by CT. The majority of the injuries identified by CT was minor and required no treatment.[11] However, this conclusion has been challenged by several other studies. Trupka et al.[19] prospectively investigated severely injured blunt trauma patients with average ISS of 30 and AIS of 3. The authors found that CT was

Table 2
Patients' distribution according to the CXR and chest CT findings resulted in change of management, *n* (%).

Variables	Group 1 ($n = 289$)	Group 2 ($n = 184$)	*p* value
Age (years)	18–64	≥ 65	
Normal initial CXR	203 (70.2)	110 (59.8)	<0.05
Abnormal CXR and CT	86 (29.7)	74 (40.2)	<0.05
Occult injuries with normal initial CXR	25 (12.3)	33 (30.0)	0.001
Change in management	20 (6.9)	31 (16.8)	0.002
Normal initial CXR	9 (4.4)	12 (10.9)	
Abnormal initial CXR	11 (12.7)	19 (25.7)	

CXR: chest X-ray.

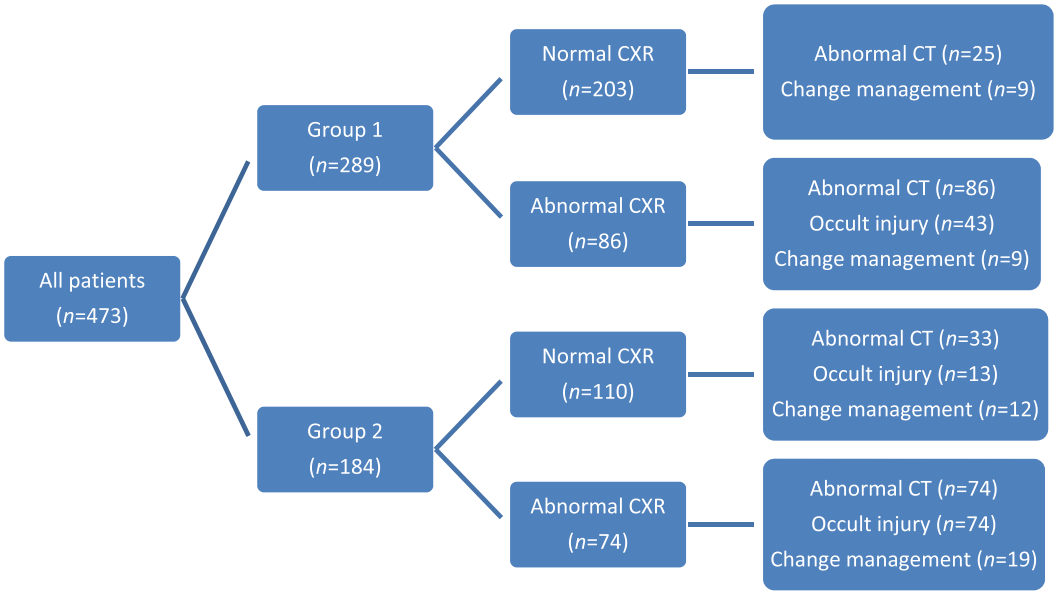

Fig. 1. Distribution of patients in according to results of CXR and chest CT, and changed management. CXR: chest X-ray.

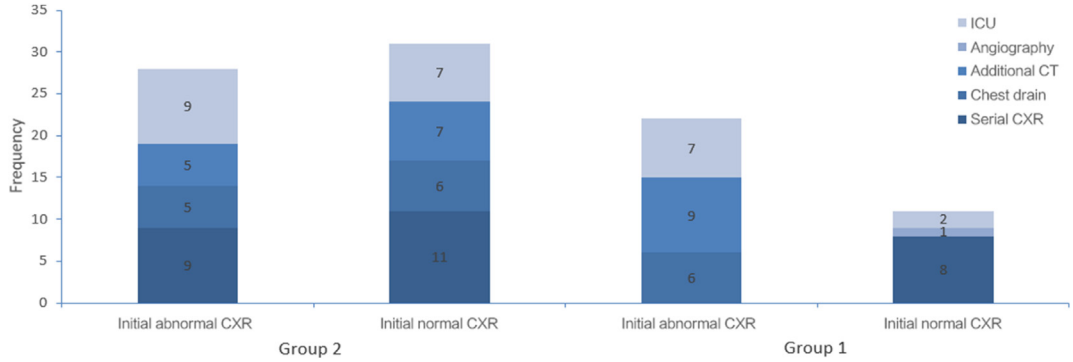

Fig. 2. Change in management in two groups of patients with a normal CXR compared abnormal CXR. CXR: chest X-ray, ICU: intensive care unit.

significantly more effective than routine CXR in detecting lung contusions, pneumothorax, and hemothorax. In 42 patients (41%) the additional CT findings resulted in a changed management.[19] Deunk et al.[12] reviewed CXR and chest CT of 106 blunt chest trauma patients and demonstrated a change of treatment in 34% (95% *CI*: 23%–44%) of the patients. Salim et al.[20] in a prospective observational study of 592 awake and evaluable trauma patients found 19.6% clinically significant abnormalities on chest CT, resulted in change of treatment in 19% of patients.

Therefore, some authors strongly recommend chest CT as a screening tool in patients with chest trauma due to the lower sensitivity of conventional CXR. Exadaktylos et al.[13] recommended primary routine chest CT in all patients with high energy blunt chest trauma, based on the results of their study: 50% of patients with normal initial CXR showed multiple injuries on the CT scan, among which 8% were also potentially fatal. Omert et al.[21] reported a prevalence of 39% of chest injuries in patients with normal physical examination and normal initial CXR (95% *CI*: 27%–51%).

Seeking to resolve these controversies and to reduce unnecessary blunt chest trauma imaging, the National Emergency X-Radiography Utilization Study (NEXUS) tool was developed from 8661 included patients who underwent both CXR and CT to evaluate blunt chest trauma and supported selective use of CT in general trauma population. According to this study, all patients > 65 years old get a point on the NEXUS tool designed to rule out significant intrathoracic injury and diagnosed patients who do not require any imaging. But if the physician decided that risk of having a significant chest injury is low, there is no mandatory imaging required. Chest CT may thus be omitted when CXR is normal and in the absence of any of the following: rapid deceleration mechanism, scapular, sternum, thoracic spine, and chest wall tenderness.[22,23] However, it should be taken into consideration that these guidelines may not be applicable to geriatric patients, since they were developed from the data predominantly composed of young patients with a mean age of 46 years.

We found only one recently published retrospective single-center study tried to shed light on the population of elderly patients with isolated blunt chest trauma. Three hundred and thirty patients aged over 65 years that had suffered a blunt chest trauma were included. All of the patients underwent both CXR and CT. The authors found a statistically significant increase in hospital admission for patients with occult rib fractures. There was no association between detection of occult rib fractures and management change. They reported that only patients with CXR evident rib fractures had a statistically significant increase in identification of hemothorax and pneumothorax requiring chest tube insertion.[24]

In the present study, 111/289 (38.4%) of all chest CT examinations were abnormal in young patients and 107/184 (58.2%) in elderly patients. We found that chest CT identified significant additional injuries that may have been missed by CXR alone and has led to change in management and treatment. These findings were significantly higher in elderly patients. We found that in nearly one third of elderly patients with a normal CXR (59.8% of all elderly patients), additional injuries were diagnosed and this has led to change of management in 10.9% of patients. This trend was also observed in young patients but was significantly smaller. Additional injuries were found in 12.3% of young patients with normal CXR and change of management was required in 4.4% of these patients. Additional occult injuries were also found when CXR was abnormal. This resulted in a change of management in 25.7% of elderly patients and in 12.7% of young patients. Taken together, these results support the notion that the chest CT plays an important role in the diagnosis of stable blunt trauma, especially in elderly patients. Moreover, the yield of identifying additional significant injuries by CT was high and led to change of management in a substantial proportion of patients, which lead us to believe that routine use of CT should be encouraged, especially in elderly patients.

This study does have some limitations that must be highlighted, beginning with the inherent limitations of a retrospective nature of data collection. Specifically, we were not able to determine the indications and significance of clinical presentation for obtaining a chest CT in the presence of negative CXR. Imaging was obtained at physician discretion. The retrospective design of the study did not allow determining whether more subtle change in clinical management occurred because of occult findings (e.g., fluid restriction, epidural catheter insertion, pulmonary physiotherapy). In addition, it is unknown how many occult injuries might have been discovered after repeat CXR. Furthermore, we did not investigate patients' outcomes due to management changed based on occult findings. This study did not address a possible difference in outcome and mortality between groups of patients. There were no differences found in age groups in terms of ISS but patients with abnormal initial CXR had a higher ISS than patients with normal CXR in both groups (6 *vs.* 12, $p < 0.001$). Future investigations to identify the utility of chest CT in geriatric trauma patients may benefit from a prospective study design with data including clinical findings, full extent of chest injuries, real time indications for obtaining CT scan, all spectrums of management change, and clinical outcome.

We are aware that routine chest CT does bring about risk to the patients: it requires radiation exposure and removes the patients from clinical observation and close monitoring. Routine chest CT algorithm is time-consuming, increases examination time and costs. Another point to consider is that the contrast used for chest CT is with risk of complications, such as renal failure, especially in elderly population with many co-morbidities.

Ultrasound may offer a useful alternative modality with higher sensitivity than CXR for detecting chest injuries. Currently, there is not enough data to recommend chest ultrasound as first preferred modality in the subset of blunt trauma patients.[25] The inherent drawbacks of ultrasound, such as operator dependency, lacking of reference standards, and learning curve, should be taken into consideration. Ultralow-dose chest CT may be another reasonable choice to standard CT for evaluating trauma patients. It was found more reliable than a CXR for minor blunt thoracic trauma assessment.[26]

As the elderly population expands and adopts increasingly more active lifestyles, the need for imaging evaluation guidelines is growing. Despite the incidence and significance of elderly blunt chest trauma, there is currently no guidelines regarding imaging modalities and the literature on this subject is scarce. In our study we sought to determine the utility of CT chest and its impact on change management in elderly (>65 years) patients. We have established that the routine use of chest CT in the subset of geriatric patients with isolated blunt chest trauma resulted the change of management required surgical intervention in significant number of patients. Although the identification of a single fractured rib or small pulmonary contusion may not affect the management of a young patient, these injuries can be significant in elderly patients. Therefore, we recommend chest CT as a first-line imaging modality in patients aged over 65 years with isolated blunt chest trauma.

Significant differences exist between old and young patients in injury patterns, and in the frequency and type of complications. These differences in turn demand prompt diagnostic approaches identifying all spectrums of injuries.

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Nil.

Ethical statement

This study was approved by the Institutional Review Board.

Declaration of competing interest

None.

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