Blunt trauma of bone structures of the chest – computed tomography vs multidetector computed tomography

Tupa trauma koštanih struktura grudnog koša – kompjuterizovana tomografija vs multidetektorska kompjuterizovana tomografija


*Center of Radiology, Clinical Centre of Vojvodina, Novi Sad, Serbia; †Department of Radiology, St. Elisabeth Hospital, Bad Kissingen, Germany

Abstract

Background/Aim. Computerized tomography (CT), especially multidetector CT (MDCT), has had a revolutionary impact in diagnostic in traumatized patients. The aim of the study was to identify and compare the frequency of injuries to bone structures of the thorax displayed with 5-mm-thick axial CT slices and thin-slice (MDCT) examination with the use of 3D reconstructions, primarily multiplanar reformations (MPR). Methods. This prospective study included 61 patients with blunt trauma submitted to CT scan of the thorax as initial assessment. The two experienced radiologists independently and separately described the findings for 5-mm-thick axial CT slices and thin-slice (MDCT) examination with the use of 3D reconstructions. Results. No statistically significant difference in interobserver evaluation of 5-mm CT examination was recorded (p > 0.05). Evaluation of fractures of sternum with 5 mm CT and MDCT showed a statistically significant difference (p < 0.05) in favor of better display of injury by MDCT examination. Conclusion. MDCT is a powerful diagnostic tool that can describe higher number of bone fractures of the chest in traumatized patients compared to 5 mm CT, especially in the region of sternum for which a statistical significance was obtained using MPR. Moreover, the importance of MDCT is also set by easier and more accurate determination of the level of bone injury.

Key words: thoracic injuries; wounds, nonpenetrating; diagnosis; tomography, x-ray computed; imaging, threedimensional; diagnostic techniques and procedures.

Apstrakt

Uvod/Cilj. Kompjuterizovana tomografija (CT), naročito multidetektorska (MDCT), ima revolucionarni uticaj na dijagnostiku kod traumatizovanih bolesnikov. Cilj istraživanja bio je da se utvrdi in uporedi učestalost povreda koštanih struktura grudnog koša prikazanih aksijalnim CT snimcima debljine 5 mm in tankoslojnimi MDCT pregledom uz upotrebo 3D rekonstrukcija, prvenstveno multiplanarnih reformacija (MPR). Metode. Ova prospektivna studija obuhvatila je 61 bolesnika sa tupom traumom kojima je urađena CT grudnog koša kao deo inicijalne dijagnostike. Dva iskusna radiologa opisali su posebno (nezavisno) aksijalne CT preseke debljine 5 mm (5-mm CT) kao što se to čini na monoslajnem skeneru; MPR in druge 3D rekonstrukcije zajedno sa tankoslojnimi aksijalnim presecima koje omogoča MDCT tehnologijo. Nakon opisa tankoslojnog pregleda, u slučaju nesuglasica u ovom nalazu ponovo je zajедnički opisivan tankoslojni pregled koji je na kraju smatran istinitim nalažom. Rezultati. Razlika pregleda preloma kostiju grudnog koša (5 mm CT) izmedu istraživača nije bila statistički značajna (p > 0,05). Poredenje rezultata pregleda sternuma (5 mm CT in MDCT) pokazuje postojanje statistički značajne razlike (p < 0,05) v korist boljeg prikaza povrede od strane MDCT pregleda. Zaključak. Multidetektorski CT je močno dijagnostičko sredstvo kojim se može prikazati večji broj preloma kostiju grudnog koša kod bolesnika sa tupom tramom v odnosu na 5 mm CT, naročito v področju sternuma v kateri je uočena statistično značajna razlika v korist MPR. Sem toga, važnost MDCT ogleda se v lahek in preciznem prikazu povrede kosti.

Ključne reči: toraks, povrede; povrede, zatvorene; dijagnostika, kompjuterizovana, offendenska; snimanje, trodimenzionalno; dijagnostičke tehnike in procedure.
Introduction

Trauma affects young people, and has a high rate of morbidity and mortality and major socioeconomic consequences. Studies on the incidence of thoracic trauma indicate that injuries occur in 12 out of a million people every day. Knowledge of the mechanism and time of injury, condition of the motor vehicle and speed during collision, and the presence of associated injuries are essential for better understanding and access to chest trauma.

Initial radiological diagnostic approach to chest trauma is classically based on the assessment of chest radiography in the moment of hospital admission. Therefore, it is necessary to be familiar with the possibilities and limitations of this method in displaying thoracic injuries. Nowadays it is known that the information provided by conventional chest radiography sometimes can be insufficient for diagnosing thoracic injuries. Since the advent in clinical practice in the 1970s, computerized tomography (CT) has had a revolutionary impact on diagnostic in patients under emergency setting. Speed, precision, and the increasing availability make multidetector computerized tomography (MDCT) a valuable new tool in modern medicine. Present-day scanners have high-quality multiplanar reformatted (MPR) images with spatial resolution the same as that of images in the axial plane.

Although trauma is one of the most important topics in radiology, there is insufficient number of published papers on the contribution of MDCT technology to diagnosing blunt trauma of the chest. The fact that CT examination is more sensitive in displaying traumatic lesions of the chest in relation to the conventional radiography is generally known, however there are some questions about the contribution of multiplanar and other 3D reconstructions in traumatized patients compared to standard axial CT sections.

The aim of the study was to identify and compare the frequency of injuries of bone structures of the thorax displayed with 5-mm-thick axial CT slices and thin-slice MDCT examination using 3D reconstructions, primarily multiplanar reformations (MPR).

Methods

The study was a prospective review of 61 patients (mean age 43.9 years) with blunt trauma who were treated in our clinical center and submitted CT scan of the thorax in the initial assessment. It should be pointed out that the patients got their CT examination report within clinically reasonable time, independently on our study.

These CT examinations were saved in the computer and afterwards two experienced radiologists independently and unblinded to referring diagnosis, but with no insight into physical examination and laboratory results, described the findings. The same examination was interpreted using two ways: firstly, as in monoslice CT – 5-mm-thick axial CT slices (5 mm CT); and secondly, using MDCT technology performed at the workstation – 1-mm-thick axial sections, coronal and sagittal MPR and other 3D reconstructions (MDCT).

In describing, the data of each patient were entered separately in the protocol of the study regarding fractures of the ribs, vertebra, sternum, scapula and clavicle.

All the data were entered separately by the two examiners. After describing thin-slice examination, in case of disagreement in the findings the examiners redescribed thin-slice examination (MDCT) together that was ultimately considered as the “gold standard” since its findings made a definitive determination of the presence or the absence of bone fractures. The results of 5 mm CT were mutually compared.

Description of numeric variables was performed using classical methods of descriptive statistics (arithmetic mean, mode) and measures of variability (standard deviation, minimum and maximum values). Relative values were to show read values. The Pearson’s chi-square (χ²) and McNemar’s test (χ²MCN) were used for comparison of a frequency difference in non-parametric data. 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 mL 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 was 43.9 years (min 14.0, max 82.0, SD 17.7 years). The number of male patients was 45, and of female patients 16, the ratio 3.46 : 1, which was statistically significant (χ², p < 0.01).

Regarding interobserver evaluation of traumatized patients using 5 mm CT (Table 1), no statistically significant differences in interpreting injuries of the ribs, sternum, scapula, clavicle, vertebral bodies and posterior processes were recorded (χ²MCN, p > 0.05). The same structures of the chest were further analyzed using MDCT (Table 1).

The number of fractures of the ribs on both sides evaluated by MDCT was higher than the number of fractures evaluated by 5 mm CT, but not statistically significant (for both sides: χ²MCN, p > 0.05). On the right side, 23 patients suffered rib injury with the average number of almost 5 fractured ribs (S = 4.7), whereas in 32 patients with rib injury on the opposite side the average number of fractured ribs was slightly above 4 (S = 4.2). The fifth rib was the most often fractured rib on both sides (mode = 5).

Considering the number of fractures of the scapula (n = 11; 18%), there was no statistically significant difference between those evaluated by 5 mm CT and MDCT (χ²MCN, p > 0.05).

Evaluation of sternum fractures (n = 10; 16.4%) with 5 mm CT and MDCT, showed a statistically significant difference (χ²MCN, p < 0.05) in favor of better display of injury by MDCT examination (Figure 1).
No statistically significant difference in displaying fractures of clavicle \((n = 7; 11.5\%)\) using 5 mm CT and MDCT was recorded \((\chi^2_{MCN}, p > 0.05)\).

Comparison of the results of examination of vertebral bodies showed no statistically significant difference regarding the results of mutual comparison of 5 mm CT and MDCT \((\chi^2_{MCN}, p > 0.05)\). However, MDCT examination showed a higher number of fractures and more accurately presented injuries of vertebral bodies compared to the standard 5 mm axial CT examination. Considering fractures of posterior vertebral processes, similar results were obtained \((\chi^2_{MCN}, p > 0.05)\).

**Discussion**

Rib fractures are the most common injuries in blunt chest trauma, as was the case in our study, with 64% of patients with rib fracture on one or both sides of the body. By themselves, rib fractures are not life-threatening unless a flail chest occurs. The main advantage of using CT in evaluation of potential rib fractures is its capability of showing costal chondral fractures which could not be attributed to chest radiography. In addition, chest radiography may miss 50% of rib fractures \(^6\). Analyzing our results, the value of MDCT compared to 5 mm CT could be seen in depicting greater number of rib fractures, though not statistically significant, and in better displaying of the level of injury. The contribution of volume rendering technique (VRT), as a part of MDCT examination, in diagnosing rib fractures is in time-efficiency which is a crucial factor in an emergency setting \(^7\). It was estimated that the mortality incidence and probability of respiratory failure was greater in those patients who had higher number of rib fractures. Moreover, the incidence of respiratory failure was doubled in patients with rib fracture in more than one anatomic region \(^8\). Holcomb et al. \(^9\) concluded that patients above 45 and with more than 4 fractured ribs were at risk of prolonged intensive care unit stays and overall hospital days. Since the patients in our study had fractures of 5 ribs on the right side on average, it could be estimated that they were at risk of developing respiratory failure regarding their age. The fact that the 4th to 10th ribs are the most frequent fractured is in concordance with our results \(^6\). It should not be forgotten that each rib fracture may be associated with pneumothorax, hemothorax or extrapleural hematoma \(^10,11\).
Sternum fracture is usually overlooked on conventional chest radiography unlike CT examination 11. In our study the percentage of patients with sternum fractures (16.4%) was higher than in previously published results (7%–10%) that relied mostly on evaluation of axial CT scans 2, 10–12. Empirically, we noticed that MPR is more accurate than VRT in diagnosing sternal fractures (Figure 1), though it was not the aim of our study. Traditionally, patients with an isolated sternal fracture are admitted to the hospital for observation in order not to miss other injuries (heart, great vessels, spinal cord) 11. However, since there are no evidence-based data that would support this clinical approach, it is recommended that patients with no hemodynamic instability, dysrhythmia or previous history of ischaemic heart disease can be safely discharged home provided pain control is adequate 14.

The association of scapula fractures with rib fractures was recorded in 81.8% of the patients on the right and in 100% of the patients on the left side. Scapula fracture suggests that the high energy influenced on the chest, therefore injury of deeply placed structures or organs must be suspected 15. MDCT is particularly useful in the diagnosis of fracture of coracoid process, scapular spine and glenoid cavity 16. Scapulo-thoracic dislocations must be identified on a conventional radiography or CT examination, due to its 100% association with brachial plexus injury. The advantage of CT in this condition is clear depiction of subscapular hematoma which is responsible for lateral displacement of the scapula 17.

Fractures of the thoracic spine make 16%–30% of all spinal fractures 17. Unfortunately, despite the severity of injury, fractures of the thoracic spine often remain unrecognized during the initial critical period for patient evaluation and treatment 10, 18. There are technical difficulties in performing conventional radiography, often requiring additional examinations which demand time, radiological units, higher radiation exposure and manipulation of the patient 18. Historically, monoslice CT was considered as additional diagnostic modality in order to assess the extent and stability of spinal fractures diagnosed at conventional radiography due to its inability to display the entire spine and, to make a reconstruction, which is already sufficient advantage of MDCT 19. Roos et al. 20 concluded that injuries of thoracolumbar spine can be fully assessed using standard MDCT protocol for trauma of the thorax and abdomen with targeted reconstructions. Based on clinical experience, in our study MDCT was expected to show statistically significant higher number of fractures of spine compared to 5 mm CT examination, however, MDCT accurately and easily determined the level of the fracture. We assume that this might be the result of a relatively small number of patients with fractures of the spine.

Although the benefit of using CT in trauma patients from the aspect of treatment and outcome is indisputable, high doses of detrimental ionizing radiation and high costs associated with its use are growing concern. As of now, there has not yet been established a protocol for referring trauma patients to CT examination in our emergency ward. Most of the injured patients, especially during a motor vehicle collision, underwent a so-called “pan-CT” examination including scanning from the head to the pelvis. Justification of this procedure certainly is debatable, however, reviewing the literature Brink et al. 21 concluded that no predictor can possibly exclude all pertinent traumatic injuries that can be depicted by CT. On the other hand, the same group of authors in their next prospective study concluded that if CT is performed only in patients who suffered high-energy blunt trauma with any of strong independent predictors [age ≥ 55 years; abnormal chest physical examination (PE); altered sensorium; abnormal thoracic spine PE; abnormal chest and thoracic spine conventional radiography (CR); abnormal abdominal ultrasonography or pelvic CR; hemoglobin < 6 g/dL and arterial blood gas base excess < -3 mmol/L], the sensitivity for the presence of chest injuries on CT is 95%. Therefore, the number of CT examinations can be considerably reduced with low risk of missing relevant injuries 22.

The weakness of the study were: the unblinded observers to referring diagnosis, though they were uninformed about the results of PE and laboratory findings; no clear difference was distinguished between MPR and other 3D reconstructions such as VRT and surface shaded display. Consensually, the findings of MDCT were ultimately regarded as a real true finding.

Conclusion

MDCT is a powerful diagnostic tool that can depict higher number of bone fractures of the chest in traumatized patients compared to 5 mm CT, especially in the region of the sternum where a statistical significance using MPR was obtained. Moreover, the importance of MDCT is in easier and more accurate characterization of the level of bone injury.

REFERENCES

7. Alkaabbi H, Wildermuth S, Marinsek B, Boelm T. Accuracy and time efficiency for the detection of thoracic cage fractures:


Received on January 7, 2012.
Revised on April 12, 2012.
Accepted on April 17, 2012.