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Original Article

The Role of Multidetector Computed Tomography in Diagnosis And Therapy of Patients With Chest Trauma

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Abstract

Introduction: *Chest traumas are a significant cause of mortality and morbidity. They commonly occur in the younger population and are the most common cause of death in people between 25 and 40 years of age. This article summarizes the place of MDCT in the diagnosis, examination technique and findings in injuries of the chest trauma patients.*

Methods: *Multidetector computed tomography (MDCT) is considered to be the most effective imaging method in this field. Its advantages include especially high speed and high geometric resolution at any plane. The method allows us to view large parts of the body with minimal motion artifacts and to create accurate multiplanar and three-dimensional (3D) reformations.*

Results: *MDCT allows us to view diagnosis significantly more accurate. One hundred and twelve patients are examined at the Emergency department. The injuries of the chest and intrathoracic organs are found. In 56 (50%) of all 112 patients included in our study, fractures of the ribs are the most common traumas. Also fracture of the scapula, sternum, extra pleural hematomas, pneumothorax, hemothorax, pulmonary contusions, laceration of trachea and bronchi, rupture of esophagus, diaphragmatic rupture and injuries of blood vessels are established.*

Conclusion: *Because of its advantages MDCT has become the first-choice method in chest trauma patients.*

Introduction

In recent years, major chest injuries have been observed, which represent a significant socioeconomic problem. They commonly occur in the younger population and are the most common cause of death in people between 25 and 40 years of age. Chest injuries occur in about 20% of all trauma patients. In up to 80% of cases, they are associated with injuries to other body parts such as the head (69%), abdomen and pelvis (43%), and extremities (52%) [1, 2]. Diagnostic imaging plays a key role in deciding the therapeutic procedure [3]. Multidetector computed tomography (MDCT) is considered to be the most effective imaging method in this field and, therefore, should be a part of the emergency department [4]. We are trying to evaluate the place of MDCT in the diagnostic algorithm in major trauma patients.

Methods

Clinical symptoms of chest trauma are diverse and often do not correlate with their severity. This is the reason why diagnostic imaging is among the first procedures performed after admission to an emergency department. The simplest and fastest methods include chest radiography and ultrasound. They can provide important information about the presence of serious injuries requiring emergency intervention, such as tension pneumothorax, large hemothorax, hemoperitoneum, and injuries of the abdominal organs. However, these methods are very unreliable in detecting injuries to the heart and great vessels [5–8]. Compared to these methods, MDCT enables sufficiently accurate assessment of all compartments of the chest and also reveals changes that are not detectable by other methods (Figure 1).

Excellent spatial and temporal resolution is the main benefit. Because of the isotropic data field, it allows performing two-dimensional (2D) and three-dimensional (3D) reformations in any plane and angle of view without loss of geometric resolution.

The choice of a diagnostic procedure depends on the patient's condition and traumatic mechanism. In stable patients with no need for emergency intervention, the MDCT examination can be performed directly after admission to an emergency department

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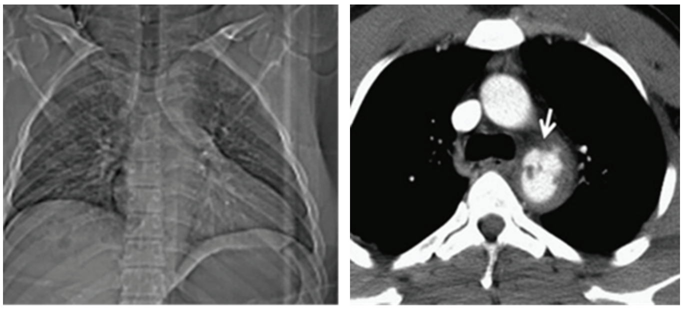

Figure 1. *Patient with laceration of the aorta. a Topogram (analogical to chest radiograph) shows normal mediastinal width. b MDCT reveals rupture of the aorta with small hematoma (arrow)*

and primary clinical examination. In the case of circulatory instability, the chest X-ray in the supine position is usually performed, as well as ultrasound examination, to exclude findings that require immediate intervention. In the event that MDCT is a part of the emergency department, it can be used as the primary imaging method.

Generally speaking, in order to minimise motion artifacts, high examination speed should be used in traumas, and because of the need to perform reformations in other planes, the highest resolution in the Z-axis should be used as well. Dose reduction is achieved: the kilovolt value can be reduced to 80–100, and the mAs value can be decreased to 30–80 (Figure 2) [6].

The application of contrast media is essential for the assessment of vascular structures and parenchymal organs and for the detection of active bleeding. Therefore, we used a longer scanning delay (30–40 s) compared with standard chest examinations. A small amount of contrast material was used in cases of suspected rupture of the esophagus. In this case, a water-soluble iodinated contrast medium (usually 5–10% solution) was used. The slices were reconstructed in three principal planes (axial, coronal, and sagittal). We used thinner slices (1–1.5 mm) reconstructed using a high-resolution kernel.

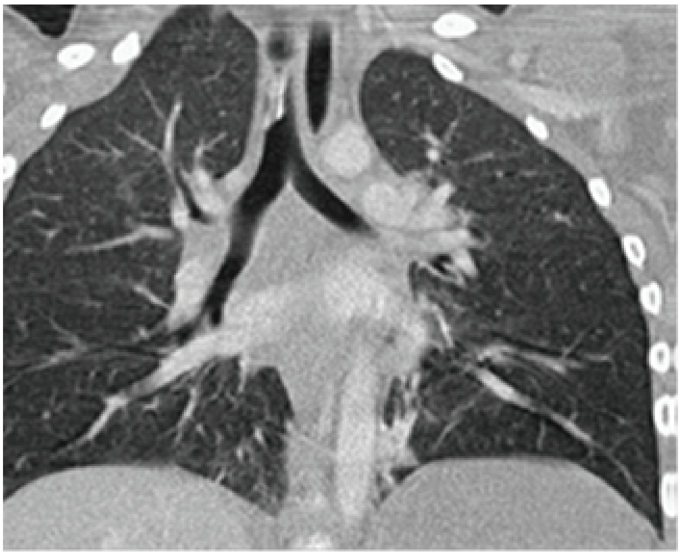

Figure 2. *Low-dose examination. Significant dose reduction was achieved (80 KV, 40 effective mAs, dose-length product 37 mGy*cm). Coronal edge enhancement reconstruction.*

Results and Discussion

Chest wall injuries are very common. Fractures reflect the intensity and direction of forces during trauma. However, the extent of a chest wall injury does not have to correlate with the injuries to the intrathoracic organs. This is evident especially in children and young adults with a flexible skeleton, in whom severe visceral traumas may occur despite there being no fractures.

Patients according to the type of injuries are presented on Table. 1

Type of injuries	**Number of patients**	**% of all**
Fractures of the ribs	56	50%
Fracture of the scapula	11	9.82%
Sternal fractures	9	8.03%
Extrapleural hematomas	45	40.17%
Pneumothorax	35	31.25%
Hemothorax	39	34.82%
Pulmonary contusions	79	70.53%
Lung laceration	64	57.14%
Lung torsion	21	18.75%
Lung herniation	34	30.35%
Laceration of trachea and bronchi	59	52.67%
Rupture of esophagus	13	11.60%
Diaphragmatic rupture	7	6.25%
Large chest vessels	45	40.17%
Other blood vessels	28	25%
Heart contusion	32	28.54%

The total number and percentages do not equal the total number of patients because one patient may have several types of injuries.

Fifty-six (50%) of all 112 patients included in the study experienced fractures of the ribs, which are the most common chest wall traumas. They are, in fact, usually not clinically significant. MDCT determines the number of fractures, their location, and the degree of dislocation more accurately than X-rays. Contrary to X-rays, it is also able to detect fractures of the rib cartilages [3,5].

In eleven (9.82%) of the cases, a fracture of the scapula was established. It is usually caused by strong direct impact or large axial forces. In up to 40% of cases, it is associated with pulmonary contusion, pneumothorax, or hemothorax [10,11]. The areas of the scapular body and neck are mostly affected (Figure 3).

Sternal fractures occur in 9 (8.03%) of cases. They are usually caused by a direct impact on the anterior chest wall (typically impact with the steering wheel). Anterior dislocation is more common and clinically less severe. Posterior dislocations may be associated with major vascular traumas [13]. In the MDCT examination, we can find a blood collection separated from the lungs and pleural cavity by a thin strip of fat (Figure 4) [14].

In forty-five (40.17%) of patients, extrapleural hematomas are caused by injury to the intercostal artery. They occur relatively

Figure 3. *Volume-rendered image. Fracture of the right scapula and multiple rib fractures on the right.*

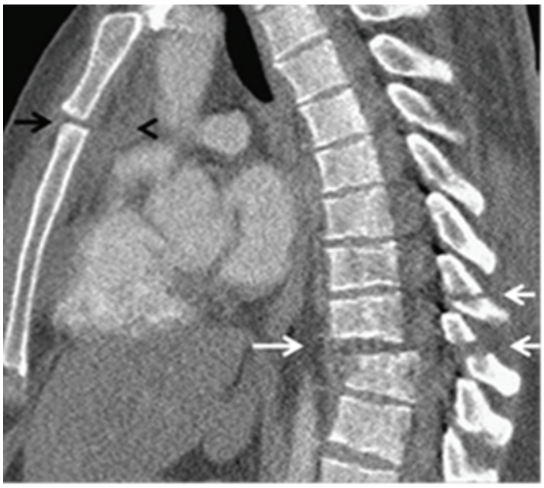

Figure 4. *Unstable dislocated fracture (white arrows), combined with dislocation in the sternal angle (black arrow) and retrosternal hematoma.*

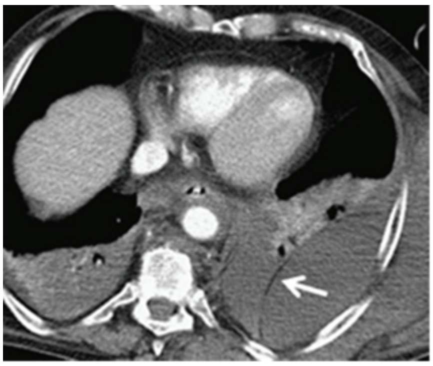

Figure 5. *Combination of extrapleural hematoma and hemothorax. Extrapleural hematoma is surrounded by a thin strip of fat (arrow)*

rarely as a result of chest wall injury or as a complication of interventions (drainage, insertion of the central venous catheter). Blood accumulates between the parietal pleura and endothoracic fascia. In the MDCT examination, we find a blood collection separated from the lungs and pleural cavity by a strip of fat (Figure 5) [14].

Figure 6. *Pneumothorax: MDCT shows significant pneumothorax in the ventral part of the left pleural cavity.*

In 35 (31.25%) of all cases, pneumothorax accompanies blunt and penetrating chest trauma. It is the second most common finding after rib fractures. It is caused by direct injury to the pleura, but also by a rupture of the alveoli accompanied by increased pressure in the airways. On CT, it is manifested as a collection of gas in the pleural cavity. In chest X-ray examinations performed in the supine position, it is often manifested very discretely, and it cannot be seen at all (Figure 6) [15,16].

The clinical significance of pneumothorax depends not only on its size at the time of the initial examination but also on its development over time. In 5 (4.46%) of the patients, tension pneumothorax is a serious, life-threatening condition requiring immediate drainage. It is often clinically diagnosed before MDCT. Its basic symptoms include an increase in the volume of the affected hemithorax, a shift of the mediastinum to the healthy side, and compression of the mediastinal vessels (mainly veins), heart, and depression of the diaphragmatic arch (Figure 7).

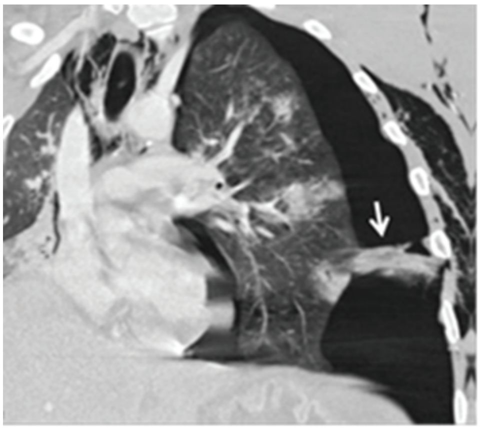

Figure 7. *Tension pneumothorax: a/ Increased volume of the left hemithorax, multiple lung contusions.b/ Maximum intensity projection: mediastinal shift to the right, dislocation and compression of the heart, and compression of the left pumonary artery.*

In 39 (34.82%) of all cases with hemothorax, bleeding into the pleural cavity is most commonly caused by laceration of the pulmonary parenchyma and pleural injury. In these cases, bleeding is usually slowly progressive and limited. In 12 (10.71%) of cases, the injury to an artery (usually intercostal) causes bleeding that progresses rapidly and requires surgical therapy. MDCT is an unrivaled method for the diagnosis of pleural fluid. Blood has a higher density than water. The density of liquid blood is between 30 and 50 HU, and the density of blood clots is 50–90 HU. Hematomas can sometimes have a layered structure (Figure 8).

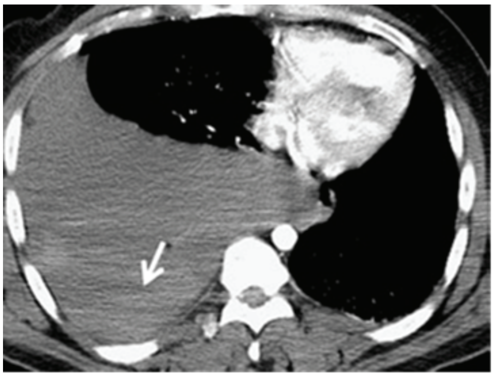

Figure 8. *Large layered hemothorax. Hyperdense clots (50 HU) in the dorsal part of the right pleural cavity (arrow). Mediastinal shift to the left side.*

Injury to the lung parenchyma includes pulmonary contusion, laceration, torsion, and herniation. These conditions can be complicated by atelectasis, aspiration pneumonia, or acute respiratory distress syndrome (ARDS) [6]. Lung trauma is a reason for surgical treatment in 32 (28.57%) of the patients. This is indicated in cases of injury to the major blood vessels, signs of active bleeding, large hematomas, or hemodynamic instability.

Pulmonary contusions were found in 79 (70.53%) of all 112 cases and are the most common trauma of the lung parenchyma. They can be detected on the X-ray image with up to a 6-hour delay. On the other hand, CT is very sensitive to contusion changes, and it can detect them earlier and more accurately and allows their quantification, which is important in the determination of further treatment. In contusions exceeding 20–30% of the total lung volume, mechanical ventilation is indicated to prevent the development of complications, especially acute respiratory distress syndrome [17,18].

The CT findings depend on the severity of parenchymal affection. Simultaneously, parenchymal lacerations can occur (Figure 9). The peripheral areas of the lung are affected, and

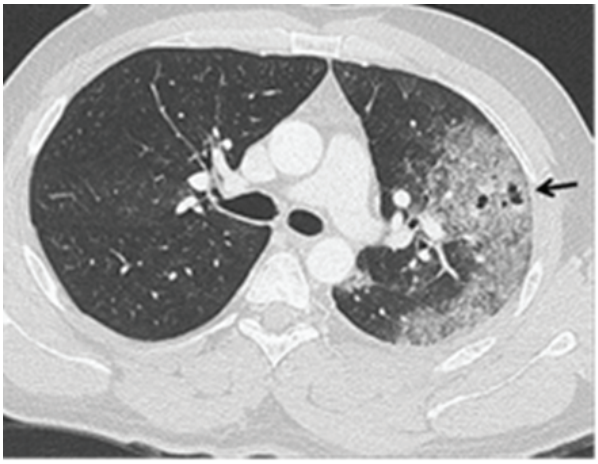

Figure 9. *Lung contusion with small lacerations (arrow)*

the distribution does not respect the boundaries of the lobes and segments [6].

X-ray examination is usually negative because of the superposition of simultaneously occurring contusion. Lung laceration occurs in 64 (57.14%) of penetrating injuries as a result of direct shearing forces. At present, we can find it relatively commonly because of the broad use of CT in traumatized patients. If a laceration reaches the pleural cavity, it can cause pneumothorax or hemothorax. A laceration closed in the parenchyma has the appearance of a thin-walled, spherical, oval, or tubular cavity containing air, blood, or their combination (Figure 10). There are usually contusion changes around it. When they are absorbed, the laceration, which does not contain air, can mimic a pulmonary nodule [6].

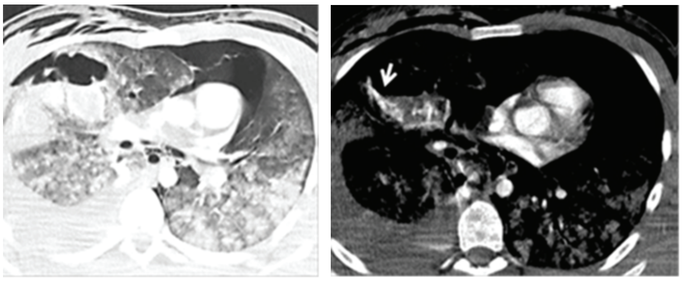

Figure 10. *Extensive lung laceration. a/ Cavities with air-fluid levels in the right upper lobe, right-sided pneumothorax, bilateral subcutaneous emphysema,pneumomediastinum, mediastinal shift to the left. b/ Extravasation of the contrast material into the cavity due to active bleeding; the finding was an indication for surgery*

Lung torsion in 21 (18.75%) of patients is a rare, life-threatening complication of pulmonary surgery or trauma. In rare cases, it can occur spontaneously. It affects the whole lung or a lobe [19]. On CT, torsion is manifested as an abnormal position of the lung or its lobe with condensation and obstruction of the airways or distortion and abnormal position of the bronchi and blood vessels [20].

Like torsion, lung herniation occurs in 34 (30.35%) patients as a rare complication of chest injuries. It occurs at the site of a defect in the chest wall with a significant increase in intrathoracic pressure. The chest wall defects are caused by multiple fractures of the ribs or by sterno- and costoclavicular dislocation. If parenchymal tearing occurs at the same time, the herniation may be associated with pneumothorax and hemothorax [21].

In 59 (52.67%) of the patients, laceration of the trachea and bronchi is caused by two mechanisms: by increasing the intraluminal pressure with a closed vocal slot due to sudden compression of the chest or by compression of the main bronchi against the spine. Tracheobronchial trauma is often difficult to find. In addition to thin slices in the axial plane and multiplanar reformations, 3D visualization of the bronchial tree (using virtual bronchoscopy or the volume-rendering technique) can be helpful for detecting the rupture (Figure 11) [22]. A defect in the wall of the airways with leakage of air into the surrounding area is a direct sign of airway trauma. Other symptoms, such as pneumomediastinum, subcutaneous emphysema in the neck and chest, pneumothorax, and hemothorax, are nonspecific and more commonly have other causes [23].

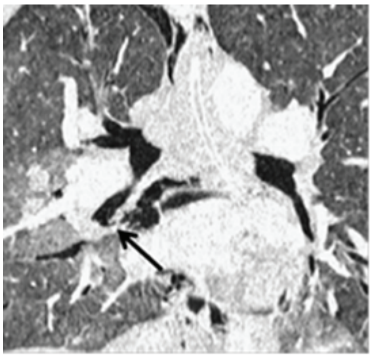

Figure 11. *Multiplanar reformation—the tear is poorly visible (arrow).*

Rupture of the esophagus is present in 13 (11.60%) patients as part of blunt or penetrating chest trauma. Most often, it occurs in the cervical and upper mediastinal parts. It is usually caused by bone fragments from the injury of adjacent sections of the spine. The CT findings include thickening of the esophageal wall, pneumomediastinum, and paraesophageal fluid collections [24,25].

Diaphragmatic rupture occurs in 7 (6.25%) of patients hospitalized with major trauma [26]. It is a frequently overlooked injury, but it is clinically very serious. Laceration on the right side is more difficult to detect. Sensitivity of the initial X-ray examination is low, 17% and 27–60% on the right and left sides, respectively [27]. Compared to this, MDCT reaches a sensitivity of 50–83% and 78–100% on the right and left sides, respectively. Evaluation of multiplanar reformations in the coronal and sagittal planes is very important for making the diagnosis. The CT signs of diaphragmatic rupture include discontinuity of the diaphragm with thickening at the edge of the defect, herniation of the abdominal organs into the chest, strangulation of the organs at their passage through the diaphragmatic defect (collar sign), and the location of herniated abdominal organs in the dorsal part of the thorax where they are in contact with the chest wall (dependent viscera sign) (Figure 12). Diaphragmatic injuries are often associated with injuries of the spleen, liver, lungs, and rib fractures.

Trauma of the large chest vessels represents about 45 (40.17%) of all major trauma patients, but its incidence is probably underestimated. Although relatively infrequent, it is the second most common cause of death after head injuries [30,31]. The aorta is the most commonly affected vessel. Rarely, we see injuries of the aortic branches, internal thoracic artery, or major mediastinal veins. In the case of blunt trauma, there are three traumatic mechanisms leading to the injury—deceleration, torsion, and increased intraluminal pressure. Findings on the X-ray examination are usually nonspecific and do not allow differentiation of trauma of the large vessels from other less serious conditions with similar X-ray findings, as described above [5]. If this type of trauma is suspected, MDCT is currently the first-choice method. Its sensitivity and specificity are almost 100%. Angiography is indicated only in cases of doubt and for navigation of interventional procedures [32].

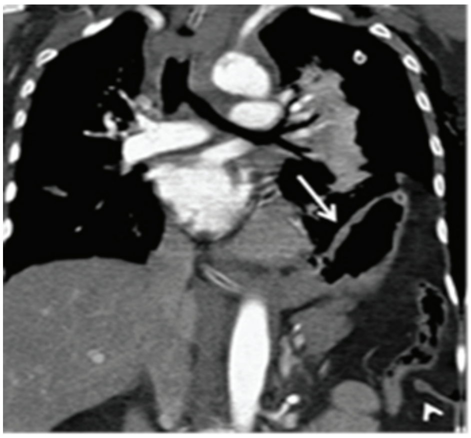

Figure 12. *Herniation of abdominal organs into the left hemithorax (arrow), clubshaped edge of the ruptured diaphragm (arrowhead).*

The mortality of untreated aortic trauma exceeds 95% [33]; those who come to the hospital have a 70% chance of survival if the trauma is quickly diagnosed and treated. Treatment is either surgical or radiointerventional (endovascular stent grafting). The most common site of injury (approximately 90%) is the isthmus, which represents the transition between the relatively mobile arch and the fixed descending part. A complete wall rupture (transection) usually results in immediate death. Direct signs of aortic trauma are pseudoaneurysm (Figure 13), direct extravasation of contrast medium into the mediastinum, intimal flap, irregular contour, mural thrombus, or pseudocoarctation.

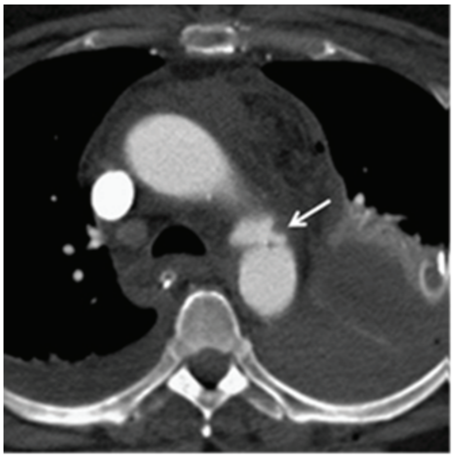

Figure 13. *Aortic isthmus laceration. Pseudoaneurysm in a typical location (arrow), mediastinal hematoma, bilateral hemothorax .*

In 28 (25%) of patients, injuries of other blood vessels, such as the internal thoracic artery, branches of the aortic arch, pulmonary artery, or mediastinal veins, are less common than aortic trauma, but their severity is similar. In case of bleeding from the internal thoracic artery, a hematoma occurs in the anterior mediastinum, and it may compress the right ventricle. Injury of the branches of the aortic arch occurs most frequently in the traction mechanism in case of abnormal extension of the neck or pulling of the arm. It is manifested by occlusion, dissection of the affected artery, or extravasation of contrast material into the hematoma, which is typically located in the upper part of the mediastinum.

Rare injuries of the venous structures are manifested as hematoma with extravasation of contrast medium (Figure 14). The mechanism is similar to injuries of the arteries. Injury of the superior vena cava can spread to the right atrium as well.

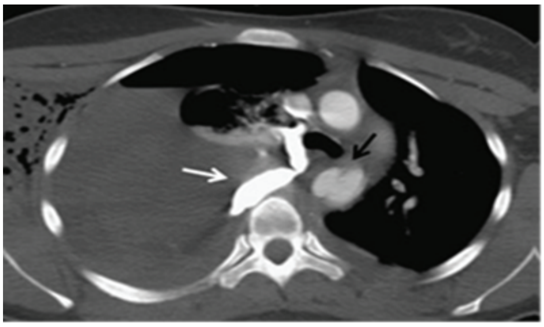

Figure 14. *Rupture of the azygos vein with contrast material leakage into the large hemothorax (white arrow) combined with aortic pseudoaneurysm (black arrow)*

Contusion is the most common heart injury in 32 (28.54%) of our cases, affecting primarily the right ventricle. It is generally radiologically silent and causes arrhythmia or other electrocardiographic changes. Because of its very high mortality, cardiac rupture is rarely diagnosed by imaging methods. Diagnosis of hemopericardium using X-ray examination is extremely problematic. The finding can be negative even in cases of cardiac tamponade. In contrast, the CT examination, as well as ultrasound, is a highly sensitive method. Cardiac tamponade is manifested by flattening and a reduction of the cardiac parts (Figure 15). More rarely, we see pneumopericardium, which, if large, may also result in cardiac tamponade. Herniation of the heart is a serious complication of traumatic rupture of the pericardium.

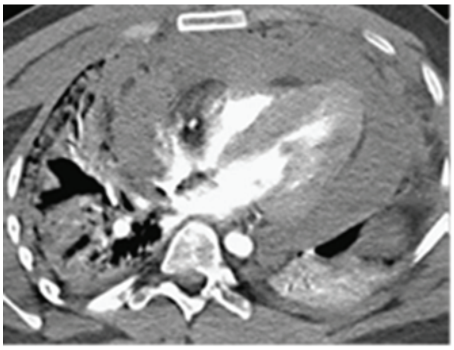

Figure 15. *Hemopericardium with heart tamponade: compression of all heart parts.*

Conclusion

Our experience and literature reports suggest that imaging methods are an integral part of the diagnostic algorithm in major chest traumas. MDCT is the main component. It shows traumatic changes quickly, accurately, and clearly, and allows their classification. Therefore, a trauma radiologist becomes a member of the team making decisions about the therapeutic process.

References

1. Wintermark M, Schnyder P. MDCT of chest trauma. In: Schoepf UJ, ed. Multidetector-row CT of the Thorax. Springer; 2004:409-421.
2. LoCicero J, Mattox KL. Epidemiology of chest trauma. Surg Clin North Am. 1989;69:15-19.
3. Lomoschitz FM, Eisenhuber E, Linnau KF, Peloschek P, Schoder M, Bankier AA. Imaging of chest trauma: radiological patterns of injury and diagnostic algorithms. Eur J Radiol. 2003;48:61-70.
4. Scaglione M, Pinto A, Pedrosa I, Sparano A, Romano L. Multi-detector row computed tomography and blunt chest trauma. Eur J Radiol. 2008;65:377-388.
5. Kaewlai R, Avery LL, Asrani AV, Novelline RA. Multidetector CT of blunt thoracic trauma. RadioGraphics. 2008;28:1555-1570.
6. Elmali M, Baydin A, Nural MS, et al. Lung parenchymal injury and its frequency in blunt thoracic trauma: the diagnostic value of chest radiography and thoracic CT. Diagn Interv Radiol. 2007;13:179-182.
7. Brink M, Deunk J, Dekker HM, et al. Added value of routine chest MDCT after blunt trauma: evaluation of additional findings and impact on patient management. Am J Roentgenol. 2008;190:1591-1598.
8. Brink M, Kool DR, Dekker HM, et al. Predictors of abnormal chest CT after blunt trauma: a critical appraisal of the literature. Clin Radiol. 2009;64:272-283.
9. Tack D. Radiation dose optimization in thoracic imaging. JBR-BTR. 2010;93:15-19.
10. Haapamaki VV, Kiuru MJ, Koskinen SK. Multidetector CT in shoulder fractures. Emerg Radiol. 2004;11:89-94.
11. McGinnis M, Denton JR. Fractures of the scapula: a retrospective study of 40 fractured scapulae. J Trauma. 1989;29:1488-1493.
12. Kim EY, Yang HJ, Sung YM, et al. Sternal fracture in the emergency department: diagnostic value of multidetector CT with sagittal and coronal reconstruction images. Eur J Radiol. 2011;14. [Epub ahead of print].
13. Maier D, Jaeger M, Izadpanah K, Bornebusch L, Südkamp NP. Traumatic injuries of the sternoclavicular joint. Unfallchirurg. 2011;114:611-621.
14. Aquino SL, Chiles C, Oaks T. Displaced extrapleural fat as revealed by CT scanning: evidence of extrapleural hematoma. Am J Roentgenol. 1997;169:687-689.
15. Ball CG, Kirkpatrick AW, Laupland KB, et al. Incidence, risk factors, and outcomes for occult pneumothoraces in victims of major trauma. J Trauma. 2005;59:917-924.
16. Omar HR, Abdelmalak H, Mangar D, et al. Occult pneumothorax, revisited. J Trauma Manag Outcome. 2010;4:3-6.
17. de Moya MA, Manolakaki D, Chang Y, et al. Blunt pulmonary contusion: admission computed tomography scan predicts mechanical ventilation. J Trauma. 2011;71:1543-1547.
18. Strumwasser A, Chu E, Yeung L, et al. A novel CT volume index score correlates with outcomes in polytrauma patients with pulmonary contusion. J Surg Res. 2011;170:280-285.
19. Wong PS, Goldstraw P. Pulmonary torsion: a questionnaire survey and a survey of the literature. Ann Thorac Surg. 1992;54:286-288.
20. Gilkeson RC, Lange P, Kirby TJ. Lung torsion after lung transplantation evaluation with helical CT. Am J Roentgenol. 2000;174:1341-1343.
21. Sukkarieh F, Vanmeerhaeghe A, Brasseur P. Post traumatic intercostal lung herniation: a case report. J Radiol. 2002;83:1085-1087.
22. Le Guen M, Beigelman C, Bouhemad B, et al. Chest computed tomography with multiplanar reformatted images for diagnosing traumatic bronchial rupture: a case report. Crit Care. 2007;11:R94.
23. Rezende-Neto JB, Hoffmann J, Al Mahroos M, et al. Occult pneumomediastinum in blunt chest trauma: clinical significance. Injury. 2010;41:40-43.

24. Tjardes T, Wafaizadeh A, Steinhausen E, et al. Extension injury of the thoracic spine with rupture of the oesophagus and successful conservative therapy of concomitant mediastinitis. Eur Spine J. 2009;18:240-244.
25. Young CA, Menias CO, Bhalla S, et al. CT features of esophageal emergencies. RadioGraphics. 2008;28:1541-1553.
26. Meyers BF, McCabe CJ. Traumatic diaphragmatic hernia: occult marker of serious injury. Ann Surg. 1993;218:783-790.
27. Reesa O, Mirvis SE, Shanmuganathan K. Multidetector-row CT of right hemidiaphragmatic rupture caused by blunt trauma: a review of 12 cases. Clin Radiol. 2005;60:1280-1289.
28. Bhullar IS, Block EF. CT with coronal reconstruction identifies previously missed smaller diaphragmatic injuries after blunt trauma. Am Surg. 2011;77:55-58.
29. Al-Refaie RE, Awad E, Mokbel EM. Blunt traumatic diaphragmatic rupture: a retrospective observational study of 46 patients. Interact Cardiovasc Thorac Surg. 2009;9:45-49.
30. Mattox KL, Feliciano DV, Burch J, et al. Five thousand seven hundred sixty cardiovascular injuries in 4459 patients. Epidemiologic evolution 1958 to 1987. Ann Surg. 1989;209:698-705.
31. Onan B, Demirhan R, Öz K, Onan IS. Cardiac and great vessel injuries after chest trauma: our 10-year experience. Turk J Trauma Emerg Surg. 2011;17:423-429.
32. Steenburg SD, Ravenel JG. Acute traumatic thoracic aortic injuries: experience with 64-MDCT. Am J Roentgenol. 2008;191:1564-1569.
33. Parmley L, Thomas W, Manion W, Jahnke E. Nonpenetrating traumatic injury of the aorta. Circulation. 1958;17:1086-1101.