VIA MEDICA

PRACA ORYGINALNA

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The application of MDCT in the diagnosis of chest trauma

Zastosowanie wielorzędowej tomografii komputerowej w diagnostyce urazów klatki piersiowej

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Abstract

Introduction: Traumas are the third most common cause of death worldwide, after cardiovascular diseases and neoplasms, and the main cause of death of patients under 40 years of age. Contemporary image diagnosis of chest trauma uses chest X-ray (CXR), multidetector computed tomography (MDCT), transthoracic and transoesophageal ultrasound (USG), X-ray angiography and magnetic resonance. The aim of the present study was to evaluate MDCT results in the examination of posttraumatic chest injuries and to compare the results of CXR and MDCT in chosen chest traumatic injuries.

Material and methods: The sixty patients with chest trauma included in the study were diagnosed at the Department of Radiology of the Institute of Tuberculosis and Lung Diseases between May 2004 and October 2007. MDCT was performed in all patients. Two groups with different types of injury (blunt or penetrating chest trauma) were distinguished. The analysis of injuries in both groups was conducted depending on the mechanism of trauma. The detection of 20 selected injuries at CXR and MDCT was compared. Moreover, the compatibility of MDCT with the results of intraoperative assessment and bronchoscopy was analysed. The influence of MDCT on the treatment modality was also assessed.

Results: History of blunt chest trauma was found in 51 patients (group 1) and of penetrating trauma in 9 patients (group 2). The most frequent injuries among group 1 were lung contusion and rib fractures, and among group 2 it was pericardial hematoma. Compared to MDCT, the sensitivity and specificity of CXR were 66.7 and 58%, respectively. Change of treatment modality was observed after MDCT in 83% of patients. The sensitivity and specificity of MDCT in diagnosing tracheobronchial injury, compared to bronchoscopy, were 72.7% and 100%, respectively. Compatibility of MDCT results and intraoperative assessment was observed in 43% of patients, and the main reason for discrepancy was underdiagnosis of diaphragm injury in MDCT.

Conclusions: MDCT was a valuable diagnostic method in recognition of chest trauma, characterized by high sensitivity and specificity in the assessment of life-threatening injures and for depicting tracheal and bronchial injuries. The diagnostic value of CXR was low. The compatibility of MCTD and intraoperative assessment was confirmed, with the exception of diaphragm injures and lung laceration. Change of treatment modality was certified after MDCT in 83% of patients.

Key words: chest trauma, multidetector computed tomography, occult injuries

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Streszczenie

Wstęp: Urazy stanowią główną przyczynę zgonów pacjentów do 40. rż., trzecią pod względem częstości występowania na świecie, po chorobach układu krążenia i nowotworach. Współczesna diagnostyka obrazowa urazów klatki piersiowej wykorzystuje klasyczne zdjęcia rentgenowskie (RTG), wielorzędową tomografię komputerową (WTK), badanie USG przez ścianę klatki piersiowej, USG przezprzełykową, angiografię RTG i rezonans magnetyczny. Celem pracy była ocena wskazań do wielorzędowej tomografii komputerowej (WTK) u chorych po urazie klatki piersiowej oraz ocena przydatności tej metody w ocenie uszkodzeń urazowych.

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Materiał i metody: 60 chorych z urazem klatki piersiowej diagnozowanych w Zakładzie Radiologii IGiChP w Warszawie w okresie od maja 2004 roku października 2007 roku miało wykonane WTK klatki piersiowej. Wyodrębniono dwie grupy zależne od typu urazu — tępego albo drążącego, analizowano uszkodzenia urazowe w grupach oraz zbadano zależność poszczególnych obrażeń od rodzaju urazu. U 30 pacjentów porównano wykrywalność 20 wybranych typów obrażeń w RTG i WTK. Przeanalizowano zgodność wyników WTK z rozpoznaniem śródoperacyjnym i bronchoskopią oraz wpływ wyniku WTK na leczenie.

Wyniki: Uraz tępy w wywiadzie stwierdzono u 51 chorych (grupa 1), uraz drążący u 9 (grupa 2). U chorych z grupy 1 stwierdzono istotnie częściej stłuczenie płuca i złamania żeber, w grupie 2 — krwiak osierdzia. Przyjmując wynik WTK jako punkt odniesienia czułość i swoistość RTG w badanej grupie chorych wynosiła odpowiednio 66,7% i 58%. Zmianę postępowania leczniczego na podstawie wyników WTK wykazano u 83,3% pacjentów. Czułość i swoistość badania WTK w ocenie uszkodzenia dróg oddechowych, w odniesieniu do bronchoskopii wynosiła: 72,7% i 100%. Zgodność wyników WTK z oceną śródoperacyjną wyniosła 43%, a wiodącą przyczyną niezgodności był brak rozpoznania uszkodzenia przepony w badaniu WTK.

Wnioski: WTK jest cenną metodą obrazową w diagnostyce urazów klatki piersiowej, o wysokiej czułości i swoistości w wykrywaniu zagrażających życiu obrażeń, także w ocenie uszkodzeń tchawicy i oskrzeli. Wartość diagnostyczna RTG była niska. Wykazano zgodność WTK z oceną śródoperacyjną, za wyjątkiem przypadków uszkodzeń przepony i rozerwania płuca. W przedstawianym materiale WTK zmieniła postępowanie lecznicze u 83% badanych pacjentów.

Słowa kluczowe: uraz klatki piersiowej, wielorzędowa tomografia komputerowa, utajone uszkodzenia urazowe

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Introduction

Traumas are the third most common cause of death worldwide, after cardiovascular diseases and neoplasms, and the main cause of death of patients under 40 years of age [1, 2].

Chest traumas are divided into two groups: blunt and penetrating. Blunt traumas are caused predominantly by road traffic accidents, the second most frequent cause are falls from height. Penetrating chest traumas constitute from 7 to 15% of all admissions to traumatology centres, and are almost exclusively caused by sharp tools and firearms [3]. Blunt chest traumas constitute approximately 90% of all chest traumas in Europe and the United States, and they are the cause of approximately 20% of deaths due to traumas [4, 5].

Contemporary image diagnosis of chest trauma uses chest X-ray (CXR), multidetector computed tomography (MDCT), transthoracic and transoesophageal ultrasound (USG), X-ray angiography and magnetic resonance.

The diagnostic algorithm is strictly connected with the state of the patient. Patients with trauma usually have CXR made in the recumbent position. The diagnostic value of X-ray images is lowered by recumbent and asymmetric position, and the possibility of respiratory artefacts. Chest MDCT performed after trauma is usually the part of trauma protocol which includes scanning of the brain and cervical spine, and (after administration of contrast) scanning of the chest and abdominal cavity with the pelvis. Modern multidetector scanners enable imaging of the whole body during one respiratory arrest [6]. MDCT result is crucial for the decision on medical or surgical treatment, and on further diagnostic imaging and fiberoscopy. In the case of difficulties concerning imaging in MDCT of the mediastinum, heart and large vessels — transoesophageal USG and aortography are performed.

Currently, aortography is performed only in cases when it is difficult to evaluate a potential aorta injury based on MDCT. Angiography enables also a single-stage endovascular treatment of the injuries of the aorta and other arterial vessels [7]. An auxiliary diagnostic tool in imaging of traumatic chest injuries is magnetic resonance.

Haemodynamically unstable patients, who usually need immediate surgical intervention, should have a supine CXR and ultrasonography performed. MDCT is recommended when the patient state is stabilized [8].

The aims of the present study were the following:

1. Evaluation of MDCT value in the examination of posttraumatic chest injuries;
2. Comparative analysis of the results of CXR and MDCT in chosen chest traumatic injuries.

Material and methods

The study group consisted of 60 patients with chest trauma diagnosed at the Department of Radiology of the National Institute of Tuberculosis and Lung Diseases in Warsaw, in the period from May 2004 to October 2007.

Inclusion criteria were: diagnosed chest trauma that needed more precise evaluation at MDCT and haemodynamic stability of the patient.

Exclusion criteria were lack of consent to MDCT, the need for urgent surgical intervention or available MDCT correctly performed at another centre.

Table 1. The type of trauma and treatment modality in the group of 60 patients with chest injury

Tabela 1. Rodzaj urazu i sposób leczenia w badanej grupie 60 chorych z urazem klatki piersiowej

		Urgent admission n = 40 (100%)	Planned course n = 20 (100%)	Study group n = 60 (100%)
Type of trauma	blunt (group 1)	31 (77,5%)	20 (100%)	51 (85%)
	penetrating (group 2)	9 (22,5%)	0	9 (15%)
Applied treatment	surgical	24*(60%)	14(70%)	38(63,3%)
	conservative	16 (40%)	6 (30%)	22 (36,6%)

*in 1 case — laparotomy

The initial group, consisting of 60 patients, was divided into two groups depending on the type of chest trauma: blunt (group 1) or penetrating (group 2).

Blunt chest traumas prevailed — they were found in 51 patients (85%); traffic road accidents were the cause of 38 traumas, whereas 13 cases were the result of a fall from height. Penetrating traumas concerned 9 patients (15%), and in the majority (8 patients) they were caused by wounding with a sharp tool. One patient had gunshot wounds of the chest.

The reason for urgent admission of patients (pts) was blunt chest trauma (31 pts), including road traffic accident (21 pts) and fall from height (10 pts), or penetrating trauma (9 pts).

The planned visits concerned only past blunt chest traumas (20 pts) — caused by road traffic accident (17 pts) and fall from height (3 pts).

The applied diagnostic methods included CXR, chest MDCT, computed tomography (CT) of the brain, MDCT of cervical spine, abdominal cavity and pelvis, USG of the abdominal cavity and the heart, broncho- and esophagoscopy, and magnetic resonance.

In 60 studied patients, apart from chest trauma, traumatic injuries of the abdominal cavity and pelvis (15 pts), of the central nervous system (6 pts) and the musculo-sceletal system outside the chest (23 pts) were found.

The applied treatment and the type of trauma are presented in Table 1.

Chest MDCT with the help of a 16-MDCT scanner was performed in all patients included in the study. The following data acquisition parameters were used: 120–140 kV, current strength of the lamp — alternated, appr. 200 mAs, pitch coefficient — 1.5, layer collimation 0.75/1.5, layer width/reconstruction interval -2/1. The chest was examined only after administration of contrast medium; there was no phase without contrast. Non-ionic, iodic contrast medium of iodine concentration 370–400 mg/ml in volume of 90––120 mL was used.

Chest MDCTs were assessed retrospectively in pulmonary, mediastinal and bone windows, in three planes, using MIP (maximum intensity projection) or MinIP (minimum intensity projection) and shaded surface display (SSD). MIP images and the so-called reconstructions enabled a better visualization of vascular structures; MinIP images were used for assessment of the bronchial tree. When damage of the trachea or bronchi was suspected, virtual bronchoscopy was performed. SSD images were used for the presentation of polyfractures of osseous elements of the chest.

Several analyses were conducted in the study group:

1. Individual traumatic chest injuries visible at MDCT and their relationship with the type of trauma were determined. We assessed 1) injury of thoracic aorta, 2) injury of other vessels, pulmonary thromboembolism, 3) lung contusion, 4) lung laceration, 5) other parenchymal changes (ARDS, atelectasis, inflammatory changes), 6) pneumothorax, 7) haemothorax, 8) mediastinal emphysema, 9) haematomediastinum, 10) tracheal and bronchial injury, 11) oesophageal injury, 12) pericardial hematoma, 13) myocardial injury, 14) diaphragm injury, 15) thoracic spine fracture, 16) subcutaneous emphysema, 17) chest wall hematoma, 18) rib fractures, 19) shoulder girdle fractures and 20) sternum fracture. The influence of MDCT on therapeutic modality was also assessed, and the influence of MDCT on therapeutic modality was analysed.
2. Detection of traumatic injuries at CXR and MDCT was compared in the group of 30 pts who had both CXR and MDCT performed at a time interval not longer than 48 hours and who did not undergo any instrumentation between CXR and MDCT. CXR and

Table 2. Quantitative and proportional analysis of type of chest traumatic injuries in group 1 (blunt injuries) and group 2 (penetrating injuries)

Tabela 2. Analiza ilościowa i procentowa rodzaju uszkodzeń urazowych klatki piersiowej w grupie 1 (urazy tępe) i grupie 2 (urazy drążące)

Type of chest traumatic injury	Group 1 n = 51 (100%) number (%)	Group 2 n = 9 (100%) number (%)	p
1) thoracic aorta	3 (5.8)	0	0.4554
2) lung contusion	16 (31.4)	0	0.0497
3) lung laceration	9 (17.6)	2 (22.2)	0.7436
4) atelectasis	12 (23.5)	4 (44.4)	0.1908
5) aspiration changes	7 (13.7)	0	0.2370
6) pneumothorax	21 (41.2)	6 (66.7)	0.1564
7) hemothorax	29 (56.8)	8 (88.9)	0.0684
8) mediastinal emphysema	6 (11.8)	2 (22.2)	0.3948
9) hematomediastinum	8 (15.7)	1 (11.1)	0.7230
10) trachea/bronchi	10 (19.6)	1 (11.1)	0.5436
11) esophagus	0	0	–
12) pericardial hematoma	0	2 (22.2)	0.0006
13) heart	0	1 (11.1)	–
14) diaphragm	9 (17.6)	0	0.1716
15) vertebral column	14 (27.4)	0	0.0726
16) subcutaneous emphysema	14 (27.4)	4 (44.4)	0.3050
17) chest wall hematoma	5 (9.8)	3 (33.3)	0.0556
18) ribs	37 (72.5)	1 (11.1)	0.0004
19) shoulder girdle	14 (27.4)	0	0.0726
20) sternum	8 (15.6)	1 (11.1)	0.7230

MDCT were analysed in respect of 16 types of injuries: rib polyfractures, shoulder-blade fracture, sternum fracture, clavicle fracture, spinal fracture, pneumothorax, bleeding/ /fluid in the pleural cavity, lung contusion, lung laceration, inflammatory and aspiration changes in the lung, atelectasis, mediastinal emphysema, airways injury, diaphragm injury, subcutaneous emphysema and chest wall haematoma.

3. Compatibility of MDCT results with intraoperative assessment was evaluated in 23 patients admitted as a matter of urgency, who underwent surgical treatment.
4. Compatibility of MDCT results and bronchoscopy was assessed in 11 patients with suspected injury of the broncho-tracheal tree at MDCT.

Statistical analysis of the examination results was performed using STATISTICA 9.0 software for Windows XP, with the use of the sign test, chi-square contingency table and Mann-Whitney U test. $P \leq 0.05$ was assumed as significance level for the above-mentioned tests.

Results

Results of quantitative analysis of traumatic chest injuries in groups 1 and 2, and their relationship with trauma type are presented in Table 2

In 51 patients with history of blunt chest trauma (group 1) the following injuries predominated: rib polyfractures (37 pts, 72.5%) (Fig. 1a, b), bleeding to the pleural cavity (29 pts, 56.8%) (Fig. 2) and pneumothorax (21 pts, 41.2%). In 9 patients with history of penetrating trauma (group 2) the most frequent chest injuries were: haemothorax (8 pts, 88.9%), pneumothorax (6 pts, 66.7%) and subcutaneous emphysema (4 pts, 44.4%). Lung contusions ($p = 0.0497$) and rib polyfractures ($p = 0.0042$) were found significan-

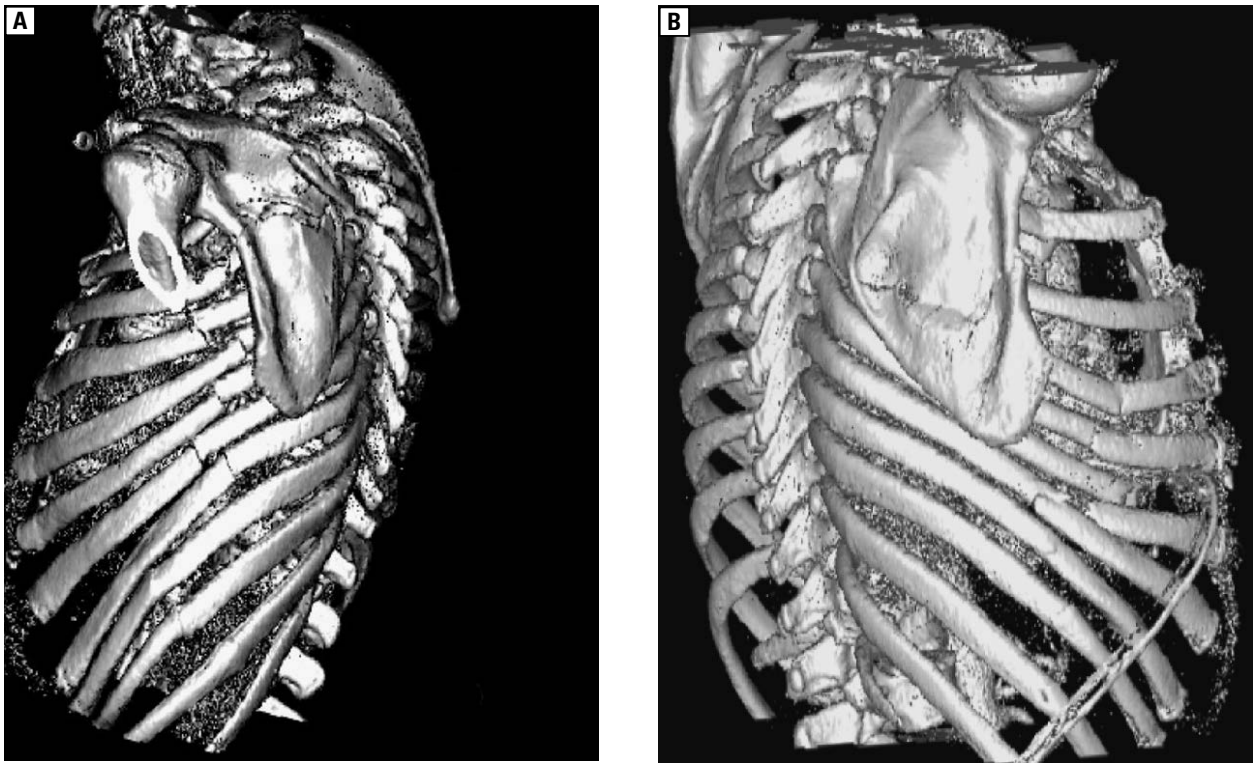

Figure 1A, B. Multiple rib fractures, shaded surface display

Rycina 1A, B. Mnogie złamania żeber w rekonstrukcji *shaded surface display*

tly more frequently in patients from group 1 than group 2. Pericardial haematoma was diagnosed significantly more frequently in group 2 than in group 1 ($p = 0.0062$).

Lung contusion and rib polyfractures predominated in the group of blunt chest traumas, whereas pericardial haematoma was found only in the group of penetrating traumas.

The influence of MDCT result on therapeutic decisions was examined in 30 pts in respect of type of treatment and diagnostic procedures, i.e. insertion and repositioning of a draining tube in the pleural cavity, intubation, change of ventilation mode, bronchoscopy, thoracotomy and video-assisted thoracoscopy. MDCT examination influenced directly further diagnosis and treatment in 25 pts (83.3%). Chest MDCT value was also important for 20 patients who were admitted to planned visits. 14 pts (70%), after acquisition of MDCT image, underwent operation.

Figure 2. Multidetector computed tomography. Left hemothorax. Hyperdense bands in the pleural fluid indicate an active pleural bleeding

Rycina 2. Wielorzędowa tomografia komputerowa. Lewostronny krwiak opłucnej. Hiperdensyjne pasma widoczne na tle płynu wskazują na aktywne krwawienie do jamy opłucnowej

Comparison of CXR and MDCT in detection of traumatic injuries

Sensitivity of CXR for all radiologically examined injuries in the study group was 66.7%, specifity was 58%, positive predictive value (PPV) was 43% and negative predictive value (NPV) was 78%. The results of comparative analysis of detection of traumatic injuries at CXR and MDCT in 30 patients, and the diagnostic value of CXR compared to MDCT, are presented in Table 3.

Table 3. Assessment of diagnostic value of CXR compared to MDCT in diagnosis of traumatic injuries

Tabela 3. Ocena wartości diagnostycznej RTG klatki piersiowej w odniesieniu do WTK w diagnostyce uszkodzeń urazowych

No	Radiological symptom	MDCT	CXR	Occult injuries	Sensitivity/specifity/accuracy of CXR
1)	rib fractures	20	14	6	70/100/0.80
2)	shoulder-blade fracture	6	0	6	0/100/0.80
3)	sternum fracture	4	1	3	25/100/0.90
4)	clavicle fracture	4	1	3	25/100/0.90
5)	spinal fracture	5	0	5	0/100/0.83
6)	pneumothorax	19	11	8	57.9/100/0.73
7)	hemothorax	24	14	10	58.3/100/0.67
8)	lung contusion	11	8	3	72.7/100/0.90
9)	lung laceration	10	2	8	20/100/0.73
10)	aspiration changes	5	4	1	80/100/0.97
11)	atelectasis	12	7	5	50/94.4/0.77
12)	mediastinal emphysema	8	3	5	37.5/100/0.83
13)	tracheal and bronchial injury	7	0	7	0/100/0.77
14)	diaphragm injury	4	2	2	50/100/0.93
15)	subcutaneous emphysema	15	12	3	80/100/0.90
16)	chest wall hematoma	6	2	4	33.3/100/0.87
	TOTAL	160	81	79	66.7/58/0.78

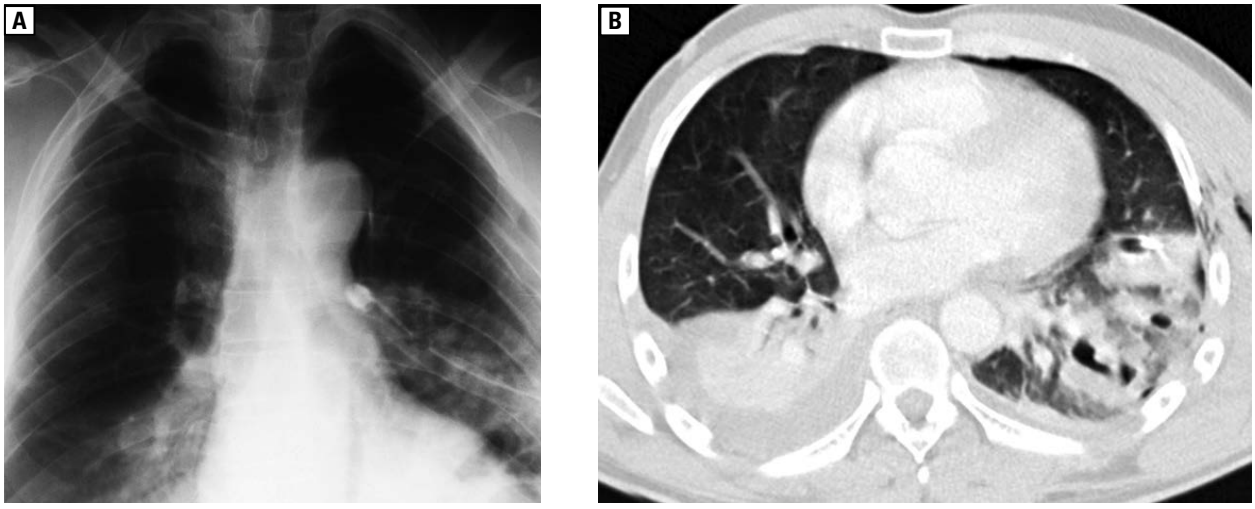

Figure 3A, B. Blunt chest trauma. Left lung contusion and lung laceration with hematocele and hemato-pneumocele; (a) chest X-ray; (b) multidetector computed tomography

Rycina 3A, B. Pacjent po tępym urazie klatki piersiowej. Stłuczenie i rozerwanie lewego płuca z obecnością krwiaków — hematocele i hemato-pneumocele; (a) zdjęcie rentgenowskie; (b) wielorzędowa tomografia komputerowa

Analysis showed a diagnostic advantage of MDCT over CXR in the detection of all chosen chest traumatic injuries. Low sensitivity of CXR concerned all injuries, including those for which a statistically significant difference between CXR and MDCT was not proved, i.e. sternum and clavicle fracture, lung contusion, diaphragm injury and subcutaneous emphysema. Injuries discovered at MDCT and invisible at CXR were defined as occult injuries. 160 injuries of the chest were detected by MDCT, whereas only 81 were detected by CXR. Consequently, there were 79 occult injuries on X-ray images. Statistically significant differences in detection between CXR and MDCT

were found for rib polyfractures, shoulder-blade fracture, pneumothorax, haemothorax and lung laceration. A distinct advantage of MDCT was found for sternum and clavicle fractures, bleeding to the pleural cavity, lung laceration (Fig. 3A, B) and mediastinal emphysema.

Comparison of MDCT with intraoperative assessment

A total of 23 patients underwent thoracosurgical treatment. Complete compatibility between the MDCT result and intraoperative assessment was noted in 10 patients (43.5%, 95% CI 25.6–63.2%). Lack of compatibility was found in 13 patients (56.5%), incompatibility of 1 symptom concerned 11 examinations and incompatibility of 2 and 4 symptoms occurred at MDCT in individual patients. The most frequent reason for incompatibility was underdiagnosis of slight diaphragm injuries or indication of the places of lung laceration, obscured with density due to lung contusion. The type of chest trauma in the study group did not influence the accuracy of MDCT examination.

The sensitivity and specificity of MDCT comparing to intraoperative assessment for the listed chest traumatic injuries was as follows: lung contusion — 100/94; lung laceration — 70/100; atelectasis — 99/77.8; pneumothorax — 93.8/100; haemothorax — 84.2/100; mediastinal emphysema — 100/100; haematomediastinum — 80/100; tracheal and bronchial injury — 80/88.9; pericardial haematoma — 66.7/100; diaphragm injury — 33.3/90, subcutaneous emphysema — 100/92.3; chest wall haematoma — 83.3/100; and rib fractures — 94.1/100. In respect of life-threatening injuries, the calculated diagnostic values were high; relatively low values were obtained for diaphragm injuries. The calculated values were not reliable for cardiac and aortic injuries due to the small number of such injuries diagnosed in the study group.

Comparison of MDCT and bronchoscopy

A total of 11 injuries of the trachea or bronchi were diagnosed at MDCT examination. Complete compatibility of MDCT and bronchoscopy in diagnoses of tracheal and bronchial injuries was found in 8 cases, incompatibility — in 3 patients. Bronchoscopy did not confirm suspected injury of the membranous part of the trachea (2 patients) and injury of the bronchus filled with secretion, with coexistence of massive pulmonary changes — contusion and atelectasis (1 patient). No statistically significant difference was proved between the results of bronchoscopy and MDCT. Sensitivity of MDCT comparing to bronchoscopic assessment in the analysed cases was 100%, specificity was 72.7% and NPV was 86.4 %.

Discussion

A high number of chest trauma is the consequence of development of civilization. The mechanism of trauma influences the severity of sustained injuries. Many authors use the term high energy trauma for car accidents at a speed of > 50 km/h, accidents involving severe damage to the vehicle, falls from a height > 3 m and for being crushed by a heavy object [9]. High energy trauma increases the risk of occurrence of life-threatening chest injuries, including the risk of aortic rupture.

The study group included patients with a history of blunt trauma (85%) and penetrating trauma (15%). The majority of sustained injuries fulfilled criteria of high energy trauma and nearly every analysed MDCT scan showed numerous traumatic chest injuries. Among patients with blunt chest trauma, admitted as a matter of urgency, the most frequent severe injuries were pneumothorax, haemothorax and lung contusion, and in patients admitted to planned visits it was haemothorax and diaphragm rupture. In the group of blunt traumas the most frequent injuries were rib polyfractures. The most frequent injuries in the group of penetrating traumas were haemothorax and pneumothorax; 1/3 of patients had subcutaneous emphysema and chest wall hematomas. In the analysed material a statistically significant relationship was shown between the type of trauma and traumatic injury. In patients from group 1 lung contusion and rib fractures were found significantly more frequently, in the group 2 it was pericardial haematoma.

The comparative analysis of CXR images and chest MDCT in respect of chosen traumatic injuries, including lung contusion and laceration, tracheal and bronchial injuries, fractures of osseous elements, pneumothorax, haemothorax and diaphragm injuries, revealed the advantage of MDCT in all listed types of injuries. MDCT showed 160 chest injuries, whereas CXR images showed only 81. The number of injuries not recognized on CXR images amounted to 79, and they usually concerned haemothorax, pneumothorax, lung laceration, tracheal and bronchial injury, and rib and shoulder-blade fractures.

The prevalence of severe injuries was similar in the presented group to those presented in

the literature [10, 11]. In the analysed material, a large number of severe injuries, invisible on X-ray, were found during MDCT. All fractures of shoulder-blade and thoracic spine, tracheal and bronchial injuries were invisible at X-ray examination. For rib polyfractures, shoulder-blade fractures, pneumothorax, haemothorax, lung laceration and tracheal and bronchial injuries, the difference in detection between X-ray and MDCT was statistically significant. The exception was lung contusion, for which the difference in detection between X-ray and MDCT was not significant. CXR showed 8 cases, and MDCT showed 11 cases. The lack of difference between the MDCT and CXR values in this field might have been connected with the time of examinations performed at our centre. We analysed patients with severe chest traumas, earlier diagnosed and stabilized at local traumatic centres; therefore, as some time had passed, the symptoms of lung contusion were visible also on X-ray images.

For all assessed injuries, sensitivity of X-ray examination was 66.7%, specificity — 58%, negative predictive value — 78% and positive predictive value — 43%. The sensitivity and specificity of X-ray examination determined by Exadactylos et al. in 2001 were not high either; they amounted to 82% and 57%, respectively, with PPV and NPV coming to 87% and 48%, respectively [4]. In 2009 Hammad et al., in a prospective analysis of X-ray and MDCT values in 443 patients with chest trauma, showed a low sensitivity of CXR (66.9%), with a specificity of 100% and NPV of 18.6% [12]. Diagnostic efficacy rates of CXR reported in the literature and from our own observations are presented in Table 4.

The advantage of CT over CXR in the assessment of early consequences of trauma has been proven in the present study and in the available literature. MDCT allowed diagnosis of severe and life-threatening injuries such as lung contusion, pneumothorax, haemothorax and lung laceration.

In the analysed material, in 25/30 patients (83.3%) the result of CT significantly influenced further therapy. A high proportion of surgical procedures in the study group were the result of the severity of injuries diagnosed at our centre. Different data concerning the influence of MDCT on the treatment of chest traumas in the literature may result from lower incidence of severe injuries [10]. The studies in which the influence of MDCT on therapeutic decisions was low concerned a great number of patients with no abnormalities on CXR image (Table 5).

In the studied material, chest MDCT was used not only in emergency assessment of trauma. It was also a valuable method of assessment of patients admitted to a planned visit; 70% of them were operated after acquisition of MDCT images. These patients usually suffered from delayed haemothorax and injuries predominating in the group of blunt injuries. Persistent bleeding to the pleural cavity occurred 2–3 days after trauma, often coexisting with rib polyfractures and usually the result of intercostal artery damage [15, 17].

Complete compatibility of the MDCT image with intraoperative assessment was found in 43.5% of cases. In the vast majority of cases, the lack of compatibility concerned a single symptom, and the most frequent reasons for it was underdiagnosis of slight diaphragm injuries or lung laceration focus, obscured by the parenchymal density being the result of lung contusion. Lung laceration obscured by parenchymal or pleural changes is reported in the literature as a frequent

Table 4. Diagnostic efficacy rates of CXR in chest trauma in the literature and in the material from own study

Tabela 4. Wskaźniki skuteczności diagnostycznej RTG w urazach klatki piersiowej w piśmiennictwie i materiale własnym

Author	Sensitivity of CXR	Specificity of CXR
Exadactylos [4]	82%	57%
Salim [13]	69%	94%
Lopes [14]	61%	71%
Hammad [12]	66.9%	100%
Own material	66.7%	58%

Table 5. The influence of CT results on medical tratment in the literature and material from this study

Tabela 5. Wpływ wyniku tomografii komputerowej na postępowanie lecznicze w piśmiennictwie i materiale własnym

Author	Alteration of therapeutic modality after MDCT result	Proportion of normal CXR images in the material
Trupka [11]	70%	22%
Lopes 14]	22%	61%
Traub 10]	19%	Not mentioned
Hammad [12]	20%	37.7%
Barrios [16]	15%	71%
Material from the study	83 %	0

cause of difficulties in diagnosis at MDCT [18].

Assuming intraoperative assessment as the gold standard, sensitivity and specificity of MDCT were calculated for evaluated individual chest traumas. For severe, potentially fatal traumatic injuries the calculated sensitivity and specificity of MDCT were high, e.g. for lung contusion it was 100 and 94%, for pneumothorax — 93.4 and 100%, haemothorax — 84.2 and 100% and for lung laceration — 70 and 100%. The relatively low diagnostic measurements for diaphragm injuries (33.3 and 90%) could be the result of artefacts, the coexistence of exudate in the pleural cavity and diaphragm relaxation, which made interpretation of MDCT images more difficult.

Tracheal and bronchial injuries were diagnosed at MDCT with sensitivity and specificity amounting to 80 and 88.9%, respectively, which is comparable to similar parameters available in the literature, which range from 70 to 100% [2]. When tracheal or bronchial injury is suspected based on MDCT results, the reference examination is bronchoscopy. Tracheal or bronchial injury suspected at MDCT in 11/60 patients was confirmed by bronchoscopy in 8 cases. False positive results of MDCT concerned suspected injury of the membranous part of the trachea due to an uneven outline of the wall and the coexistence of mediastinal emphysema in 2 patients, and in one case — suspected injury of the lobar bronchus obscured by massive parenchymal density — contusion and atelectasis. No statistically significant difference was found between MDCT results and bronchoscopy for tracheal and bronchial injuries, which confirms the high value of MDCT in the assessment of such injuries.

Conclusions

1. MDCT was a method of high sensitivity and specificity in the assessment of life-threatening injuries.
2. The diagnostic value of MDCT was slightly lower in the assessment of diaphragm injuries and lung parenchyma laceration with massive lung contusion.
3. MDCT was a valuable method in emergency assessment of injuries and traumatic complications of the trachea and bronchi.
4. MDCT results significantly influenced further treatment of patients with chest trauma, especially those with high energy trauma.
5. In comparison with MDCT, CXR image used in initial assessment had low sensitivity and specificity for diagnosing chest injuries.

Conflicts of interest

The authors declare no conflicts of interest.

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