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Treatment of blunt thoracic trauma in a Level 1 Trauma Center

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DOI: https://doi.org/10.21755/MTO.2024.067.0001.001

ABSTRACT

Blunt chest trauma has a significant high morbidity and mortality rate. In general, the treatment is conservative; in the case of hemothorax, pneumothorax, and hemopneumothorax chest tube drainage is often required. Immediate surgery is indicated in massive bleeding, tracheal and oesophageal injuries, and pericardial tamponade. Elective surgery should be performed in the case of retained hematoma, unresolved pneumothorax and flail chest. The first prioritized procedure is video-assisted thoracoscopy. The aim of this study is to analyze the treatment options and therapeutic results in reviewing 8,108 patients afflicted with blunt thoracic trauma. In over a three-year period 7,853 patients' data were analyzed. Altogether 1,624 (20.68%) patients suffered severe injuries, such as sternal or rib fracture(s), pleural or lung injuries. In this group, a simple rib fracture (1-3) was diagnosed in 1,466 (90.27%), unilateral serial rib fracture (≥4) in 84 (5.17%), bilateral rib fracture in 16 (0.99%) and flail chest in 47 (2.89%) patients. In 11 (0.68%) cases, only parenchymal injuries without rib fracture were found. Altogether, 190 (11.70%) patients were afflicted with pneumothorax, hemothorax, or both, and only 86 (45.26%) of these cases required chest tube drainage. One immediate thoracotomy was needed to staunch massive bleeding and elective video-assisted thoracoscopy was performed in 6 cases. Lung contusion was diagnosed in 57 (3.51%) patients. The most frequent complication was pneumonia with a rate of 0.19% (15 patients). Empyema (3 patients), unresolved pneumothorax (1 patient), and retained hematoma (4 patients) occurred in 0.04%, 0.01% and 0.05% of the cases, respectively. Altogether, 13 (0.17%) patients succumbed at a mean age of 63.54±21.92 years. Three of these cases (23.08%) experienced multiple trauma and 12 (92.31%) suffered from concomitant chronic diseases. Patients with blunt chest trauma rarely required immediate operation. Overall, in the case of unresolved pneumothorax and retained hematoma, surgery is indicated, in which these cases video-assisted thoracoscopy is the first and primary option.

Keywords: ***Chest injuries; Hemothorax; Pneumothorax; Thoracic Injuries; Thoracoscopy;***

INTRODUCTION

The incidence of blunt chest trauma is increasing in direct proportion to the number of traffic accidents, resulting in thoracic injuries having a high rate of morbidity and mortality due to damage to the breathing and circulation system. Pain, damage to the chest wall and/or intrathoracic organs may lead to diminished levels of breathing and circulation, and traumatic pneumothorax (PTX), hemothorax (HTX) or hemopneumothorax (HPTX), all of which can further compromise ventilation (3, 4, 11, 14, 18, 23).

The most common causes of blunt thoracic injuries are traffic accidents and falls from heights, among others. The severity of damage is dependent upon the contact area, the density, strength, rigidity and velocity of the causative object (1, 4, 14, 23, 24). Mild trauma to the chest can cause soft tissue contusion, abrasion or laceration of the chest wall. Fracture(s) of the ribs, sternum, shoulder or vertebral column are more severe. Flail chest is a life threatening condition often associated with lung and/or heart contusion, hemo- and pneumothorax, and large vessel injuries. As a result of chest wall instability, pleural air and/or blood effusions, lung contusion, pain and respiratory failure rapidly evolves (3, 4, 6, 14, 18, 21, 23). Additionally, 30–75% of patients suffering from lung contusion often leads to ARDS and/or pneumonia (4, 14, 18, 24).

The knowledge of circumstances and the mechanism of the trauma, as well as proper physical examination, are deemed essential (1, 3, 4, 14, 20, 21, 23). In consideration of a more precise diagnosis, computed tomography (CT) scans are routinely administered, since it is highly effective in diagnosing rib, sternum and vertebral fractures, PTX, HTX, lung contusion and tracheal or large vessel injuries (1, 3, 4, 6, 9, 12, 14, 17, 18, 21, 23, 24). The 3D CT reconstruction is suitable for the visualization of sternum and rib fractures, dislocation of sternoclavicular joint, as well as the operative planning of rib fixation (14), whereas chest ultrasonography (US) has a good diagnostic effect in PTX, HTX, hemopericardium, lung contusion, rib and sternal fractures (1, 3, 4, 14, 18, 20, 21).

The treatment of blunt chest trauma is essentially conservative, relying on pain management (NSAIDs, opioids, intercostal block, continuous epidural or erector spinae block), physiotherapy and early mobilization (3, 4, 11, 23), while in the case of flail chest and/or lung contusion, mechanical ventilation may also be necessary (3, 4, 6, 18, 24).

In massive PTX and HTX cases, chest tube drainage is required (1, 3, 4, 16, 21, 22, 23, 24). Despite adequate chest tube drainage, retained and/or clotted hematoma can still occur, of which, requires surgical intervention. If chest tube drainage in PTX fails, the lung lesion must be treated surgically, whereas in elective cases, video-assisted thoracoscopy (VATS) is generally the first option (2, 7, 8, 10, 19, 21, 22). In flail chest procedures, the surgical fixation of the ribs and sternum may be indicated (3, 4, 23).

The aim of this study is to analyze the treatment and assess its results in consideration of 8,108 patients with blunt thoracic trauma examined in this research.

PATIENTS AND METHODS

During a three-year period between 1 January 2017 and 31 December 2019, 8,108 patients afflicted with thoracic injuries were treated at the Institute of Orthopedics and Traumatology, University of Debrecen. Of these, 255 patients were excluded from our study, with the exclusion criteria being, blunt chest injuries was the initial treatment of which was initiated in some other institute, as well as incomplete patient data in the database. Altogether 6,229 (79.32%) of the 7,853 patients were diagnosed with only chest wall contusion and/or abrasion. The remaining 1,624 patients (20.68%) experienced severe injuries including sternal or rib fracture(s), pleural or lung injuries. This group was further analyzed in greater detail.

In our study, 951 (58.56%) of the 1624 patients were male and 673 (41.44%) were female with a mean age of 62.02±16.77 (0-99) years. Multiple traumas were observed in 27 (1.66%) patients. The most common cause of blunt thoracic trauma was the result of a standing/walking fall due to slipping, tripping or stumbling in 790 (48.65%) subjects, and traffic accidents in 229 (14.10%)

patients (*Figure 1*). Altogether, 467 (28.76%) of the 1,624 patients were offered hospital treatment, however, only 277 (17.06%) of these individuals accepted it.

The severity of the trauma was calculated using the Thorax Trauma Severity Score (TTSS). Simple rib fracture (1-3) was diagnosed in 1466 (90.27%) patients. In 39 (2.66%) of these patients, pneumothorax occurred in 62 (4.23%) hemothorax occurred in 21 (1.43%) in which hemopneumothorax was revealed. Unilateral serial rib fracture (≥4) was diagnosed in 84 (5.17%) cases. In this group, 13 (15.48%) cases of PTX, 7 (8.33%) cases of HTX and 8 (9.52%) cases of HPTX were reported. Bilateral simple rib fracture was found in 16 (0.99%) patients, accompanied by HTX in 1 (6.25%) and HPTX in 2 (12.50%) patients. Flail chest caused by multiple rib fractures was diagnosed in 47 (2.89%) patients, of which, flail chest was accompanied by PTX in 5 (10.64%), HTX in 8 (17.02%) and HPTX in 16 (34.04%) cases. In 3 (0.18%) patients, an isolated sternum fracture without any complication and in 1 (0.06%) case thoracic vertebral fracture with HTX was found. Altogether, in 7 (0.43%) patients without any fractures, 1 was diagnosed with HTX, 3 with PTX and 3 with HPTX (*Table 1*).

All patients were administered pain management (NSAIDs, opioids, intercostal block, continuous epidural or erector spinae block), physiotherapy and – in selected cases – antibiotic therapy. Altogether, 190 patients experienced pleural air and/or fluid effusion resulting from blunt thoracic trauma. Out of all the 1,624 patients, 60 had PTX, 80 were diagnosed with HTX and 50 with HPTX. Chest tube drainage due to PTX was performed in 39 (65.00%), HTX in 10 (12.50%) and HPTX in 37 (74.00%) patients. In summary, out of the 190 patients with PTX, HTX or HPTX, only 86 (45.26%) required chest tube drainage.

Lung contusion was diagnosed in 57 (3.51%) patients, 34 (59.65%) of these cases were unilateral and 23 (40.35%) were bilateral. All lung contusions were associated with rib fractures, PTX, HTX, or both PTX and HTX. Of all the cases, 1 lobe involved among 28 patients, 2 lobes in 20, 3 lobes in 5, 4 lobes in 3, and 5 lobes in 1 patient. All patients were administered conservative treatment including inhalation therapy, expectorants and antibiotics, accompanied by adequate pain management and physiotherapy. In cases of severe contusions with more than one lobe involved, intensive care was used: Non-Invasive Ventilation (NIV), Bilevel Positive Airway Pressure (BiPAP), or Airway Pressure Release Ventilation (APRV) was added to complement the conservative treatment detailed above.

Only one patient required urgent thoracotomy due to significant bleeding from the lacerated lung, in which one of the fractured ribs penetrated into the right lower lobe lacerating it. In this patient, a suture of the lung and partial resection of the fractured rib was performed. Additionally, 6 uniportal VATS were also performed due to retained and/or clotted hematoma and failure of chest tube drainage for PTX (*Figure 2*).

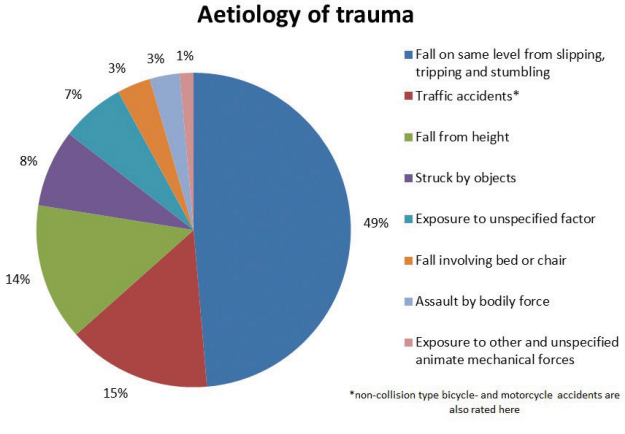

Figure 1
Aetiology of trauma

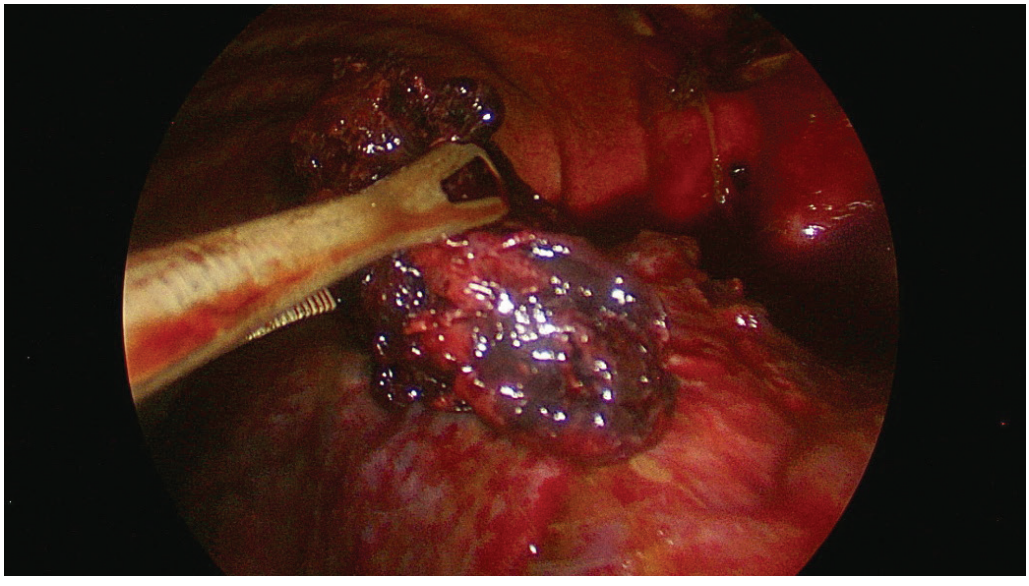

Figure 2
Uniportal VATS for retained, clotted haematoma

		PTX	HTX	HPTX	No pleural injury
Simple rib fracture (1-3) n=1466		39	62	21	1344
Unilateral serial rib fracture (≥4) n=84		13	7	8	56
Bilateral simple rib fracture (1-3) n=16		0	1	2	13
Flail chest n=47		5	8	16	18
No rib fracture n=11	Isolated sternal fracture n=3	0	0	0	3
	Thoracic vertebral fracture n=1	0	1	0	0
	No fracture n=7	3	1	3	0
all n=1624		60	80	50	1434

Table 1
Distribution of patients with severe thoracic injury
(PTX: pneumothorax, HTX: haemothorax, HPTX: haemopneumothorax)

RESULTS

The mean of TTSS was 4.79±2.09 points (0-17). At TTSS 8 points 3.70%, at 12 points 37.50% and over 12 points, 100% of the patients required intensive care. Out of the 1,566 patients with simple, either unilateral serial or bilateral rib fractures, 13 (0.83%) cases of pneumonia or 2 (0.13%) cases of empyema were detected as a complication. Mechanical ventilation was applied in 16 (1.02%) cases. In this group, the mortality rate was 0.64% (10 patients) (*Table 2*).

There were 2 (4.26%) cases of pneumonia and one case (2.13%) of empyema observed among the 47 patients with flail chest. Mechanical ventilation was required in 10 (21.28%) patients. In this group, the mortality rate was 4.26% (2 patients) (*Table 2*). These patients also experienced lung contusion, PTX, HTX, or all of these afflictions. The cause of death is specified in the chapter referencing PTX, HTX and HPTX.

The mean time of chest tube drainage for traumatic PTX (60 patients) was 6.37 (1-11) days, the preferred length was 3-4 days. Extended chest tube drainage was applied in patients requiring mechanical ventilation. In one patient, uniportal VATS was performed since the pneumothorax unresolved following 11-days of drainage. This patient recovered with no further difficulties. In one (1.66%) case, empyema and pneumonia developed; these were treated conservatively. In this group only one (1.66%) patient succumbed, of which, the patient suffered a concomitant brain injury which was incompatible with life (*Table 2*).

In patients with HTX (80 patients), the mean time of chest tube drainage was 5.90 days (1-12). In this group, pneumonia occurred in 6 (7.50%) cases. In regards to two patients (2.50%), uniportal VATS was performed in the treatment of retained and clotted hematoma (Figure 2). These two patients recovered without any complications. In this group, the mortality rate was 3.75% (3 patients) (*Table 2*). The causes of death are summarized in Table 3.

In the HPTX group (comprising 50 patients) the mean time of chest drainage was 8.30 (1-51) days. One (2.00%) urgent thoracotomy and 3 (6.00%) VATS were performed, one of which was performed on the 5th day of hospitalization. The other two patients were operated on later (20th, 27th day), while mechanical ventilation was required due to flail chest and lung contusion accompanying HPTX. In one of these cases, the CT scan suggested a possible diaphragm injury, which was not verified intraoperatively. All of the 50 patients with HPTX 7 (14.00%) developed some type of complication. One (2.00%) had empyema, 6 (12.00%) had pneumonia and 6 (12.00%) patients expired (*Table 2*).

Out of the 57 patients with lung contusion, 4 (7.02%) had pneumonia and 2 (3.51%) had empyema as a complication of chest tube drainage. In this group, mechanical ventilation was applied in 19 cases (33.33%). Lung contusion in these patients was complicated with PTX in 12 (21.05%), with HTX in 6 (10.53%) and with HPTX in 25 (43.86%) cases. Additionally, 1 patient required VATS for retained hematoma and 1 patient required urgent thoracotomy for significant bleeding.

Out of the 86 patients who required chest tube drainage, immediate surgery (thoracotomy) was indicated in only one case, due to massive and continuous bleeding. In consideration of 6 patients, chest tube drainage was unsuccessful; therefore surgery was indicated. All operations were VATS. Two of these patients eventually succumbed to pneumonia, after having been given prolonged mechanical ventilation. Overall, 13 (0.17%) out of 7,853 patients expired at a mean age of 63.54±21.92 years. Three of the patients (23.08%) experienced polytrauma and 12 (92.31%) suffered from concomitant chronic disease(s) (*Table 3*).

	Pneumonia	Empyema	Mechanical ventilation	Surgery	Death
Rib fracture (simple, unilateral serial, bilateral) n=1566	13	2	16	3 VATS	10
Flail chest n=47	2	1	10	2 VATS 1 thoracotomy	2
No rib fracture n=11	0	0	1	1 VATS	1
all n=7853	15	3	27	6 VATS 1 thoracotomy	13
PTX n=60	1	1	6	1 VATS	1
HTX n=80	6	0	3	2 VATS	3
HPTX n=50	6	1	15	3 VATS 1 thoracotomy	6
all n=190	13	2	24	6 VATS 1 thoracotomy	10
Lung contusion n=57	4	2	19	1 VATS 1 thoracotomy	6

Table 2

Complications and treatment results

(PTX: pneumothorax, HTX: haemothorax, HPTX: haemopneumothorax , VATS: video-assisted thoracoscopy)

	Age (years)	Sex	Pleural injury	Type of fracture	Lung contusion	TTSS (point)	Concomitant diseases	Cause of death
#1	37	male	PTX	one-sided serial rib fracture (≥4)	yes	6	chronic alcoholism	subarachnoid haemorrhage, polytrauma
#2	83	male	HTX	simple rib fracture (1-3)	no	8	Alzheimer's disease, schizophrenia	pneumonia, sepsis
#3	68	male	HTX	simple rib fracture (1-3)	no	10	hypertension, atrial fibrillation	pneumonia, sepsis
#4	90	male	HTX	simple rib fracture (1-3)	no	8	prostate cancer	cardiorespiratory insufficiency
#5	79	male	HPTX	no fracture	yes	10	COPD, ICD, AV block	cardiorespiratory insufficiency
#6	74	male	HPTX	one-sided serial rib fracture (≥4)	yes	11	COPD, hypertension	pneumonia, sepsis
#7	69	male	HPTX	simple rib fracture (1-3)	yes	11	COPD	empyema, sepsis
#8	26	male	HPTX	flail chest	yes	12	hypertension	cardiorespiratory insufficiency, polytrauma
#9	22	male	HPTX	simple rib fracture (1-3)	yes	12	-	multiple organ distress syndrome, polytrauma
#10	73	male	HPTX	flail chest	no	12	benign prostatic hyperplasia	pneumonia, sepsis
#11	80	male	-	simple rib fracture (1-3)	no	6	prostate cancer, pleural metastases	cardiorespiratory insufficiency
#12	56	male	-	simple rib fracture (1-3)	no	4	hypertension, DM	cardiorespiratory insufficiency
#13	69	female	-	simple rib fracture (1-3)	no	4	hypertension, ICD	acute myocardial infarction, pneumonia

Table 3

Causes of death (PTX: pneumothorax, HTX: haemothorax, HPTX: haemopneumothorax , COPD: chronic obstructive pulmonary disease, ICD: ischaemic cardiac disease, AV block: atrioventricular block, DM: diabetes mellitus)

DISCUSSION

Blunt thoracic injuries originate from damage to the chest wall and/or intrathoracic organs, often resulting in impaired breathing and circulation. Additionally, the subsequent pain resulting from the damage also plays a crucial role in decreased ventilation. The lack of adequate expectoration results in bronchial secretion retention (3, 4, 11, 14, 23). Pneumothorax, hemothorax or the combination of the previous two cases lead to further worsening regarding ventilation. The contusion of lung parenchyma results in shunt circulation and can lead to ventilation insufficiency (3, 4, 11, 14, 18, 23).

The most common cause of blunt thoracic injuries include traffic accidents and falls from heights, among others, in which the severity of damage is dependent upon the density, contact area, strength, rigidity and velocity of the object causing the trauma (1, 4, 14, 23, 24). Contusion, abrasion, and laceration are damages inflicted to the soft tissue of the chest wall, while fractures of the chest cage (ribs, sternum, shoulder and thoracic vertebral column) evolve due to compression or high-energy injuries resulting from direct impact. Flail chest is a special life-threatening injury which results from multiple rib, sternal and vertebral fractures, and is often associated with lung or heart contusion, hemo- and pneumothorax and large vessel injuries. Due to the instability of the chest cage, PTX, HTX, lung contusion and pain, respiratory failure may unravel rapidly (3, 4, 6, 14, 18, 23). Therefore, traumatic PTX is one of the most common complications of blunt chest trauma. The aetiology can be barotrauma or pulmonary laceration due to a fractured rib. Tension PTX is a rare, yet a life-threatening form of pneumothorax. In hemothorax, the blood collection is located in the pleural cavity and can cause compression of the lung (1, 3, 4, 5, 6, 11, 14, 18, 21, 23).

Additionally, 30-75% of the patients afflicted with lung contusions of varying severity which may lead to respiratory complications such as ARDS and/or pneumonia (4, 14, 18, 24). Intrapulmonary alveolar rupture, bleeding and hematoma together may cause traumatic pseudocysts (4, 14, 17, 23), however, bronchial tree injuries resulting from blunt thoracic trauma are rare (3, 4).

Irrespective of the mechanism of the trauma, the outcome of blunt chest injuries is contingent upon the patient's age, their concomitant disease(s), the number of fractured ribs and the stability of the thoracic cage. Older patients' chest wall compliance is worse (3, 4, 14, 23). The knowledge of the mechanism of the trauma, as well as physical examination, are essential for the correct diagnosis (1, 3, 4, 12, 23, 24).

The basic imaging technique applied is the chest X-ray, which has good diagnostic value in PTX and HTX, yet poor diagnostic value in non-dislocated rib fractures. Breathing during image making and the supine position may also result in the misdiagnosis of smaller PTX and HTX (1, 3, 4, 14, 20, 21, 23). In critically ill patients, sometimes the only applicable imaging technique prior to definitive management is the chest X-ray (3).

The CT scan is a routine imaging technique in daily practice; although time is required to manage, its diagnostic efficiency is quite high. The CT scan is suitable for the visualization of costal, sternal and vertebral fractures, PTX, HTX, large vessel and tracheal injuries. It is also highly useful in lung injuries, such as contusions and traumatic pseudocysts (1, 3, 4, 6, 9, 12, 14, 17, 18, 21, 23, 24). In the case of sternal and rib fractures, sternoclavicular joint dislocation, as well as in planning the fixation of the fractured bones, it is the 3D CT reconstruction which is most helpful (14).

Chest US is a commonly used simple imaging technique. It is excellent in thoracic and pericardial fluid effusion (HTX, hemopericardium), air collections (PTX) and lung contusion. It also has high sensitivity and specificity in rib and sternal fractures (1, 3, 4, 14, 18, 20, 21).

To determine the severity of chest wall trauma, the AAST's (American Association for the Surgery of Trauma) scoring system is used, based on the number and location of fractured ribs and the depth of lacerations (14). The TTSS (Thorax Trauma Severity Score) is a system used for calculating the severity of chest trauma, which has a good correlation with the complications and mortality (15). Among the presented patients, TTSS was used for scoring.

At 8 points, intensive care was only needed in 3.70% of the cases, however, in the case of 12 points or more, the rate was 100%.

Contusion and simple rib or sternal fractures require conservative therapy including pain relief (NSAIDs), physiotherapy and early mobilization (3, 4, 23), with adequate pain management being the basic pillar regarding treatment. In cases involving severe pain, intercostal blockage or continuous intrapleural, epidural or erector spinae block may be indicated. In consideration of bilateral rib fractures, epidural anesthesia is preferred (3, 4, 11, 23).

In cases of significant HTX and PTX, chest tube drainage is required (1, 3, 4, 16, 21, 22, 23, 24), and if the attempt of drainage proves unsuccessful, surgery is indicated. In spite of adequate chest tube drainage, in 5-30% of hemothorax cases, retained and/or clotted hematoma occurs, which also requires surgical treatment; in such cases, the first choice procedure is VATS (2, 7, 8, 10, 19, 21, 22). In the case of unresolved PTX, the lung lesion should be repaired and any kind of pleurodesis is suggested (8, 10).

The treatment of flail chest is generally conservative, with mechanical ventilation often being necessary (6). The surgical fixation of the ribs and sternum using wire cerclage, clamping branches, plate or intramedullary fixation can shorten the ICU stay and also reduce the number of complications. However, there is no consensus regarding conservative or surgical treatment (3, 4, 23).

The treatment of lung contusion is basically supportive. The observation of vital functions, O2 therapy, adequate pain management, antibiotics, correct fluid balance, physiotherapy and mechanical ventilation are all essential in the process. Additionally, the concomitant HTX, PTX and flail chest should also be treated (3, 4, 18, 24). Despite the multidisciplinary therapy, lung contusion has a high rate of morbidity and mortality (3). The incidence of lung contusion in the presented cases was 3.51%. To highlight the severity regarding lung contusion, it must be specified, 40.35% of these cases were bilateral and were complicated due to rib fracture(s) in 94.74% of the cases. HTX, PTX, or both in 75.44% of the cases, and 38.60% of the patients required ICU stay. The mortality rate was 10.53%.

Immediate intervention is indicated in case of tension or open PTX, massive hemothorax, pericardial tamponade, major tracheal injury and flail chest; altogether in 2-3% of the cases (1, 3, 12, 16, 21, 23, 24).

Generally speaking, an indication for surgical intervention can be immediate or elective. Immediate surgery is indicated in critical, unstable patients with the risk of severe bleeding due to a large vessel, heart or lung injuries. In the case of acute (immediate) indication, open surgery (thoracotomy, sternotomy) is recommended, while in elective cases, video-assisted thoracoscopy is recommended. Elective surgery is indicated for retained and/or clotted intrathoracic hematomas, persistent pneumothorax, flail chest, and major dislocation of ribs (1, 2, 4, 7, 8, 10, 13, 16, 19, 21, 22, 23, 24). In cases of blunt thoracic trauma, the first choice surgical procedure is VATS, which is indicated if the chest tube drainage for PTX and/or HTX failed, or in case of retained or clotted hematoma, empyema and possible diaphragmatic injury (1, 2, 3, 4, 5, 7, 8, 9, 10, 12, 13, 19, 21, 22). Lin et al. recommends fixing the fractured ribs during VATS (9). The incidence rate of empyema in retained intrathoracic hematoma is 26.8% with risk factors including rib fracture, high ISS (Injury Severity Score) and surgery for hematoma (5, 7). The results of early VATS (within 3-5 days following the trauma/ hospitalization) for retained hematoma are better (2, 7, 8, 10, 13, 19, 21, 22).

In this study VATS was indicated in one ineffective chest tube drainage for PTX, and one case of a potential diaphragm injury. In 4 cases, VATS was performed due to retained clotted hematoma. Urgent thoracotomy was performed in only one (0.13%) case, in which the patient was treated for a severe lung laceration due to a dislocated fractured rib.

The mean mortality rate of blunt chest trauma is 4-20% (12, 14). In this study, the mortality rate was 0.17% (13 out of 7,853 patients), with a mean age of 63.54 years. Three (23.08%) of the 13 patients suffered multiple forms of trauma and 12 (92.31%) experienced severe comorbidities.

Patients with blunt chest trauma required immediate operation, mostly in cases of

uncontrolled bleeding. In cases of unresolved PTX and retained clotted hematoma, early surgery is indicated and VATS is recommended as the first choice.

Acknowledgements

This work was supported by the Department of Traumatology and Hand Surgery, Institute of Orthopedics and Traumatology, University of Debrecen. The authors thank the staff of the department for their assistance.

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