



Blunt chest trauma – An audit of injuries diagnosed by the MDCT examination

Tupa trauma grudnog koša – pregled povreda dijagnostikovanih MDCT pregledom

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Abstract

Background/Aim. Multidetector computed tomography (MDCT) characterised by speed and precision is increasingly accessible in emergency wards. The aim of our study was to determine the most common injuries to the chest region, as well as type associated extrathoracic injuries, and the treatment outcome. **Methods.** This prospective study included 61 patients with blunt trauma who were submitted to computed tomography (CT) of the thorax. The number of injuries was evaluated by organs and organ systems of the chest. The cause of the injury, the length and the outcome of the treatment, and the presence of injuries in other regions were assessed. **Results.** Chest injuries were associated with injuries to other regions in 80.3% cases, predominantly injuries to extremities or pelvic bones in 54.1% cases, followed by head injuries in 39.3% patients. Associated thoracic injuries were present in 90.9% of patients with lethal outcome. Lung parenchymal lesions, pleural effusions and rib fractures were the most common injuries affecting 77.1%, 65.6% and 63.9% of the cases, respectively. **Conclusion.** Blunt chest trauma is a significant problem affecting predominantly males in their forties and it is usually caused by a motor vehicle accident. In case of pneumomediastinum or mediastinal haematoma, the use of 3D reconstructions is advised for diagnosing possible tracheobronchial ruptures and thoracic aorta injuries. Increased resolution of CT scanners yielded a large number of findings that are occult on radiography, especially in the event of lung parenchymal and pleural injuries. However, none imaging modality can replace surgical judgement.

Key words:

wounds, nonpenetrating; thorax; diagnosis; tomography, x-ray computed; multiple trauma; treatment outcome.

Apstrakt

Uvod/ Cilj. Multidetektorska kompjuterizovana tomografija (MDCT) koja se odlikuje brzinom i preciznošću sve više se koristi u odeljenjima urgentne medicine. Cilj istraživanja bio je da se utvrde najčešće povrede grudnog koša, udružene vantarakalne povrede, kao i da se ustanovi ishod lečenja. **Metode.** Ova prospektivna studija obuhvatila je 61 bolesnika sa tupom traumom. Svakom bolesniku urađen je CT grudnog koša, kao deo inicijalne dijagnostike. Procenjen je broj povreda po organima i organskim sistemima grudnog koša. Evidentiran je uzrok povrede, dužina i ishod lečenja, kao i prisustvo povreda u drugim regijama. **Rezultati.** Povreda grudnog koša bila je udružena sa drugim regijama kod 80,3% bolesnika i to najčešće sa povredama ekstremiteta ili kostiju karlice kod 54,1% bolesnika, potom sa povredama glave kod 39,3% bolesnika. Kod 90,9% bolesnika sa smrtnim ishodom postojale su pridružene povrede grudnog koša. Lezije plućnog parenhima, pleuralni izlivi i frakture rebara bile su najčešće povrede kod 77,1%, 65,6% i 63,9% bolesnika, respektivno. **Zaključak.** Tupa trauma grudnog koša je značajan problem prevashodno kod muškarca u četrdesetim godinama i obično je uzrokovana saobraćajnim nezgodama. U slučaju pneumomediastinuma ili medijastinalnog hematoma, savetuje se korišćenje 3D rekonstrukcija u postavljanju dijagnoze potencijalne traheobronhijalne povrede i povrede grudne aorte. Povećana rezolucija CT skenera dala je veliki broj nalaza koji su teško vidljivi na radiografiji, naročito u slučaju povrede plućnog parenhima i pleure. Trebalo bi imati na umu međutim, da nijedna tehnika snimanja ne može da bude jedini faktor pri odlučivanju o hirurškom lečenju.

Ključne reči:

povrede, zatvorene; toraks; dijagnoza; tomografija, kompjuterizovana, redgenska; povrede, multiple; lečenje, ishod.

Introduction

The clinical presentation of thoracic trauma ranges from a minimum of pain to a state of shock, and about a third of thoracic injuries require hospital treatment¹. Two thirds of patients with multiple blunt injuries have a chest injury, whereas severe chest injuries are associated with other injuries in 70–90% of patients². What matters is whether a patient is in immediate danger and if radiological examinations can be made safely³. After initial clinical evaluation and stabilisation of traumatised patients, radiological methods play an important role in evaluation of injuries⁴. The initial diagnostic approach to chest trauma is typically based on chest X-ray at admission. With respect to its limits, chest X-ray can be a valuable diagnostic tool providing a wide range of information. However, it is well-known that information provided by standard chest X-ray could be insufficient in diagnosing both vascular and non-vascular thoracic injuries^{3, 5–8}. Computed tomography (CT) was primarily used for thoracic aortic injuries, but numerous studies found that CT is more sensitive to other thoracic injuries^{2, 4, 9–11}. Due to the lack of time and in order to avoid unnecessary radiation, chest CT is often performed in injured patients when CT examination of the abdomen or head has already been indicated, because of the frequent association between thoracic and extrathoracic injuries^{4, 12}. Multidetector computed tomography (MDCT), a new valuable tool in modern medicine that is characterised by speed and precision, is increasingly accessible in emergency wards. However, regardless the growing application of MDCT examinations in emergency departments, it should be borne in mind that MDCT examination should not delay necessary surgery¹³.

The aim of this study was to determine the most common type of injuries to the chest region, associated extrathoracic injuries, and the treatment outcome.

Methods

This prospective study included 61 patients (mean age 43.9 years) with blunt trauma who were treated in our clinical center and who were submitted to CT scan of the thorax as part of their initial assessment. It should be emphasised

terms of the chest. The description thereof was carried out by entering each patient's data separately into the protocol of the study. These data included the following injuries: rib fracture, vertebral fracture, sternal fracture, scapular fracture, clavicular fracture, subcutaneous emphysema, chest wall haematoma, pneumothorax, pleural effusion, lung injury, pneumomediastinum, mediastinal haematoma, tracheobronchial rupture, oesophageal injury, aortic injury, pneumopericardium, pericardial effusion, and diaphragmatic rupture.

After transferring or discharging a patient, we assessed the cause and the time of injury, the length and the treatment outcome, and the presence of injuries in other regions.

The description of numeric variables was performed using classical methods of descriptive statistics (arithmetic mean) and measures of variability (standard deviation, minimum and maximum values). Relative values were used in tables. Nonparametric analysis of variance (F) for the comparison of three or more groups of data was also used. The value of $p < 0.05$ was considered significant.

All CT studies were performed using Siemens 16 and 64-section MDCT (120 kV, 220 mAs/slice, 5 mm section thickness, pitch of 1.4). Approximately 1.2 m of iodinated contrast agent (Ultravist 370 or Omnipaque 350) *per* kilogram of body mass was injected intravenously using a mechanical power injector at 2 mL/s. The volumetric MDCT data were reconstructed into axial and MPR 1-mm-thick sections.

Results

The average age of the patients included in this study was 43.9 years (min 14.0, max 82.0, SD 17.7 years). The number of male patients was 46 (75.4%), whereas the number of female patients was 15 (24.6%).

The length of treatment, meaning the length of hospitalisation at the Institute for Surgery, Clinical Center of Vojvodina, ranged from 1 to 64 days, with the average of 13.8 days and standard deviation of 14.9. The most common cause of injury was traffic accident (39; 63.9%). The differences in the number of patients in relation to the type of injury were statistically highly significant ($F = 8.014$, $df = 3$, $p < 0.01$), because traffic accidents greatly exceed other causes of injury (Table 1).

Table 1
Causes of blunt chest injuries

Mechanism of injury	Patients	
	n	%
Traffic accident	39	63.9
Fall from height	12	19.7
Severe blow with a heavy blunt object	6	9.8
No reliable data	4	6.6
Total	61	100.0

that the patients got their CT examination report within clinically reasonable time, independently on our study.

These CT examinations were recorded and saved, to let us evaluate the number of injuries by organs or organ sys-

Upon observing the association of thoracic injuries to other body regions, it can be seen that chest injury was associated with injuries of other regions in 49 (80.3%) patients (Figure 1). Thoracic injuries were associated with injuries to

extremities or pelvic bones in 33 (54.1%) cases, head injuries in 24 (39.3%) patients, abdominal and/or pelvis injuries in 16 (26.2%) patients and spine injuries in 15 (24.6%) patients.

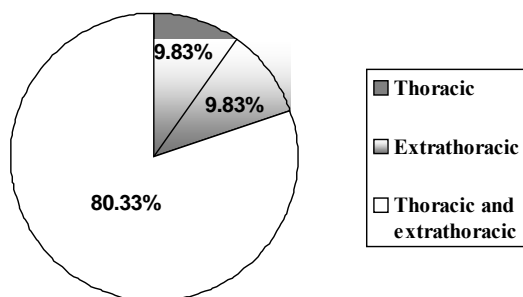


Fig. 1 – Association of thoracic injuries with injuries to other regions of the body.

The analysis of the treatment outcome of the patients showed that the patients were usually (20; 32.8%) discharged to home treatment (Table 2). Lethal outcome was recorded in

According to the protocol of the study, Table 3 presents the number of patients with injuries in various regions of the chest. Lung parenchymal lesions, pleural effusions and rib fractures were the most common injuries affecting 77.1%, 65.6% and 63.9% of the cases, respectively.

Subcutaneous emphysema was detected in 21 (34.4%) patients. By comparing the association between subcutaneous emphysema and rib fractures we observed that following patients had a rib fracture: 7 (87.5%) out of 8 patients with subcutaneous emphysema on the right; 7 (77.8%) out of 9 patients with subcutaneous emphysema on the left; and 3 (75%) of the 4 patients who had bilateral subcutaneous emphysema. We also found that 11 (47.8%) out of a total of 23 patients with right-sided rib fractures had subcutaneous emphysema, whereas 19 (59.4%) out of the 32 patients with left-sided rib fractures had subcutaneous emphysema.

Mediastinal haemathoma was diagnosed in 14 (22.9%) of the patients, while none of them had an aortic rupture as a source of bleeding (Figure 2).

Table 2

The outcome of treatment		
Outcome	Patients	
	n	%
Discharged	20	32.8
Transferred to the home institution	12	19.7
Transferred to the Institute for Pulmonary Diseases	18	29.5
Lethal outcome	11	18.0
Total	61	100.0

Table 3

Frequency of injuries to the chest structures		
Type of injury	Patients	
	n	%
Lung injury	47	77.1
Pleural effusion	40	65.6
Rib fracture	39	63.9
Pneumothorax	31	50.8
Subcutaneous emphysema	21	34.4
Vertebral fracture	17	27.9
Chest wall haematoma	14	23
Mediastinal haematoma	14	22.9
Scapular fracture	11	18
Sternal fracture	10	16.4
Pneumomediastinum	10	16.4
Clavicular fracture	7	11.5
Tracheobronchial rupture	1	1.6
Pneumopericardium	1	1.6
Pericardial effusion	1	1.6
Oesophageal injury*	1	1.6
Aortic injury	0	0
Diaphragmatic rupture	0	0

*No clinical feedback confirmed the diagnosis of oesophageal injury.

the smallest number of the cases (11 patients, 18%). Comparing the fatal outcome with the type of injury, we found that associated thoracic injuries were present in 10 (90.9%) out of 11 exited patients, whereas an isolated spine injury existed in only one patient. Independent isolated thoracic injuries did not lead to death.

Discussion

Our study indicates that chest trauma is an important issue affecting younger population, aged 43.9 on average. Li-man et al.¹⁴ reported similar mean age (45 years), whereas Shorr et al.¹⁵ and Wagner et al.¹⁶ presented even lower val-



Fig. 2 – Contrast enhanced axial computed tomography (CT) slice shows a mediastinal haematoma, pneumomediastinum, pleural effusion, rib fracture with dislocation and chest wall haematoma on the left. Multiplanar reformations excluded the possibility of thoracic aortic injury as a source of mediastinal bleeding.

ues with the mean age of 32.2 and 36.7 years, respectively. The fact that males were injured three times more than females is in accordance with previous publications that reported the participation of male patients in more than 70% of cases^{2, 14, 15}.

The length of treatment was 1–64 days (13.8 days on average). From the Institute for Surgery, Clinical Center of Vojvodina, the patients were transferred to the home institution, the Institute for Pulmonary Diseases, rehabilitation centres, or were discharged to home treatment.

Traffic accidents were the most common cause of trauma and they accounted for 63.9% of the cases. For this reason, they are considered the primary and most common cause of blunt chest trauma^{2, 12, 15}. The second most common cause of injury in our study was fall from height, which occurred in 19.7% of the patients, and this is also consistent with the aforesaid publications^{2, 12, 15}.

Observing the association of thoracic injuries to other body regions in our group of patients, it can be seen that the chest injury was associated with injuries to other body regions in 49 (80.3%) patients. Traub et al.² and Trupka et al.¹⁷ also found a very frequent association of the chest injuries with extrathoracic injuries, namely in 70–90% and 91.3% of the cases. Sampson et al.⁶ and Shorr et al.¹⁵ reported that thoracic injuries were most commonly associated with head injuries. In our report, thoracic injuries were associated with head injuries in 39.3% of the cases, which were the second most frequent associated injury after limb injuries, which, though often not diagnosed by CT, were the most frequent associated injury (54.1%).

The patients' condition as equal as imaging findings played important part in the management, which was implemented according to the modern recommendations¹⁸. For example: the cases with pulmonary contusions were treated supportively, with early detection and treatment of complications; the finding of a pleural effusion or pneumothorax was most often followed by tube thoracostomy drainage of the respective pleural space; most of the rib fractures were

treated conservatively, except in the cases of flail-chest when surgical intervention was indicated.

Our finding of 18% of fatal outcomes is similar to that reached by Wicky et al.¹², that reported the mortality rate of 15.5%. Regarding the outcome of the treatment of polytraumatised patients with or without a chest injury, it can be concluded that an associated chest injury existed in 10 (90.9%) out of 11 deceased patients, while the isolated spinal injury was diagnosed in only one case. This observation is supported by the fact that a polytraumatised patient with an associated chest injury is severely injured by classification. Such a patient requires a longer hospital stay and suffers lethal outcome in a greater number of cases than patients with serious injuries without an associated thoracic injury¹⁹. Additionally, independent isolated thoracic injuries did not lead to death.

Primack and Collins⁴ found the occurrence of rib fractures in over 50% of the patients, as was the case in our study (64%). Previous studies^{4, 5, 12, 20} presented data in sternal fracture occurring in 7–10% of patients, whereas in our study this percentage was higher (16.4%) and referred to the number of fractures identified by MDCT examination. Fractures of the scapula were also slightly higher than in previous studies^{4, 5, 12, 20}, although Traub et al.² had found a similar percentage of clavicular fractures, namely in 9.2% of patients.

It can be observed that at least 75% of patients with subcutaneous emphysema, seen as stripes and lines of air in the chest wall, have at least one fractured rib. This percentage is significantly higher compared to the data presented by Liman et al.¹⁴, according to which 18.4% of the patients with fractures of the ribs had an associated subcutaneous emphysema. The difference in the results is probably due to the fact that a number of our patients already had a tube thoracostomy because of pneumothorax, as well as because the results reported by Liman et al.¹⁴ did not apply to the MDCT examination but to the standard axial CT examination.

Pulmonary contusions appear as geographic, non-segmental areas of ground glass or nodular opacities on CT that do not respect lobar boundaries¹⁰. On the one hand, while pulmonary contusions have been estimated to affect 30–70% of the injured patients^{4, 20, 21}, our study reported the slightly higher rate of 77.1%. On the other hand, Sampson et al.⁶ and Traub et al.² stated that lung contusions comprised 40% of cases, which is significantly less than in our study. Fluid collections in dependent part of a pleural space were attributed to pleural effusions¹⁰. The frequency of pleural effusion in our study was higher compared to the studies of other authors^{2,6}, whereas our previous report²² detected the presence of pleural effusion in 73% of the 36 patients who suffered a blunt trauma. Pneumothorax was detected as an accumulation of air in the pleural space²³. The fact that more than a half of the patients had been diagnosed with pneumothorax and that even a small one could enlarge under positive mechanical ventilation emphasises the importance of early diagnosis, for which CT had high sensitivity²³. The increasing use of CT scanners has led to defining the term ‘occult injuries’ of pulmonary parenchyma and pleural space, which are radiographically hard or impossible to detect. Consequently, adequate treatment of these injuries has been and still remains controversial²⁴. Certainly, more research is necessary to understand the clinical significance of these findings.

The rate of mediastinal haematoma in our study (14 patients, 22.9%) is slightly higher than in previous studies, which reported the frequency of 7% and 17.7%, respectively^{2, 6}. The presence of this haematoma, which is reflected through increase in density of mediastinal fat, should always give rise to a suspicion of thoracic aorta injury²⁴. However, even though thoracic aorta injury was assumed in two patients due to clinical findings and chest x-ray (Figure 2), detailed MDCT examination using 3D reconstructions excluded this possibility. Therefore, mediastinal haemorrhage in our patients could be attributed to lesions of the small veins and fractures of the bone structures, whose prevalence is estimated at 87.5% in the literature¹².

Pneumomediastinum was observed on CT as streaks of air surrounding and paralleling the bronchovascular bundles²⁴. It was registered in 16.4% of the cases, which is higher than what was stated by other authors^{4, 25}. Neither tracheal rupture nor oesophageal perforation was diagnosed in the 9 out of 10 (90%) patients with traumatic pneumomediastinum. This could be explained by the Macklin effect, according to which an alveolar rupture is followed by centripetal air dissection through the pulmonary interstitium into the mediastinum²⁶. Tracheobronchial rupture is rare and occurs in 0.4–1.5% of cases^{5, 12}, like in our study, where it was registered in only one

(1.6%) patient. Even on the axial CT slices, we assumed that the tracheobronchial rupture existed due to pronounced subcutaneous emphysema, pneumomediastinum and pneumothorax. Nonetheless, the site of injury could only be located using MDCT 3D reconstruction. The site of the rupture was unusually high in the trachea, unlike frequently described locations, namely 2.5 cm from the carina for bronchial injuries and 2 cm above the carina for tracheal injuries²³.

The diagnosis of oesophageal injury was made in one (1.6%) patient, due to the typical appearance of the mediastinum around the oesophagus that included indirect signs such as the presence of cervical and mediastinal emphysema, pleural effusion, pneumothorax, change of mediastinal contour due to a leak of fluid and/or mediastinal haemorrhage²³. Unfortunately, the lack of clinical feedback precluded a complete evaluation of the patient. In making a diagnosis of oesophageal injury, usually perforation, CT could be a diagnostic modality in patients who are too ill to cooperate in oesophagography or a supplement in contrast-enhanced luminal studies, so as to further delineate the extent of the disease and assess the complications²⁷.

Diaphragmatic injury was not observed in our study, probably confirming the fact that this kind of injury is more associated with abdominal rather than thoracic injuries¹². Although some 19 CT signs of diaphragmatic injury were detected, no single CT sign could be considered a marker leading to the correct diagnosis of a blunt diaphragmatic rupture. Instead, accurate diagnosing requires analysis of all the signs present²⁸.

Conclusion

Blunt chest trauma is a significant problem affecting predominantly males in their forties and it is usually caused by motor vehicle accidents. In more than 80% of cases it is associated with extrathoracic injuries, predominantly injuries to extremities or pelvic bones, followed by head injuries.

The widespread use of MDCT facilitates the diagnosis of clinically relevant injuries. The existence of subcutaneous emphysema should always spark suspicion that rib fracture exists. In any case of pneumomediastinum, especially in the abundant ones, we advise the use of 3D reconstructions in search of potential tracheobronchial and oesophageal injuries. The integrity of the thoracic aorta must be evaluated in all the planes so as to exclude its contribution to mediastinal haemorrhage.

Increased resolution of CT scanners yielded a large number of findings that are occult on radiography, especially in the event of lung parenchymal and pleural injuries. However, no imaging modality can replace surgical judgement.

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