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Treatment of blunt thoracic trauma in a Level 1 Trauma Center

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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*).

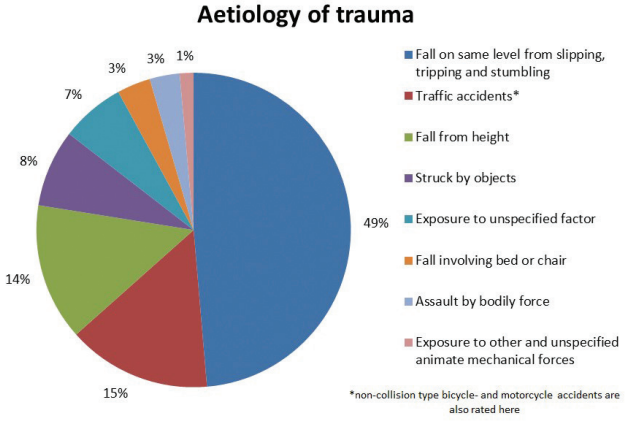

Figure 1
Aetiology of trauma

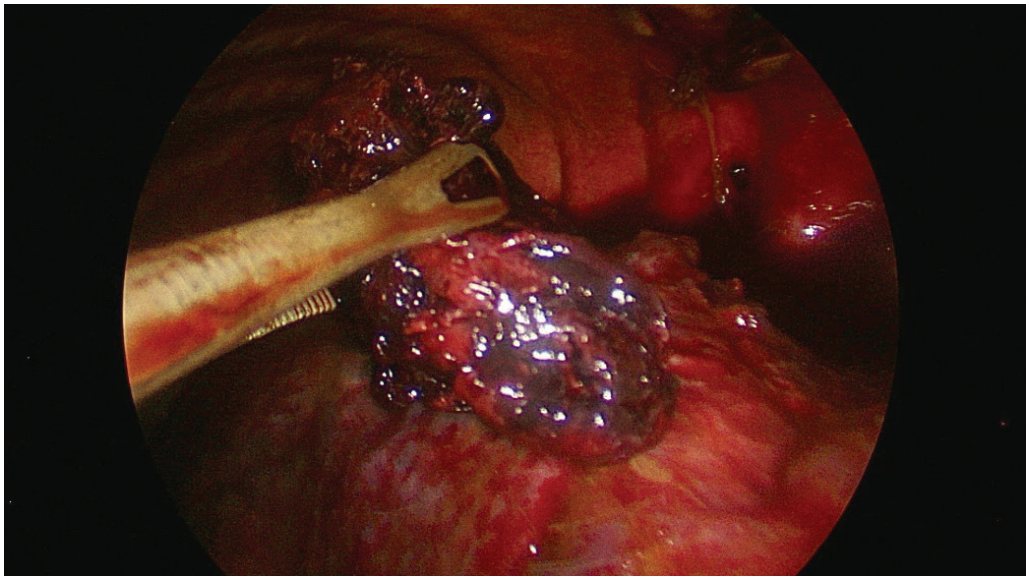

Figure 2
Uniportal VATS for retained, clotted haematoma

		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.

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Chronic anticoagulation therapy and acute hip trauma

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ABSTRACT

Regardless of the association between hip fracture surgery and mortality, morbidity and bleeding risks, there are still significant contradictions in various published articles concerning hip fracture surgery outcomes when patients are prescribed anticoagulant medication. The primary objective of this study was to investigate if patients prescribed anticoagulants experienced delayed surgery when compared to non-users. The secondary goal was to investigate if patients prescribed anticoagulants underwent an extended hospital stay and complications such as increased bleeding, mortality and a higher rate of comorbidities when compared to non-users. Data from proximal hip fracture patients were prospectively collected at a level I university trauma center. From 1 January, 2020, through 1 January, 2021, 519 eligible patients were identified. Anticoagulant medication upon admission, time prior to surgery, hospitalized days, 30-day mortality rates, 1-year mortality, blood transfusion requirement and various comorbidities were noted. 222 of the 519 hip fracture patients were prescribed anticoagulants. Of the 222 patients, 75% were females and 25% were males. In total, 46% required a blood transfusion, with no significant differences between the anticoagulated and non-anticoagulated patients. 50% of the anticoagulated group and 42% of the control group required perioperative blood transfusion. Neither the 30-day nor the 1-year mortality rate showed statistically significant differences between the groups. However, the time to surgery and the length of hospital stay was significantly longer in the anticoagulated group. Comorbidities were found in 87% of the patients: in 95% of the anticoagulated group and in 81% of the non-anticoagulated group. Patients prescribed anticoagulants at the time of hip fracture experienced delayed surgery, longer hospital stays and more comorbidities when compared to patients not on anticoagulants. Neither a blood transfusion requirement, 30-day mortality rate nor a 1-year mortality rate showed no significant difference between the two cohorts.

Keywords: ***Anticoagulants – adverse effects; Hip fractures – drug therapy/surgery; Postoperative complications – Prevention & control;***

INTRODUCTION

Hip fractures are one of the major burdens in orthopedic surgery and one of the most common fractures occurring among elderly patients. Low-energy trauma, such as senior patients falling from standing height, commonly results in proximal femoral fracture (PFF) which is associated with high morbidity and mortality rate (18). Many such patients require long-term nursing care. *Pedersen* et al. found there were 140,000 hip fracture patients admitted to nursing homes in the United States annually (17).

Today, due to the increasing life expectancy worldwide, a higher proportion of the population reaches 65 years or more. It is more likely a larger group of individuals suffer from osteopenia and osteoporosis, consequently increasing fracture risk. Hip trauma among the elderly is thus considered a worldwide epidemic with socioeconomic factors and a burden upon the public health system. Retrospective research by *Chatziravdeli* et al. describes the burden of hip trauma treatment on public health and how hip trauma patients prescribed anticoagulation medication often require delayed surgery and more postoperative care. They found the excess financial burden from the baseline costs of 447,904.60€ to be 4,074.64€ for those operated on within 48 hours and 45,654.14€ for those with delayed surgery (4).

In addition to warfarin, the new DOACs (Direct Oral Anticoagulants), also known as NOACs (New Oral Anticoagulants) such as rivaroxaban, dabigatran and apixaban are becoming increasingly favorable. A study from 2019 by *Schuetze* et al. describes one-third of all patients with PFF ingest oral anticoagulants and DOACs appeared to have 3 to 4 times increased risk of blood transfusion (20). Warfarin is the longest-used anticoagulant and its antidote, Vitamin K, is also more affordable than reversible agents used for DOACs. However, warfarin comes with disadvantages; it requires monitoring and interacts with various drugs. After ceasing warfarin therapy, it usually takes several days to decrease the INR (International Normalized Ratio) value, since it has an indirect coagulation effect (13). DOACs, on the other hand, do not require monitoring and have fewer drug interactions than when compared to warfarin (1).

The disadvantage of clopidogrel when compared to other anticoagulants is there is no known reversing agent, therefore, it can only be reversed by the production of new platelets within seven days from the last dosage. There is some concern clopidogrel may have an increased risk of bleeding in acute cases (5). Thus, it is recommended to interrupt clopidogrel for 5–10 days prior to a hip fracture surgery, which is done by more than 40% of UK orthopedic departments (8).

Guidelines from NICE (National Institute of Health and Care Excellence) recommend hip surgery is performed on the same day as admission and, if not, the day following (16). A retrospective cross-sectional study from 2019, published by *Caruso* et al., shows a delay in surgery and a significant increase in mortality in the warfarin group when compared to the control group within one year from the surgery. The delay in surgery is described as mostly being due to reaching the target INR value <1.5. This delay can be reduced by prescribing Vitamin K and prothrombin complex concentrate, preoperatively (2). Supporting *Caruso* et al., in 2011, *Dettoni* also found patients prescribed warfarin therapy, when compared to non-users, had a higher preoperative and postoperative risk of complications (7).

The primary purpose of this study was to examine if patients prescribed anticoagulants who sustain a PFF experienced delayed surgery when compared to non-users. Furthermore, we aimed to estimate the association between anticoagulant use and prolonged length of hospital stay, the presence of comorbidities and complications such as the increased need for blood transfusion, 30-day mortality and the 1-year mortality following a PFF.

PATIENTS AND METHODS

This research was approved by the Regional Research Ethics Committee, University of Pecs Clinical Center. Patients admitted to the level I orthopedic trauma department with the diagnosis of S7200 or S7210 between 1 January, 2020, and 1 January, 2021, of which, were identified in the electronic medical records. There was no age limit set. Data

regarding age, sex, use of anticoagulants, time to surgery, hospitalized days, blood transfusion, mortality within 30 days and one year and comorbidities were evaluated. The patients were divided into two cohorts based on whether they were anticoagulated at the time of the hip fracture or not: anticoagulated and non-anticoagulated groups. Statistical workup was done using Pearson's Chi–squared test, Kruskal–Wallis rank sum test, and Fisher's exact test. Significance was set at $P \leq 0.05$.

RESULTS

During the prospective study period, 614 hip fracture patients were identified. 93 cases with insufficient data were excluded. 521 patients were found relevant to this study.

Anticoagulants

The 521 patients were reduced to 519 due to insufficient data regarding anticoagulant use. Of the 519 extracted patients, 222 were prescribed anticoagulants at the time of the fracture. There were 75% female and 25% male patients. The anticoagulated group was divided into three groups based on the type of anticoagulant drug prescribed; 1. Platelet aggregation inhibitors; 2. Other anticoagulants than platelet aggregation inhibitors; 3. Both 1 and 2. The results in *Table 1* show most patients used platelet aggregation inhibitors from the anticoagulated group. Group 4 represents patients with no anticoagulant use.

Table 1 *Subgroups based on the anticoagulated status. NA: data not available*

Type of anticoagulant	N=521
1 - Platelet aggregation inhibitors	120 (23%)
2 - Other anticoagulants than platelet aggregation inhibitors	94 (18%)
3 - Both 1 and 2 use	8 (1.5%)
4 - No anticoagulant use	297 (57%)
NA	2

Time to surgery

When dividing the patient group into two cohorts, anticoagulated and non-anticoagulated, we could estimate the time to surgery for each group. The time to surgery was reported in hours, from the admission to the hospital until the onset of surgery (the surgical delay). A mean of two days was estimated for the entire patient group of 466, with a statistically significant difference (p–value = 0,001) between the anticoagulated group with a mean of 2.57 and the control group with a mean of 1.63 days (*Figure 1.*).

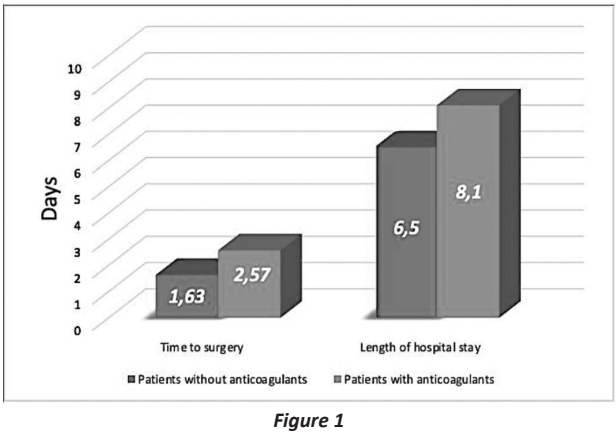

Figure 1
Time to surgery and the LOS in days for both groups

Length of hospital stay

The anticoagulated group showed a mean of 8.1 days hospitalized, while the control group was hospitalized a mean of 6.5 days. In total, the minimum number of days hospitalized was one day, and the highest number of days was 37 for the control group and 25 days for the anticoagulated group. The patients prescribed anticoagulants, on average, had a longer LOS (length of hospital stay) when compared to non-users.

Mortality

Mortality was estimated both for the total patient group and the calculated differences between the anticoagulated and the control group. The 30-day mortality rate of the anticoagulated group was 9.6%, and the control group had a slightly similar mortality rate of 9%, giving a p–value of 0.816. In total, 47 patients succumbed. The 1-year mortality rate, on the other hand, was increased among the anticoagulated patients. 27% of the anticoagulated patients expired within one year, and 18% of the patients from the control group, in total 72 patients died. Still, with a p–value of 0,063, it failed to achieve statistical significance. Additionally, 47 of the total 337 patients succumbed within one year, meaning they were already noted expired in the hospital or within the 30-day columns. 21 of these were anticoagulated, and 26 of them were not. There was no existing mortality data regarding 182 patients due to the fact, when mortality data were collected, only deaths occurring at the hospital of Pécs were found (*Table 2.*).

Table 2 *Patients' characteristics, time to surgery, hospitalized days, blood transfusion, and deaths within 30-days and one year. (Pearson´s Chi-Squared test and Wilcoxon rank sum test.) 0, N= Control group 1, N= Anticoagulated group*

			anticoagulant			
Characteristic	**N**	**Overall** N=519	**0.** N=297[1]	**1.** N=222[1]	**p-value**	**q-value[2]**
Sex	519(100%)				0.017[3]	0.024
1		160(31%)	104(35%)	56(25%)		
2		359(69%)	193(65%)	166(75%)		
time to surgery	466(90%)				**<0.001[4]**	<0.001
N (% not missing)		466(90%)	259(87%)	207(93%)		
Mean(SD)		2.05(2.18)	1.63(1.88)	2.57(2.40)		
Median(IQR)		2.00(1.00,3.00)	1.00(0.00,2.00)	2.00(1.00,3.00)		
Miniumum; Maximum		0.00;23.00	0.00;12.00	0.00;23.00		
NA		53	38	15		
Hospitalized days	518(100%)				**<0.001[4]**	<0.001
N (% not missing)		518(100%)	296(100%)	222(100%)		
Mean(SD)		7.2(4.0)	6.5(4.1)	8.1(3.7)		
Median(IQR)		6.0(5.0,9.0)	6.0(4.0,8.0)	8.0(6.0,10.0)		
Miniumum; Maximum		1.0;37.0	1.0;37.0	1.0;25.0		
NA		1	1	0		
Needed transfusion	517(100%)				0.088[3]	0.104
1		235(45%)	125(42%)	110(50%)		
2		282(55%)	171(58%)	111(50%)		
NA		2	1	1		
Death 30 days	506(97%)				0.816[3]	0.816
1		47(9.3%)	26(9.0%)	21(9.6%)		
2		459(91%)	262(91%)	197(90%)		
NA		13	9	4		
Death within 1 year	337(65%)				0.063[3]	0.082
1		72(21%)	35(18%)	37(27%)		
2		218(65%)	139(70%)	79(58%)		
4		47(14%)	26(13%)	21(15%)		
NA		182	97	85		

Blood transfusion

Of 517 patients, 235 (45%) required blood transfusion perioperatively. Of these, 110 (50%) belonged to the anticoagulated group. 125 (42%) patients received blood in the control group.

Comorbidities

448 of the total 517 hip fracture patients had comorbidities. 208 (95%) of these patients used anticoagulants. 240 (81%) patients from the control group also had comorbidities. Hypertension, coronary artery disease, stroke, atherosclerosis, diabetes mellitus and osteoporosis were conditions registered. Overall, the most common conditions were hypertension and coronary artery disease (*Figure 2.*)

Hypertension was found in many (384 of 517) patients. Of this, 186 (85%) belonged to the anticoagulated group and 198 (67%) to the control group. Statistically significant results were obtained with a p–value of 0.001. 144 of the 517 patients studied had coronary artery disease and 85 were anticoagulated (p–value= 0.001).

Furthermore, 40 patients were registered with stroke, and 27 were anticoagulated (p-value=0,001). Atherosclerosis was discovered in 28 of 517 examined patients, 19 from the anticoagulated group (p–value=0.005). Of the 517 studied patients, 121 had DM. The anticoagulated group with a markedly higher number of 73 patients represents 33% of the group, while the control group had 48 patients with DM, including 16% of the control group. P–value=0.001 (*Table 3.*)

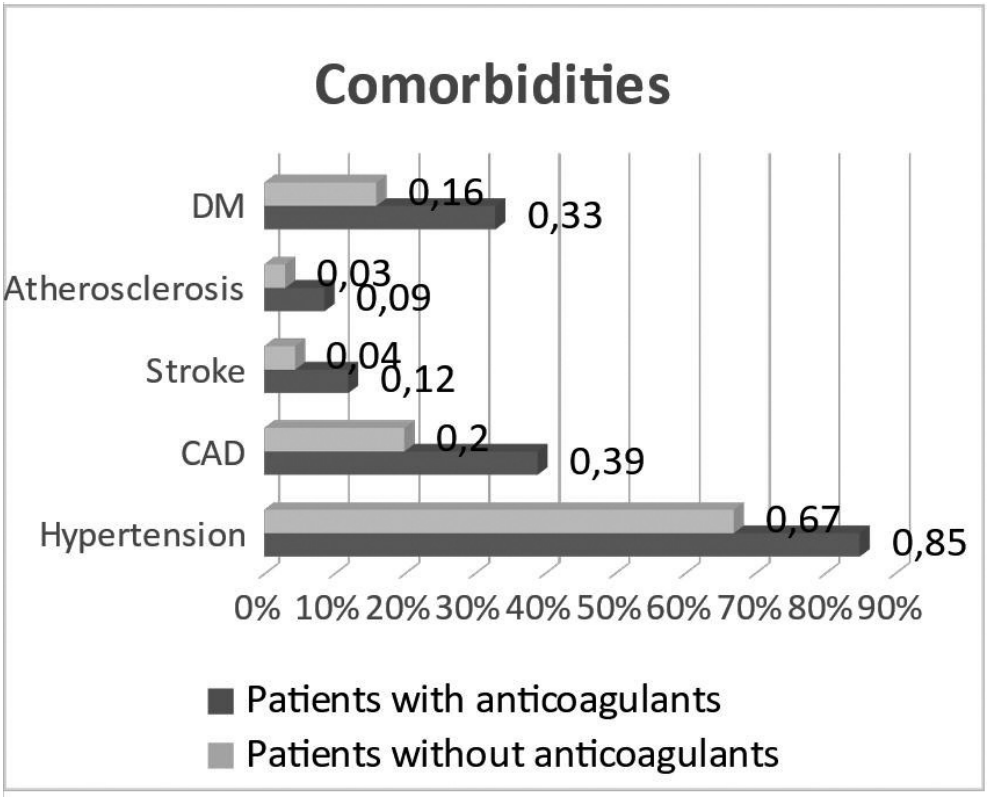

Figure 2
The prevalence of comorbidities in each studied cohort, with hypertension as the majority in both groups

Table 3 *Patients' comorbid conditions (Pearson's Chi-squared test)*

			anticoagulant			
Characteristic	**N**	**Overall** N=519	**0.** N=297[1]	**1.** N=222[1]	**p-value**	**q-value[2]**
Concomitant disease	517(100%)				**<0.001[3]**	<0.001
1		448(87%)	240(81%)	208(95%)		
2		69(13%)	57(19%)	12(5.5%)		
NA		2	0	2		
Hypertension	517(100%)				**<0.001[3]**	<0.001
1		384(74%)	198(67%)	186(85%)		
2		133(26%)	99(33%)	34(15%)		
NA		2	0	2		
CAD	517(100%)				**<0.001[3]**	<0.001
1		144(28%)	59(20%)	85(39%)		
2		373(72%)	238(80%)	135(61%)		
NA		2	0	2		
stroke	517(100%)				**<0.001[3]**	<0.002
1		40(7.7%)	13(4.4%)	27(12%)		
2		477(92%)	284(96%)	193(88%)		
NA		2	0	2		
osteoporosis	492 (95%)				0.664[3]	0.719
1		458(93%)	260(94%)	198(93%)		
2		34(6.9%)	18(6.5%)	16(7.5%)		
NA		27	19	8		

DISCUSSION

This single-center retrospective study revealed the use of anticoagulants at the time of hip fracture results in increased time to surgery, longer hospitalization and association with higher numbers of comorbidities among patients. The mean time to surgery regarding the anticoagulated patients was 2.57 days, versus 1.63 days for the non-anticoagulated group. Also, the multiple comorbidities play a significant role in the outcome since it requires more time to evaluate and prepare the patients for surgery. *Castelli* et al. observed an increase in LOS up to seven days for patients suffering from comorbidities at the time of the fracture (3). Comorbidities can also lead to an increase of surgical complications resulting in an increased hospital stay.

Whether anticoagulated hip fracture patients have poorer surgery outcomes is debatable. According to our results, it does not appear to be significantly worse, presumably, due to similar ages between the two cohorts or since concomitant diseases are affecting them both equally.

Hossain et al. and *Collinge* et al. showed no considerable elevation regarding the risk in hemorrhaging, bleeding complications and/or mortality in consideration of patients prescribed clopidogrel, aspirin or warfarin and undergoing early hip fracture surgery (5, 8). A possible explanation in support of the conflicting results implies each hospital uses different protocols, especially between countries, due to the lack of standardized international guidelines. Using different perioperative treatment protocols, including reversal agents and other hospital quality measures likely play a role. The method of surgical care of hip fractures may vary between countries and can also impact the results.

The necessity of delayed surgery once the patient is prescribed anticoagulants is also a source of controversy. A study by *Caruso* et al., in 2019 found patients prescribed

warfarin experienced increased surgical delay and decreased survival when compared to patients not prescribed anticoagulants (2). *Daugaard* et al. found patients on antiplatelets had an increased need of blood transfusion and mortality. Additionally, DOACs were only associated with a higher risk of blood transfusion (6). *Lawrence* et al. in 2016 highlighted warfarin as a "red flag" among patients who suffered a femoral neck fracture and found warfarin use to be associated with increased time to surgery, LOS and decreased survival (10). However, *Leer Salvesen* et al. in 2020 found no increased surgical delay, LOS nor bleeding complications in a group of 314 hip fracture patients on DOACs when comparing them to non-users (11).

Most of the proximal femoral fracture patients are elderly with comorbidities which require chronic anticoagulant medication. Therefore, it may be advisable to wait on surgery until the INR value is less than 1.5 reducing the risk of perioperative bleeding regarding these patients. It is also suggested in the use of vitamin K antagonists and other reversal agents, we can reach INR<1.5 faster and minimize unnecessary delays. A case-control study from *Mattison* et al. reported it is safe to use vitamin K and four-factor prothrombin complex concentrates on achieving INR values below 1.5 at a faster rate, when they analyzed 198 extracapsular PFF patients (15). Contradictory to this, *Caruso* et al. found even with the use of Vitamin K and a four-factor prothrombin complex, anticoagulant use leads to surgical delay (2).

In an article published in 2023 by *Levack* et al., 55 years or older proximal femoral fractured patients were evaluated, of which, 210 patients were undergoing warfarin therapy and 420 patients served as the matched control cohorts. The study revealed those patients treated with warfarin increasingly experienced delayed surgery and a greater number of post-operative complications when compared to matched controls without warfarin therapy (12).

A study by *Jørgensen* et al. studied the association between clopidogrel use and fracture risk. They found patients on recommended clopidogrel dosages had an increased risk of fractures, as well as osteoporotic fractures. It is still not known how clopidogrel affects bone metabolism. It is suggested the inhibiting effect of the platelets affects certain pathways in the osteoblasts and both osteoblasts and osteoclasts express P2Y12 receptors, potentially affecting bone remodeling (9).

A retrospective analysis representing 531 isolated hip fracture/PFF patients above 60 years-old was performed by *Lott* et al., from October 2014 through September 2016. It involved a comparison of the hospital quality outcomes between an anticoagulated group with either of the following: clopidogrel, warfarin, factor Xa inhibitors including rivaroxaban and apixaban, dabigatran and aspirin and a non-anticoagulated group. Initially, their results showed an increase in the mean LOS and time to surgery for the anticoagulated patients. After controlling for age, Charlson comorbidity index and the type of anesthesia used, they concluded anticoagulation alone is not independently responsible for exposing patients to increased risk, since the results were not significant (14).

No significant differences were found in our study regarding the mortality. The 1-year mortality showed a difference between the anticoagulated and the control group; however it was not statistically significant.

Most guidelines regarding hip fractures recently recommend surgery is performed within 48 hours from the time of the fracture. The Norwegian national quality indicator recommends surgery ideally within 48 hours from admission (19). This has been proven to be crucial in reducing postoperative complications and mortality. Surgical delay and comorbidities appear to be the main factors contributing to hip fracture complications among patients prescribed anticoagulants. A stricter management of comorbidities is important to diminish the postoperative complications and mortality. This can include measures such as more frequent screening for the different comorbidities as well as greater focus on reducing modifiable risk factors such as high blood pressure, elevated low-density lipoprotein cholesterol and osteoporosis. Additionally, more research regarding the antidotes of the various anticoagulants is essential.

Limitations of the study are numerous. Data were collected during the COVID restrictions, which may have influenced surgery delay data. The sample may be regarded heterogeneous since it involves fractures which required different types of surgeries. However, we feel the cohort is sufficiently large enough to minimize this bias. Mortality data were collected only from the hospitals in Pécs and the outcomes based on those data must be observed with discretionary caution. Our study only divides the anticoagulated cohort into "platelet aggregation inhibitors" and "other anticoagulants in addition to platelet aggregation inhibitors", hence, there is no sub-analysis performed for each anticoagulant, representing another limitation.

We believe further studies are needed to be able to establish an internationally accepted guideline regarding the management of patient prescribed anticoagulant therapy at the time of hip fracture.

CONCLUSION

Hip fracture patients are considered a vulnerable population with high morbidity and mortality rates. With the increase of the geriatric population and the comorbidities, the number of hip fractures is also increasing. More individuals require chronic anticoagulant therapy, which further causes challenges in treating an acute hip fracture.

Our study found there is delayed surgery, increased LOS and an increase in comorbidities in patients prescribed anticoagulants when suffering from a hip fracture compared to non-users at our department. However, the anticoagulated patients did not appear to be at substantially increased risk for perioperative bleeding. There were no significant differences in the 30-day mortality and 1-year mortality between the two cohorts.

We found published literature represents conflicting results. This highlights the importance of more accurate and understandable guidelines regarding perioperative procedures and the consequences for anticoagulated hip trauma patients.

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Emergency thoracostomy as a safe and effective intervention in prehospital trauma

A five year experience from the Hungarian Air Ambulance

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ABSTRACT

Traumatic tension pneumothorax is one of the most frequent causes of early mortality among the severely injured. Different methods are recommended for chest decompression. The aim of this study is to examine whether emergency thoracostomy can improve the real 30-day survival compared to the expected Revised Trauma Score (RTS) based survival, the Return of Spontaneous Circulation (ROSC) rate in Traumatic Cardiac Arrest (TCA), reduce the occurrence of tension pneumothorax (tPTX) and to determine the complication rate of the intervention.

Keywords: ***Emergency medical services; Hemothorax; Pneumothorax; Thoracostomy; Trauma Scores;***

BACKGROUND

Traumatic tension pneumothorax is one of the most frequent causes of early mortality of the severely injured (12, 25). Different methods are recommended for chest decompression such as needle decompression, small bore catheters (≤14Fr), emergency thoracostomy and different size intercostals drains. The reported effectiveness and complication rates of the methods are vastly different (2, 3, 5–11, 14, 22, 26, 28). The Hungarian Air Ambulance (HAA) is the HEMS (Helicopter Emergency Medical Service) provider in Hungary (population: 9.9 million, area: 93.000 km2), which operates from seven air bases. Prior to 2011, the HAA's pleural decompression policy included only needle decompression and small bore catheter use (≤14Fr). In 2011, a new standard operating procedure (SOP) was introduced based on London's Air Ambulance's (LAA) model. Emergency thoracostomy was introduced according to well defined indication criteria as standard treatment for mechanically/positive pressure ventilated patients requiring chest decompression (2, 16, 18).

Professional support was provided by the original authors. Training courses were organized, of which, following an admissions test, additional theoretical and skill stations practice in which hands-on training was carried out. Manikins, porcine thoraces/animal models and rib cages were used at skill stations to represent the anatomy and to demonstrate the technique. Emergency thoracostomy technique training was implemented through complex simulations in combination with non-technical skills, while applying different stress factors. Cadaver laboratory practices completed the training program.

METHODS AND PATIENTS

HAA's chest decompression procedure

Emergency thoracostomy corresponds to the Advanced Trauma Life Support (ATLS) chest decompression procedure with the exception of inserting a chest drain into the thoracostomy cavity (1). The main theoretical reasons for this omission are the prehospital inserted drain can create a false impression of security (may become clogged, kinked and/or mispositioned) and provides a colonization surface for microbes. Additionally, there is no need for a Heimlich valve or suction, since simple thoracostomy is exclusively used with positive pressure ventilation.

In the case of traumatic cardiac arrests (TCA), simple bilateral thoracostomy is an absolute indication to exclude tension pneumothorax (tPTX) as a potentially reversible cause of cardiac arrest (4H-4T). It is performed prior to the initiation of chest compressions (19).

In consideration of patients with cardiac output, emergency thoracostomy should be performed following or parallel to the initiation of positive pressure ventilation (24). Thoracostomy is implemented on the more suspicious/injured side first. If the intervention proves ineffective or deterioration occurs, the procedure is carried out on the other side as well. In the case of chest injuries, the following signs raise the suspicion of tPTX and these are to be checked during the ABCD assessment and following the initiation of positive pressure ventilation:

- Hemodynamic instability (hypotension, tachycardia or bradycardia)
- Surgical emphysema
- Bony crepitus, signs of rib fracture
- Flail chest
- Multiple rib fractures
- Severe asymmetry in breath sounds (after checking tube position and depth)
- Unilateral wheezing in breath sounds
- Sucking chest wound
- Hypoxia

Suspected or confirmed pneumothorax (PTX) of a non-ventilated patient with stable hemodynamics without imminent signs of deterioration is not an indication for the procedure.

Technique of the HAA's emergency thoracostomy

A 4 cm skin incision is made in the safety triangle (marked by the pectoralis major and the latissimus dorsi muscle and the 5th rib) in the 4th intercostals space anterior to the mid-axillary line. It is followed with a blunt

dissection of subcutaneous tissues using Spencer Wells forceps to extend into the intercostal space. The pleural space is opened by a closed Spencer Wells while observing the air hiss and thoracic bleeding. Subsequently, the intercostal muscles are detached from the upper edge of the lower rib by moving the Spencer Wells in a ventro-dorsal direction in the thoracic cavity. A finger is inserted in the thoracic cavity, in which the position and the degree of the lung expansion is examined. If any deterioration reoccurs, the thoracostomy cavity can be reopened again through re-fingering. If multiple re-tensioning occurs, a sterile endotracheal tube or chest drain may be inserted in the thoracostomy cavity.

PATIENTS

All missions (2693) were reviewed in our retrospective database analysis between 1 August 2009 and 31 October 2014. All intubated and ventilated chest trauma patients were enrolled, whom met the indication criteria for HAA's chest decompression procedure. Patients with traumatic cardiac arrest (TCA) whose chest trauma could not be clearly ruled out were also included. Non-intubated patients and patients with injuries incompatible with life were excluded. The Revised Trauma Score (RTS) was calculated in all cases. RTS based expected 30-day survival rate was calculated accordingly to the original RTS method (4).

Patients were categorized in to two groups. Group A was defined as chest trauma patients treated with no thoracic intervention, only needle decompression, small bore catheter or thoracostomy from 1 August 2009 through 31 May 2011. Group B included patients treated with emergency thoracostomy from 1 June 2011 through 1 June 2014. Additional subgroups were created in both A and B groups regarding patients with cardiac output and Traumatic Cardiac Arrest (TCA).

There were 897 cases in group A, of which, 45 cases fulfilled the selection criteria (age 46 – 15 to 78); male/female 32/13). 39/45 cases were traffic accident injuries and 6/45 suffered other trauma mechanisms. There were no penetrating injuries in this group. 29/45 patients had maintained cardiac output (RTS 5.874±1.686) and 16/45 were in TCA. In consideration of patients with cardiac output, among 24/29 cases, there was no intervention carried out, in 2/29 cases, needle decompression was performed and in 3/29 cases, a small bore catheter was inserted. In the TCA subgroup, no prehospital chest decompression was performed in 3/16 cases. In 7/16 cases, needle decompression was performed, in 1/16 cases, a small bore catheter was used, in 4/16 cases, thoracostomy was performed and in 1/16 cases along with chest drain insertion. 63 of the total 1796 cases were included in group B (age 44 (2 to 78); male/female 49/14). 47/63 cases were the result of traffic accidents, 14/63 were other trauma and 2 patients suffered penetrating injuries. 33/63 cases were patients with cardiac output (RTS 4.495±1.851) and 30/63 were in TCA. Among those patients with cardiac output, thoracostomy was performed in 28/33 cases and in 5/33 cases along with chest drain insertion. In the TCA subgroup, thoracostomy was performed in 29/30 cases and in 1/30 case along with chest drain insertion (*Table 1–2*).

Complications were also reviewed and their potential relationships to interventions. In the event of traumatic cardiac arrest, temporary and permanent (lasting at least until hospital turnover) returns of spontaneous circulation (ROSC) were evaluated. In the hospital follow-up, tPTX presence upon admission, 30 day survival rates and any prehospital chest intervention related complications were reviewed (12, 20, 21). Fisher-Irwin test and the Chi-square test were performed in which the significance level was $p<0.05$.

The primary endpoint was:

1. Comparison of real and expected (RTS based) 30-day survival rate among patients with maintained cardiac output in group A and B

The secondary endpoints were:

2. Presence of tPTX upon hospital admission in group A and B
3. ROSC in TCA subgroups of group A and B
4. Prehospital chest intervention related complications documented while hospitalized

Table 1 *Patient demografics and mechanism of injury*

	Group A (01/08/2009 to 31/05/2011)		Group B (01/06/2011 to 31/10/2014)	
Total cases	897		1796	
Total involved	45	5.0%	63	3.6%
Maintained cardiac output	29	3.2%	33	1.8%
TCA	16	1.8%	30	1.7%
Avg age involved	46 (15 to 78)		44 (2 to 78)	
Total male/female	32/13		49/14	
RTS (avg±SD)	5.874 (±1.686)		4.495 (±1.851)	
Mechanism				
Traffic Accident	39	86.7%	47	74.6%
Penetrating injury	0	0.0%	2	3.2%
Other trauma	6	13.3%	14	22.2%

Table 2 *Traumatic cardiac arrests (TCA)*

Interventions				
None	3	18.8%	0	0.0%
Needle	7	43.8%	0	0.0%
Smallborecatheter	1	6.3%	0	0.0%
Thoracostomy	4	25.0%	29	96.7%
Thoracostomy + Drain	1	6.3%	1	3.3%
ROSC	1	6.3%	7	23.3%
ROSC with hospital admission	0	0.0%	5	16.7%
30-day survival	0	0.0%	1	3.3%

RESULTS

Indication criteria distributions are presented in *Table 3*.

1. Comparison of group A and B in 30-day survival rate among patients with cardiac output

In group A, 19 of 26 patients (73.08%) survived up to thirty days following hospital admission. Based on the average of calculated RTS, the expected survival in this group was 90%. In group B, 20 of 30 patients (66.67%) survived up to thirty days following hospital admission. The expected survival was 70.7% based on the RTS. No significant difference was observed in survival rates between the two treatment protocol groups ($p=0.41$). There was a significant difference in calculated RTS expected survival rates between the two groups ($p<0.05$).

2. Presence of tPTX upon hospital admission

In group A, tPTX was confirmed upon admission in 3/26 cases (11.54%). Out of these 3 cases, two cases involved needle decompression and in one case, no chest intervention was performed. In group, B tPTX was confirmed in 0/30 cases. There was a significant difference between the two groups ($p<0.05$).

3. Difference in ROSC between group A and B

In group A, temporary ROSC was registered in one case, however, the patient expired on the scene. There was no survival at hospital admission 0/16 (0%). In group B, 7/30 (23.3%) ROSC were registered. Maintained ROSC was witnessed in 2/30 (6.7%) cases, of whom eventually expired on the scene, 5/30 (16.7%) patients survived up through hospital admission and we registered 1/30 (3.3%) patient who survived thirty days following admission. There was a significant difference between the two groups ($p<0.05$).

4. Prehospital chest intervention related complications documented while hospitalized

There was no prehospital chest intervention related complication documented in any of the groups.

Table 3 *Indications and interventions in patients with cardiac output*

	Group A n=29		Group B n=33	
Indications				
Hypoxia	21	72.4%	20	60.6%
Hypotension	9	31.0%	15	45.4%
Severe asymmetry in breath sounds	3	10.3%	17	51.5%
Surgical emphysema	11	37.9%	19	57.6%
Flail chest / multiple rib fracture	12	41.4%	13	39.4%
Unilateral wheezing	0	0.0%	15	45.4%
Interventions				
None	24	82.7%	0	0.0%
Needle	2	6.9%	0	0.0%
Small bore catheter	3	10.3%	0	0.0%
Thoracostomy	0	0.0%	28	84.9%
Thoracostomy + Drain	0	0.0%	5	15.2%

DISCUSSION

In examining the primary endpoint, we could observe there was no significant difference in survival rates between the two groups. The all-survival rate compared to the RTS based expected survival rate was worse in group A. Based on RTS expected survival rates, patients in group B experienced more serious injuries. In conclusion, emergency thoracostomy can improve the chance of survival, however, due to multifactorial injuries, no clear correlation is seen.

Prehospital chest injury treatment focuses on space management, which aims at decompression and prevention of tPTX. Despite of the needle decompression in two cases, tPTX was confirmed upon hospital admission. While implementing emergency thoracostomy, no tPTX was registered. This may be due to the various chest decompression methods (15, 17, 27).

Interestingly, tPTX is a common cause of TCA and the second most preventable cause of trauma death in the prehospital setting (23). The elevated intrathoracic pressure caused by tPTX leads to the compromise of the circulatory system, prevents lung expansion and subsequently leads to a peri-arrest or arrest situation. Survivors were registered only with the use of emergency thoracostomy. The 16.7% prehospital ROSC rate in group B correlates with published literature data (13). Among those patients who expired while hospitalized, the cause of death was not associated with chest injury. There were

no prehospital chest intervention-related complications documented. In light of the data, this implies emergency thoracostomy is a safe procedure.

CONCLUSION

Emergency thoracostomy during the prehospital phase offers a safe and simple alternative for preventing or treating tPTX in the prehospital setup regarding ventilated trauma patients. Thoracostomy with the right indications is recommended as standard practice for every service when treating severely injured patients.

We obtained ethical permission in support of our study (IV/1847-3/2021/EKU).

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Psychological treatment of neurotraumatic injuries – crisis intervention in acute care

Theoretical and practical summary

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ABSTRACT

Patients who have suffered a neurotraumatic injury undergo severe physical and psychological trauma, which in many cases also traumatizes their relatives. Severe physical trauma and its long-term consequences have a significant impact on the lives of the people affected and their relatives. Acute health care, as well as the various periods of prolonged hospitalization, are a major physical and psychological challenge for both patients and their relatives. Patients who have suffered severe physical trauma are cared for by a multidisciplinary trauma team, which includes psychological support, too, in line with international professional guidelines. The involvement of psychologists and psychiatrists should be an integral part of acute care in the case of acute stress disorder and early-onset depression. The acute onset of psychological symptoms and the potential for long-term psychological disturbances warrant crisis intervention as close as possible in time and space to the critical event following the traumatic event. In the case of severe somatic trauma, combined therapy (pharmacotherapy and psychotherapy) can be used to relieve these symptoms and timely crisis intervention can reduce psychological symptoms and prevent the development of more serious psychopathologies (post-traumatic stress syndrome, depressive symptoms, anxiety disorders, sleep disorders), which in the long term can significantly impair quality of life and the risk of suicide. Providing regular psychological support helps the patient to adapt to the hospital environment and treatment, improves compliance, supports cooperation with physiotherapists and prepares the patient for rehabilitation. Basic psychotherapeutic care, using a variety of methods related to medical treatments and bodily processes, ranges from crisis intervention through supportive therapy to rehabilitation. It is essential that professional psychological support should be provided for the patient who has suffered a serious physical trauma as well as their relatives.

Keywords: ***Traumatic brain injury; Spinal cord injury; Intensive care units; Stress disorders, post-traumatic; Crisis intervention***

INTRODUCTION

Care of patients with severe neurotraumatic and/or polytraumatic injuries is provided by a multidisciplinary trauma care team, including psychological care. The paradigm shift towards the realization that needs to heal the injured person and reintegrate them into society underlines the importance of psychological interventions. In this paper, the psychological management of neurotraumatologically injured patients will be described, and in order to narrow down what is otherwise a rather broad topic, the focus will be on acute care.

In neurotraumatological injuries, severe trauma affects the patient's body with inevitable consequences. They cause sudden radical changes in the lives of the affected individuals and their relatives.

Suffering a traumatic brain injury (TBI) is one of the most traumatic experiences for patients and their loved ones, often with lifelong consequences. Due to the specificities of the TBI patient (initial disorientation, difficulty cooperating, rejection, communication difficulties, etc.), treatment departments must have a specially trained team and practice, from acute care to rehabilitation (6).

Spinal trauma resulting from accidents (perhaps one of the most difficult injuries to endure on a human level) is followed in nearly 40% of cases by a complex disability – dysfunction of locomotor system, sensory and autonomic organs, deficit symptoms (loss of control of bowel movements and urination) that lasts for a shorter or longer period of time, which fundamentally alters their relationship with their environment, reduces their scope for self-expression and, even with the most careful rehabilitation, does not restore their pre-injury integrity (inability to work, reduced living space, sexual dysfunction, development of psychological disorders). Severe spinal cord injury is a major social, social and economic problem, affecting the patient, relatives and health care institutions (10).

The affected patients go through severe physical and psychological trauma, which in many cases traumatizes their relatives too. In the case of neurotraumatological injury, acute psychological support plays an important role in both the care of the patient and the support of the family.

PSYCHOLOGICAL CARE AT THE DR. MANNINGER JENŐ TRAUMA CENTER

The Dr. Manninger Jenő Trauma Centre is a level III trauma centre that performs hospital activities on a national level. It provides patient care in twelve wards with 299 active beds and 30 rehabilitation beds. Patient admission and traumatology care are provided 24 hours a day, 7 days a week.

Over the last few years, a team of clinical psychologists with a background in psychiatry has gradually been built at the Dr. Manninger Jenő Trauma Centre, in line with international guidelines, to provide neurotrauma care. The psychologists working at the Institute (two adult and one pediatric clinical psychologist) are involved in daily patient care regularly attend morning briefings and morning ward rounds, thus gaining a more comprehensive picture of the anamneses of newly admitted patients, the somatic and psychological status of patients treated in the ward, which makes continuous follow-up and integration into the care team more effective. Acute psychological care for neurotrauma patients requires a customized and multidisciplinary approach. Collaboration between physicians, psychologists, physiotherapists, nurses and other health professionals is essential to restore optimal psychological balance in patients. Patient centered care requires the skilled collaboration of professionals from different health disciplines. Motivated, dynamic collaboration is a key to better outcomes, as shared goals are facilitated by the sharing of tasks and optimal allocation of resources (8). We learn from each other through multidisciplinary teamwork, where we develop a common language to connect with each other, bringing disciplines closer together.

The role of the psychology team is diverse. The activities includes conducting a structured initial clinical interview, taking a psychiatric/psychological medical history tailored to the patient's condition, psychological assessment, psycho-diagnosis, crisis intervention, focused interview, providing

ongoing emotional support, conducting basic neuropsychological assessments, psycho-education for patients and relatives, support for relatives, academic teaching and research, and working through patient-related difficulties for trauma team members. Psychological intervention may be needed by patients, relatives as well as professionals caring for the injured. Professionals working in the Institute are expsosed to increased physical and psychological demands, and encounter horrendous injuries and human tragedies on a daily basis (*Table 1*). Emergency care professionals are at increased risk of burnout.

Our psychologists visit patients at the request of the attending physician or psychiatric specialist, assessing the patient's need for psychiatric support beforehand, and regular attendance at morning rounds allows our psychologists to identify the need for psychiatric support, to start the necessary intervention as soon as possible and to act as gatekeepers to the attending physician, indicating the need for a psychiatric consultation. A significant proportion of patients with severe somatic disorders receive combined psychotherapy, which uses pharmacotherapy and psychological intervention together. The use of psychological methods is usually complementary to, rather than a substitute for, pharmacotherapy.

Table 1 Diverse role of psychology team members in trauma care

PSYCHOLOGICAL TASKS
• *Crisis intervention*
• *Supportive therapy (positive suggestions, cognitive approach)*
• *Delivering bad news*
• *Motivation improvement*
• *Preparation for rehabilitation*
• *Close cooperation with psychiatrists (assessment of the patient mental state, follow-up, gatekeeper role)*
• *Conducting basic neuropsychological assessments (ACE, MMSE)*
• *Supporting relatives*
• *Educating psychology students*
• *Research*

PSYCHOLOGICAL TREATMENT OF NEUROTRAUMA PATIENTS

In neurotrauma care, patients who have suffered a serious physical trauma include those who have been involved in a serious road traffic accident, those who have fallen from a height (due to work or extreme sports), those who have attempted violent suicide, those who have suffered a street assault and those who have suffered serious domestic violence, victims and perpetrators alike. Serious somatic trauma always has psychological consequences (both short and long term); it is fair to say that serious physical trauma can also be regarded as psychological trauma (*Figure 1*). Psychotrauma is a complex emotional experience, accompanied by physiological reactions to a serious life event, with which the person is unable to cope emotionally. In the case of severe somatic trauma, a major trauma occurs to the patient's body that has inevitable consequences. Body image and functionality are permanently changed. The patients as well as their relatives are confronted with the consequences of a process that fundamentally and drastically changes their whole life. Injuries that threaten bodily integrity and life are an experience of loss and a task to be overcome for both parties. The immediate reaction to psychological trauma can be an emotional crisis, where the basic sense of security is lost and everything becomes unpredictable and uncontrollable. Without proper treatment,

psychological trauma can cause severe disturbances in the emotional balance of the person and trigger the functioning of psychological defence mechanisms, even over a long period of time (9).

SEVERE PHYSICAL TRAUMA – PSYCHOLOGICAL TRAUMA	
• *Threat to physical integrity*	
• *Confronting violence and death*	
• *Intense fear /anxiety*	
• *Dread*	
• *Vulnerability*	
• *Loss of control*	
• *Fear of annihilation*	
• *Inevitable consequences*	
• *Permanent change of body image and body functionality*	

Figure 1
Serious somatic trauma always has psychological consequences

The individual reacts to traumatic events with severe physical and psychological reactions, which have different phases. An anxiety-ridden state of readiness develops and is most typically dominated by symptoms of acute stress disorder, which appear almost immediately after the critical event (*Table 2*). The degree of this varies from individual to individual, and in more severe cases may lead to suicidal ideation and/or psychotic decompenzation (4).

Table 2 Symptoms of acute stress disorder based on the ICD–10 diagnosis code system
SYMPTOMS OF ACUTE STRESS DISORDER
• *Hyperarousal*
• *Hypervigilance*
• *More intense emotional response*
• *Irritability*
• *Sleep disorder*
• *Motor restlessness*
• *Decrease in conscious orientation*
• *Increase in psychological dependence*
• *Occurrence of regressive behavior*
• *Increased search for safety*
• *Desire for attention*

The level of acute stress disorder is determined by individual vulnerability, which is significantly dependent on the expected outcome, psychotrauma in the medical history, underlying psychiatric illness, coping mechanisms, quick and flexible adaptation skills, and adequate compliance. The symptoms of acute stress disorder resolve spontaneously in 2-3 days in a proportion of patients and may resolve during crisis intervention (25). The long-term effects of traumatic distress are post-traumatic stress reactions, which can range from symptoms of anxiety and depression to post-traumatic stress disorder (PTSD). If the individual remains helpless and vulnerable in the face of severe trauma, the emergency response does not resolve. In the long term, this type of response causes serious disturbances in psychological functioning, becomes a barrier to adjustment and significantly impairs quality of life. Trauma suffered in adulthood destroys the already established personality structure (13).

Patients who have suffered neurotraumatic injury are at increased risk of developing PTSD due to the experience of uncontrolled physical and psychological pain, as well as physical and psychological exhaustion. Patients fear pain, loss of function, and death. The experience of loss, uncertainty and loss of control caused by various conditions requiring rehabilitation (head injury, musculoskeletal injuries, etc.) leads to a negative mood, and real physical helplessness often turns into hopelessness, which inevitably leads to the development of symptoms of depression, anxiety or post-traumatic stress syndrome (24). Receiving the diagnosis, the bad news also acts as psychotrauma, triggering an intense emotional response from the patient and their relatives. Communication of bad news also warrants the involvement of a psychologist.

For a person who has suffered a serious physical trauma, the injury itself is „only" the beginning, and patients suffer psychologically cumulative trauma during hospitalization (*Table 3*). Many traumatic experiences may occur, such as the mechanism of the injury, the experience of diagnosis (especially if the disease and the consequences of the physical trauma are associated with highly threatening mental representations), painful invasive interventions, and the experience of treatment, possible consequent disability and/or other loss of function, amputation of a limb for vital indications (mainly because of damage to body image and partial or total loss of function), and the experience of loss of control. Worry, loss and guilt for family members can also seriously cloud the picture (e.g., it is not uncommon for several family members to be seriously injured or killed at the same time in a serious car accident, with both perpetrator and victim requiring care).

Table 3 Cumulative psychological trauma during hospitalization

TRAUMA SUFFERED DURING TREATMENT
• *Facing the diagnosis*
• *ICU treatment*
• *Invasive interventions*
• *Limb amputation*
• *Prolonged immobility*
• *Cognitive damage*
• *Severe somatic complications*
CUMULATIVE TRAUMATIC EXPERIENCES

Severe somatic trauma can completely override a person's previous roles for a long period of time (weeks, months, years or even permanently), and adjustment can be particularly stressful, as it can affect different aspects of self-image at the same time. The traumatized person may experience a serious loss of roles in key areas of their life (physical, relational, family, work, economic, etc.), which may also lead to a psychological crisis (19).

Following neurotraumatic injury, psychological interventions vary at different stages of the recovery process. The period immediately following the trauma is characterized by medical care and general care to ensure biological existence. Psychological treatment of the injured person can only begin later, after a certain period of consolidation. However, this is a crucial issue, since severe trauma and its consequences, which are not yet known at the time, can lead to radical personality changes and severe psychological symptoms. It has been scientifically proven that irreversible damage, whether morphological or functional, can break down the integration of the individual's personality as was known before. It is clinical experience that the focus of the traumatized person's attention after the injury is exclusively on the damaged body part or, in the event of its loss, on the sensation of its replacement (7).

For patients with spinal cord transection regulating emotional ups and downs, rationally acknowledging their somatic state, and developing new value and goal systems amount to a serious psychological crisis, sometimes an insurmountable task. Thus, the psychologist must begin, as soon as the patient is consciously available, to treat? The patient psychologically, taking into account the premorbid personality structure and its degree of differentiation, simultaneously with making the patient gradually and partially aware of the consequences of the trauma. The aim of nuanced individual psychotherapies is to bring the injured person out of the psychological deadlock, through crisis resolution, symptom reduction and then preparation for rehabilitation. It is therefore necessary to develop a motivation for rehabilitation by overcoming, the temporary lack of motivation, which will ensure a high level of spontaneous activity of the during the treatment procedures, which often take months or even years, and at the same time allow harmonious cooperation with professionals to achieve the jointly set rehabilitation goal.

Psychotherapies during crisis intervention and trauma processing must avoid any excessive, direct interference, because this may cause oppositional behavior in the injured person; moreover, an aggressive intervention may even result in iatrogenic psychological damage, so only individualized, responsible psychological work can bring the expected effective result. In the recovery process, often very modest results are not spectacular in their manifestation; often long weeks or months of struggle are necessary for the recovery of neurologically injured patients (14). In this long recovery process, psychological support is needed from the beginning, with increased attention to the patient's psychological needs and inner struggles, to mobilize their inner resources, to strengthen possible ways of psychological coping, which, unless evoked by the patient, cannot successfully cooperate with somatic treatment. As the patient's emotional state improves, we can expect better cooperation, which will affect both acute treatment and preparation for rehabilitation. Coping is a conscious process and aims to confront external threats and protect the psychological balance of the individual (*Table 4*). The role of the psychologist is to support adaptive coping mechanisms (17).

Table 4 Psychological imbalance is a consequence of the experienced trauma

PSYCHOLOGICAL CONSEQUENCES OF EXPERIENCED TRAUMA
• *Crisis response*
• *Fear*
• *Vulnerability*
• *Loss of control*
• *Re-experiencing trauma*
• *Fear of the future*
• *Anxiety symptoms (anxiety, panic, sleep disorder)*
PSYCHOLOGICAL BALANCE IS DISRUPTED

PSYCHOLOGICAL TREATMENT AT THE INTENSIVE CARE UNIT

More than 500 patients are treated in the intensive care unit of the Dr. Jenő Manninger Trauma Centre every year. Average treatment time is 7 or 8 days, which also indicates that many patients with serious conditions are treated in the unit. A significant proportion of these patients are craniocerebral trauma patients with severe disturbance of consciousness or coma, or patients with multiple traumas (multi- and polytrauma). Among these patients, those with severe head injuries, extensive chest injuries or cervical spinal cord injuries sometimes require mechanical ventilation for weeks at a time. A minority of patients are admitted for post-operative stabilization and observation, and for acute internal illness resulting in a serious condition (2). Severe neurotrauma patients are first admitted to the intensive care unit. Patients with severe spinal cord injury can only be treated safely in the intensive care unit for the first 7-14 days, as cardiovascular and pulmonary complications are most likely to develop during this period (20).

Intensive therapeutic care requires coordinated teamwork among professionals, with psychological care as part of the treatment team. ICU staff is very open to collaboration with the psychologist. They regularly ask for assessment of the patient's psychological state, suicide risk assessment, psychological treatment of the patient, or support of relatives. The longer-term psychological consequences of ICU treatment (PTSD, anxiety disorders, depressive symptomatology and sleep disturbance) are well known. These place a strain on patients with already severe somatic conditions, who are confronted with an unfamiliar and often unpredictable material environment and painful interventions that are far beyond their usual frame of reference (28). In this intense emotional state, patients are forced to confront their deepest fears, the threat to their existence, during which they experience the power of the disease, their own limitations and their changed relationship to their former self, challenging fundamental beliefs about themselves (e.g, this can't be happening to me, I'm healthy, I'm strong, I'm athletic, I can overcome any difficulty, etc.), and thus also experiences a loss of role, exacerbated by the experience of vulnerability and loss of control.

In addition to providing psychosocial support in the ICU, the aim is to avoid learned helplessness and possible psychological traumatization due to loss of control, which can cause long-term psychological disturbances, significantly impairing quality of life, impeding the rehabilitation process and increasing the risk of suicidal behavior (11). For patients, the distress caused by a severe somatic injury is compounded by the psychological distress caused by intensive care unit treatment and, not infrequently, by multiple experiences of loss, generating a cumulative crisis situation. During this period, the patient experiences a loss of normal coping mechanisms, disorganization, emotional maladjustment, fear, and anxiety. Negative emotional states and regressive functioning may interfere with effective coping with the disease and its side effects, and may impair cooperation with medical treatments (26).

The stabilization of vital functions in critically ill patients, the need for ventilators, patient monitors and special medication, and the often unpredictable time and outcome of the recovery process place enormous physical and emotional strain on both the patient and their relatives (15). In these cases, the involvement of an interdisciplinary care team is particularly necessary. The importance of interdisciplinary therapeutic work in somatic medicine is being increasingly recognized in Hungary. In the intensive care unit, our psychology team is responsible for individual case management and family consultation. Clinical psychological care in the intensive care unit places particular emphasis on stabilizing the psychological state of the patients treated there, thus supporting somatic recovery. Intensive care units are usually staffed by a well-connected team of professionals and can thus provide a safer psychological framework for themselves and for patients in serious or critical condition, who often experience very high levels of anxiety and, in some cases, fear of death. The tight-knit team providing a safe and secure framework and the patient interact with each other (26).

Owing to the development of acute stress disorder and early depression, the involvement of a psychologist or psychiatrist should be an integral part of intensive care. The acute onset of psychological symptoms and the potential for long-term psychological disturbances justify crisis intervention as close as possible in time and space to the critical event following the traumatic experience. Pain, sometimes even to the point of delirium, anxiety, tension, frequent sleep apnoe and sleep disturbance can be controlled by psychotherapy, empathy, appropriate medication and equipment (20).

Anxiety is a perfectly natural part of a disease, but when it is excessive, it can impair the somatic state, future prospects and the healing process as a whole. This is particularly true for patients who have undergone surgery. In the case of severe trauma, the most common symptoms are emotional maladjustment and increased anxiety levels, with symptoms typical of panic disorder. Overall, the personal approach initiates a positive process between patient and therapist, resulting in a facilitating relationship space. The key in this situation is relational focus, since one of the dominant elements of our patients' coping is a lack of a sense of security, and an integral part of healing is precisely the creation of a sense of security, which can be provided by a predictable relationship that offers a secure framework. In many cases, the gradual withdrawal over time, the constant provision of information, or the achievement of psychological equilibrium can provide an internal sense of security, or the establishment of control can be of paramount importance. One of the challenges of psychological treatment in neurotrauma care is that a sense of danger and constant anxiety are inherent in the acute phase of recovery. This is why, as psychologists working in the somatic ward, we must strive for the well-being of the body and the harmony of body and mind (18). A patient is always in a vulnerable, dependent situation, and the professionals who care for them should not lose sight of this.

In the ICU, psychological interventions have a limited time frame, it is essential to be effective in a short time and carefully select the interventions according to the somatic condition and psychological resilience of the patient (33). In the case of a severe somatic and psychological condition, we can talk of setting partial goals, and achieving partial outcomes, aimed at relieving the patient's anxiety and suffering in the given situation. Short, time-limited therapy allows the use of targeted psychotherapeutic interventions. The primary focus of crisis intervention sessions is to support the patient's sense of safety, stabilize their psychological state, and alleviate their cognitive distortions and anxiety symptoms; using cognitive behavioral therapy elements with a "here and now" focus (*Table 5*). In a hospital setting, a clock on the wall, the patient's own phone, photographs of relatives can help to bring the person back to the present. These are objects that, when the patient looks at them, they can feel themselves in the „here and now" again, distanced in time and space from the traumatic event. Working on the patient's mental map, creating an internal safe, reassuring space is one effective and safe method of anxiety relief and self-soothing, along with proper breath control and the use of carefully chosen brief relaxation techniques. Creating a space for ventilation has a tension-reducing, anxiety-relieving effect (25).

Table 5 Scope of crisis intervention

CRISIS INTERVENTION
• *Psychological "hemostasis"- fast assistance*
• *Stabilization of psychological state*
• *Reduction of psychopathological symptoms (relieving narrowed state of mind and anxiety)*
• *Developing coping strategies*
• *Reorientation into the present (focus on "here and now")*
• *Promoting adaptation*
• *Step-by-step focusing on the future (e.g. preparation for rehabilitation)*

Patients treated in intensive care have limited mental resilience, and it is not possible to maintain their attention for long periods of time, so it is worth planning therapy with rest periods and multiple sessions per day. The daily schedule should take into account the patient's workload (7). Before starting the intervention, it is necessary to consult the patient's doctor, assess their psychological resilience and openness to psychological support. The patient may initially be reluctant, mainly due to the situation, their unacceptable and incomprehensible somatic condition, the multiple losses suffered, and traumatic experience.

During ICU treatment, the fear of uncertain outcomes and stressful states narrow the perspective, there is a narrowing of thinking, whereby multidimensional thinking is lost and everything seems final, leading to the development of a sense of hopelessness associated with recovery (1), which may inhibit the patient's coping strategies, learned helplessness may develop - all these factors are associated with an increased risk of suicidality. Experiencing the diagnosis as a psychotrauma, long-term injuries, loss of a close relative (e.g., in the same accident) also predispose patients to an increased risk of suicidality.

During ICU treatment, patients' psychological dependency increases and their need to connect become heightened (28). This dynamic is most evident in the patient's attempts to keep a member of the treatment staff near with questions or requests or to produce symptoms in order to be listened to and cared for.

In a psychological crisis, the individual is characterized by a high degree of regression, a defense mechanism through which the patient tries to avoid anxiety, and displace the threatening consciousness that overwhelms them (21). A narrowing of the personality is observed at all levels, including attention, thinking, emotions and behavior. The individual returns to an earlier phase of self-development, but with a deepening of vulnerability, a reduction in compliance and a greater risk of learned helplessness, which is considered the least adaptive and most dangerous response to loss of control in terms of recovery outcome. In patients with poor compliance, authority conflict and aggressive, hostile behavior may also be forms of anxiety avoidance, in an attempt to avoid loss of control, feelings of helplessness and vulnerability (16).

Patients in ICUs are characterized by a sense of isolation (27). All (psycho)therapy is based on rapport building, which is key for ICU patients in order to empathize with the patient's experience. Psychological support for neurotraumatologically injured patients requires a great deal of empathy, increased attention and patience. The patient may have a speech impediment (e.g., tracheostomy, aphasia, dysarthria), which prevents them from saying what they want to say, which can be frustrating, so it is important to find a common channel of communication, for example, a whiteboard or sign system can be of significant help. ICU patients are also characterized by being overwhelmed by stimuli, flowing which also increases psychological stress associated with treatment and contributes to psychological exhaustion (26) (*Table S1*).

Table S1 Ventilated patients' experiences after leaving ICU. Ref.: Varga, Diószeghy (2004) (29)

Patients' experiences in Intensive Care Unit (ICU) treatment after leaving ICU, which later predispose them to PTSD
Loneliness (74%)
Inability to speak (65%)
Anxiety (59%)
Pain (56%)
Noise (51%)
Lack of control (46%)
Tension (46%)
Fear (44%)
Thirst (44%)
Fear (32%)
Lack of sleep (35%)
Nightmares (17%)

METHODS FOR EARLY INTERVENTION

Acute care primarily allows for short, time-limited, low-intensity psychological interventions, which are flexible to both the person and the situation, and aim to achieve a high therapeutic effect in a short time. Low-intensity interventions are well adapted to the specificities of acute severe somatic trauma (e.g. unpredictability, fluctuating symptom picture, sudden changes of state, etc.) and can therefore be effectively applied in conjunction with medical therapies (e.g. crisis intervention, use of positive suggestions, psychoeducation, carefully chosen brief relaxation, imagination technique, psychologically preparing patients for surgery, etc.). The acute onset of psychological symptoms and the prevention of potentially long-term psychological disturbances justify to providing the patients crisis intervention as close as possible to the critical event in time and space following the traumatic event (25). The therapeutic space is created at the bedside, where verbal and non-verbal communications are of paramount importance. It is important that the patient feels that the professional working with them is with them, at their side in all circumstances.

During hospital treatment, in vain do we professionals „know what to expect, what would be best", if the patient is not ready. Even with therapeutic help, psychological coping shows individual patterns which cannot be rushed. We have to accept that although we may want the best for our patient, recovery of the soul can be a slower process and not necessarily in line with recovery of the body. We need to pay particular attention to how the symptoms and residual symptoms, affect the self-esteem and mood of those affected. Their future should not be determined by loss, but by realistic goals. Patients can cope with what they are personally motivated to do. Their ability to cope can be impaired if they are confronted with activities that they are not motivated to do (24).

In the choice of therapeutic interventions, the consideration of evidence, although important, is only one component of professional psychological decision-making. The patient's individual characteristics (psychosocial status, psychopathology, emotional and intellectual intelligence, premorbid psychopathology, other comorbidities, age and sex, life expectancy, educational level, socioeconomic status, mobility limitations, nutritional and dietary characteristics, individual needs, preferences, addictions, specific characteristics and mechanisms of psychological functioning,

social support, etc.) in the assessment of the patient's individual needs and preferences.) are factors that should be taken into account and integrated in an expert manner in all cases when applying treatment evidence and therapeutic strategies set out in the guidelines. Studying a single arbitrarily selected element of psychosocial factors is uninformative, since in neurotraumatology it is not merely individual traits that determine mental/psychopathological and behavioral outcomes, but rather the complex and intricate totality of emotional life, premorbid personality, unconscious motivations/anxieties and many other factors that dynamize the psychological unit. For this reason, the application of the principles of evidence-based practice, the use of therapeutic assistance, crisis intervention and any other psychosocial intervention, and the scientific research in this field in neurotraumatology work represent a process and a challenge requiring specialized expertise and a careful integrative approach. The individual characteristics of the patient must always be taken into account (9).

Basic psychotherapy interventions

Crisis intervention

In crisis intervention, we aim to support and empower the client in crisis, to protect them from negative outcomes and to restore their functionality and adaptive capacities. It is a kind of „fire-fighting", „psychological first aid", a professional intervention that involves 1 or 2 supportive meetings in a narrow time window. Relieving current psychopathological symptoms by using the tools of psychology and, if necessary, complementing them with pharmacotherapy, crisis resolution, anxiety relief, AND coping skills. Develop active coping, and adaptive control strategies. In addition to resolving the current situation, we also address the future, preparing the person for the near future (e.g. the rehabilitation process in acute care) (5). The effectiveness of rehabilitation greatly depends on the psychological adjustment of the individual. The most important elements of bedside crisis therapy are stabilization of the patient's psychological state, promotion of psychological safety, reduction of psychopathological symptoms (typically anxiety disorders); the therapist teaches techniques that ultimately enable the patient to control and alleviate their symptoms (25) (*Figure 2*).

CRISIS THERAPY	
• *Short, time-limited therapy*	
• *Focused talk*	
• *Ensuring continuous emotional support*	
• *Activating possible psychological coping modes*	
• *Taking an active role in the healing process*	
• *Motivation*	
• *The patient can cope with what they feel personally motivated by*	
• *Providing information, emotional psychoeducation, counseling => indirect help for the patient's cooperation*	
• *Psychological coping shows individual patterns*	

Figure 2
Elements of crisis therapy

Psycho-education

Psycho-education is a professional information transfer method aimed at increasing patients' knowledge of their illness and how to cope with it, and at helping them deal emotionally with the problems associated with the illness. Clinical impact studies have shown that patient who feel competent in their own recovery process after surgery experience less pain, become self-sufficient sooner and have fewer days of hospitalization (23). Psycho-education of relatives is important, as is the continuous transfer of information to patients, which increases their sense of control and thus their sense of safety.

Psychological support based on positive suggestions

It is important that patients in intensive care receive appropriate psychological support, in their case the anxiety-relieving therapeutic techniques that we know are often not applicable at all (e.g. relaxation) or can only be applied with great care and caution (e.g. breathing control), bearing in mind the somatic and psychological safety of the patient. In the intensive care unit, we use crisis intervention mainly based on the use of positive suggestion techniques, complemented by cognitive techniques, with a view to increasing the patient's sense of safety, developing coping mechanisms, strengthening their internal resources and reserves, reducing the psychological stress associated with the treatment and preserving the patient's dignity. Psychological treatment based on positive suggestions can be safely applied to patients with severe somatic conditions (26).

Any message that has an involuntary effect on the recipient counts as a suggestion. A suggestive message can be a sign, a picture, an arrangement of objects, a word, a tone of voice, in fact anything. We may not always be aware of it, but we are constantly being hit by suggestive messages and we are also conveying suggestive messages in our communication (29).

Critically ill patients are in an altered state of consciousness, susceptible to suggestions. Altered states of consciousness (induced or spontaneous trance states), fear, vulnerability, heightened emotional demands, crisis states, lack of familiar safe frames (unusual, novel situations) increase suggestibility. In critically ill patients, several of these factors are present simultaneously (3, 30).

Negative suggestions can hinder healing, even with the right treatment. Owing to their negative emotional state, a person in an altered state of consciousness will usually interpret neutral or ambiguous comments negatively, or may perceive communication that is not intended for them as directed towards them. During treatment, ambiguous messages and all communication not related to the patient should be avoided, as the person in a state of uncertainty may have a narrowed consciousness, may refer to themselves and misinterpret everything (29).

Positive suggestions can trigger a positive physiological response, supporting the psychological and emotional side of healing. The use of positive suggestions in fear-induced negative trance states, in critical life situations, is the most effective method because it has an indirect effect on the individual: it can trigger activity and, in the case of an agitated patient, it can easily create an atmosphere in which the patient can find calm. The method is to use a text with positive content that is received as an indirect „message", which then stimulates the recipient to take action and helps to trigger self-healing processes. Positive suggestions can also be used for any action that allows the patient to experience freedom, creativity and innovation. Anything that is linked to self-determination can greatly increase the patient's self-confidence, taking him out of the daily routine of an anxiety-inducing hospital life (27).

For intubated ventilated patients, psychological management based on positive suggestions and the playback of audio materials delivered by relatives on the phone or MP3 provide psychological support for critically ill patients (22).

Supporting relatives

Serious physical injuries are a crisis not only for the patient, but also for their relatives. Care for neurotrauma patients cannot be provided

without the involvement of all members of the therapy team. All members of the staff treating the patient (medical and non-medical team members) play a crucial role in the therapeutic process, from acute care to the end of rehabilitation, of which the family is an integral part. Failure to engage family members from the outset may lead to secondary psychological damage in the injured person, which may hinder the healing process (24).

In a strong emotional response to bad news, the initial denial is replaced by anger and sadness. The resolution of the crisis is marked by a gradual acceptance of the immutable and the accompanying restructuring and adaptation to the new task. The end of the crisis is confrontation with an accurate diagnosis, acceptance and adaptation to the new condition, and giving new meaning to life. It is necessary to make sense of a future that often seems hopeless. There appears a fear of the future and a mourning of the ‚desired future', often a long and difficult process. It is important to support families and help them through crisis situations, as failure to find solutions to a situation can mean the disintegration of the family, which in turn means the loss of the greatest help in the long healing process, the family itself (24).

In the first period, the greatest need is to help the patient to cope, to relieve helplessness, to mobilize the tools of the struggle, to increase motivation and to help the family member how to support the patient in the most stable and effective way. Serious somatic trauma is a crisis not only for the individual but for the whole family. The immediate environment not only supports the patient emotionally and physically, but also has to face the reallocation of efforts, the reordering of priorities and the possibility of imminent loss. The illness changes family roles, control is rearranged, needs and tasks change, and the family is disrupted from its normal functioning. The seriously injured patient does not recover as quickly as the extra energy of the environment can be exhausted. Relatives, while empathizing and cooperating with the patient, also have to carry on with their own lives (12). It is important that relatives have access to professional emotional support during this sensitive period. Ongoing information and education about the patient's condition and setting small daily goals can help to alleviate anxiety. Our team of psychologists also provides regular professional psychological support to relatives, in addition to psychological counseling for the patients with serious somatic injury (*Table 6*).

Table 6 The elements of a crisis of relatives

CRISIS OF RELATIVES
• *Increased emotional load*
• *Future that looks hopeless*
• *Fear of the future*
• *Mourning of „desired future"*
• *Danger of the family falling apart*
• *Risk of developing secondary psychiatric impairment of the patient*

SUMMARY

In psychological literature, there is a serious gap in acute care and crisis intervention specifically for neurotraumatologically injured and polytraumatized patients. Most of the available literature focuses on the principles of general psychological crisis intervention and the process of rehabilitation. Neurotraumatic injuries can bring about sudden radical changes in the lives of the affected people and their relatives, representing a severe trauma to the patient's body with inevitable consequences that affect the whole family structure. It is essential that both the patient and the relatives receive professional psychological support during the acute care process. Neurotrauma patients and their relatives are assisted by our specialized psychologists, psychiatrists and support professionals in the acute crisis, in the prevention of the psychological consequences of serious injuries and in the management of emotional difficulties already present.

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CASE REPORT

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Successful treatment of a challenging periprosthetic femoral fracture on a premenopausal patient with a long history of immunosuppression

Case report

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ABSTRACT

While immunosuppression provides relief and care in patients with rheumatic arthritis, the prolonged usage of steroids has been known to cause various and serious complications. While in older patients it is common to find those with a long history of immunosuppression, younger patients also suffer from its prolonged complications. We present a 38 year old heavily immunocompromised female patient with excellent compliance on which we operated on multiple occasions and have treated from 2019 to 2022. The patient was originally diagnosed with rheumatoid arthritis at age 7, and has been receiving high dose immunosuppressive medication. The patient received bilateral total hip arthroplasty during 2009 and 2013, and a Total Knee Arthroplasty (TKE) in 2011. Over the course of her postoperative recovery, she suffered from multiple cases of periprosthetic fractures. In October 2019, the patient again presented with spontaneous pain in her right thigh. She was then diagnosed with a Vancouver C type periprosthetic fracture on the right femur, and was referred and admitted to our level one Trauma Center in Szeged, Hungary. After multiple trials, the patient received a Locking Compression Plate (LCP) type Proximal Femoral Hook Plate (PFHP) with cable fixation, attachments and a bone allograft to reinforce stability and neutralize stress on the fractured area. Multiple and repetitive challenges can be expected in treating bony fractures of weight bearing lower limbs for heavily immunocompromised patients. The patient, despite her young age, had the osteological biology of a elderly patient, requiring us to take into consideration not only surgical components but biological components as well. With a multidisciplinary approach from osteological, biological, and surgical fields, successful results may be acquired even in these challenging cases.

Keywords ***Arthroplasty, replacement, hip; Arthroplasty, replacement, knee; Immunosuppressive Agents; Osteoporosis; Periprosthetic fractures; Premenopause;***

INTRODUCTION

While immunosuppression provides relief and care in patients with autoimmune disorders, the prolonged usage of steroids has been known to cause various and serious complications. While in older patients it is common to find those with a long history of immunosuppression, younger patients also suffer from its prolonged complications. While immunosuppression is a relative common therapy in the elderly, we rarely come across patients who are young and have a long history of its use, leading to pre-menopausal changes in osteobiology. Treatment of periprosthetic fractures is in itself relatively rare, and it poses multiple mechanical challenges. Combined with the complicated medication therapy of rheumatoid arthritis (RA), it gives surgeons a whole different dimension of challenges. Here we report a young patient with a 30 year history of immunosuppressive therapy who underwent multiple periprosthetic fractures, the challenges and consideration of its treatment.

PATIENT INFORMATION

The patient was a 39 year old female with a 30 year history of immunosuppression (4 mg of methylprednisolone) due to Juvenile Rheumatoid Arthritis (JRA) from the age of 8. She had been prescribed and had been continuously using Methylprednisolone, Methotrexate (22.5 mg once a day), and Leflunomide. The patient gave birth in her mid 30s. She had been taking other osteoporotic medication from a young age as well, alongside her prosthetic surgeries; calcium, vitamin D (6000 International Units), Alendroate. For her advanced JRA, she later received tofacitinib therapy as well. She developed allergic reactions to numerous substances, such as phenobarbiturates, Iodine, metal, diclofenac etc. No know rheumatoid arthritis was reported in her family. The patient was extremely cooperative and compliant, and all medical treatment and rehabilitation instructions were followed.

CASE PRESENTATION

Clinical findings, Timeline, Therapeutic intervention

The patient was originally diagnosed with rheumatoid arthritis at age 7, and has been receiving high dose immunosuppressive medication (Methylprednisone, Methotrexate, Leflunomide, biological therapy every 6 weeks) ever since. All immunosuppressive medication had been halted during the acute perioperative phase. By the time of admission at our clinic, the patient had already undergone right side total hip arthroplasty (THA) in 2010, left side total knee arthroplasty (TKA) in 2011 and left side THA in 2013 (*Figure 1*). Her acute postoperative course was uneventful.

In June 2019, the patient presented with pain and discomfort in her right thigh during physiotherapy. She was admitted to her local Traumatology Department and was diagnosed with a right side femoral shaft fracture of which was surgically reduced by Open Reduction and Internal Fixation (ORIF) with plates.

In October 2019, the patient again presented with spontaneous pain in her right thigh. She was then diagnosed with a Vancouver C type periprosthetic fracture on the right femur, and was referred and admitted to our level one Trauma center in Szeged, Hungary. The patient received a Locking Compression Plate (LCP) type Proximal Femoral Hook Plate (PFHP) with attachments and a bone autograft to reinforce stability and neutralize stress on the fractured area (*Figure 2*). Unfortunately the patient suffered from left side brachial artery thrombosis on the first postoperative day. A Fogarty thrombectomy was performed immediately with successful revascularization. The patient was discharged 15 days later with no further complications.

The patient received Teriparatide therapy (Parathyroid hormone analogue) from her local hospital in November, 2019. The patient presented to our outpatient clinic for post-operative radiographic revision on the 6th week (41th postoperative days), and was instructed to commence partial weight bearing from 20kg, up to 7 kg per week. She later presented to the outpatient clinic on the 55th postoperative day due to local pain on

the operated limb during weight bearing, and was thus instructed to practice lighter partial weight bearing (10 kg, with a 5 kg increase in weight bearing every week). No radiographic anomalies were found and progressive ossifications were noticeable. By 2020.02.04 (111th postoperative day), the patient was able to complete weight bearing on the operated limb.

In 2020.06.25 the patient presented again to our outpatient clinic with pain in her operated right hip, while playing with her children. Radiology revealed that the right LCP PFHP component had been fractured (*Figure 3*). We surgically exchanged the LCP PFHP and further added a cadaver allograft component to the fractured area in hope of increased ossification (*Figure 4*). Cable fixation was utilized the stabilization of the allograft, as well as the distal end of the LCP PFHP, and completed a allograft strut osteosynthesis. The patient was observed post-operatively on our ward, with no unusual findings radiographically.

During 2020 September the patient presented with tachycardic episodes, hypertensive attacks, polyuria, and diarrhea. The patient was referred to an endocrinological institution in suspicion of pheochromocytoma. After no further improvement, approximately 3 months later evidence of pheochromocytoma had not been established. After careful deduction, parathyroid hormone therapy was halted. The patient's condition had improved, and had only presented with fewer random tachycardic episodes due to this day.

After the suture removal on the 10th postoperative day, the patient was discharged and has been presenting to our outpatient clinic for follow-ups. On the latest radiographic followup on 2020.12.15 (168th postoperative day from the reoperation) no signs of novel periprosthetic injury had been found, and complete ossification could be seen on the operated right limb.

Around October 2020, the patient presented to our clinic with the inability to move her left wrist. X ray examination revealed a subluxation of the carporadial joint (*Figure 5*), but due to the history of arterial thrombosis, conservative treatment was recommended for the time being. After multiple consultations and careful consideration, an arthrodesis and tendon reconstruction was performed on 2021.01.20. (*Figure 6*). A cast was applied postoperatively, and no apparent complications were noticeable under postoperative observation.

In our most recent revision (15 months post FHL implantation, 10 months after arthrodesis), the patient presented with full ambulatory function and with no complications neither on the femoral components nor on the wrists (*Figure 7*).

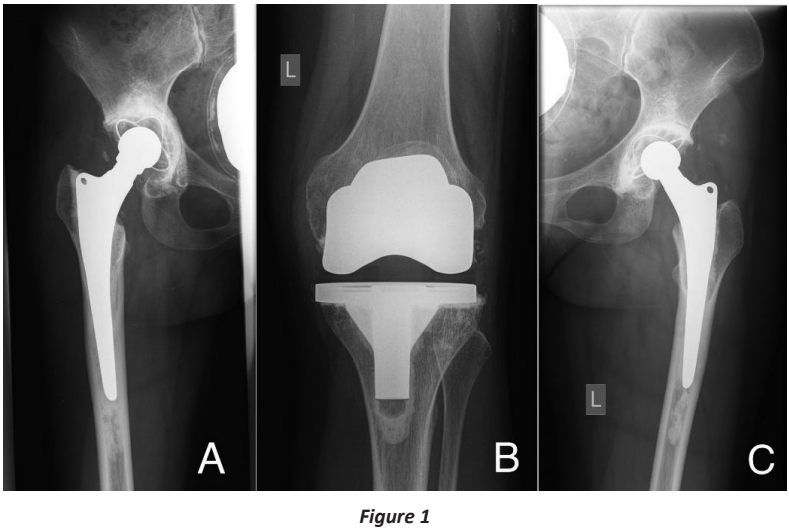

Figure 1
(A) X ray of the right side THA (2010); (B) Left side knee TKA (2011); (C) Left side THA (2013)

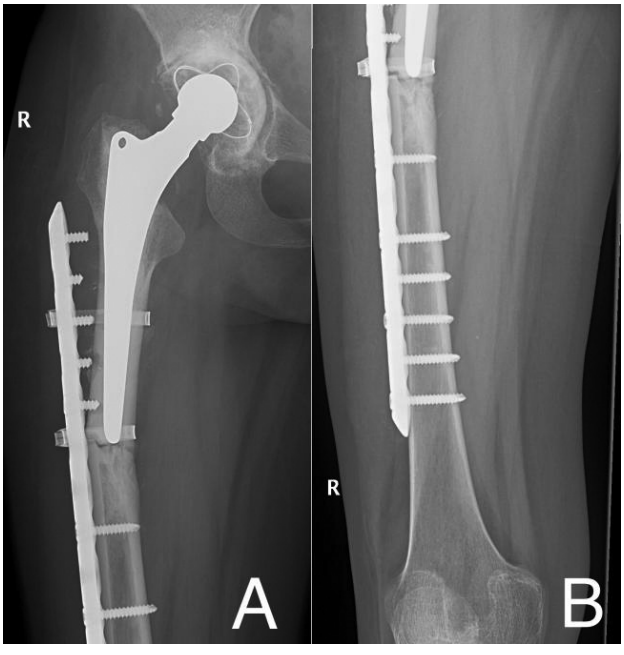

Figure 2 (A, B)
Preoperative X rays of left side periprosthetic femoral shaft fracture on October 2019

Figure 2 (C, D)
Postoperative X ray after one day of surgical intervention. The periprosthetic fracture was corrected with a LCP PFHP with a bone autograft and angular stability screws with attachments

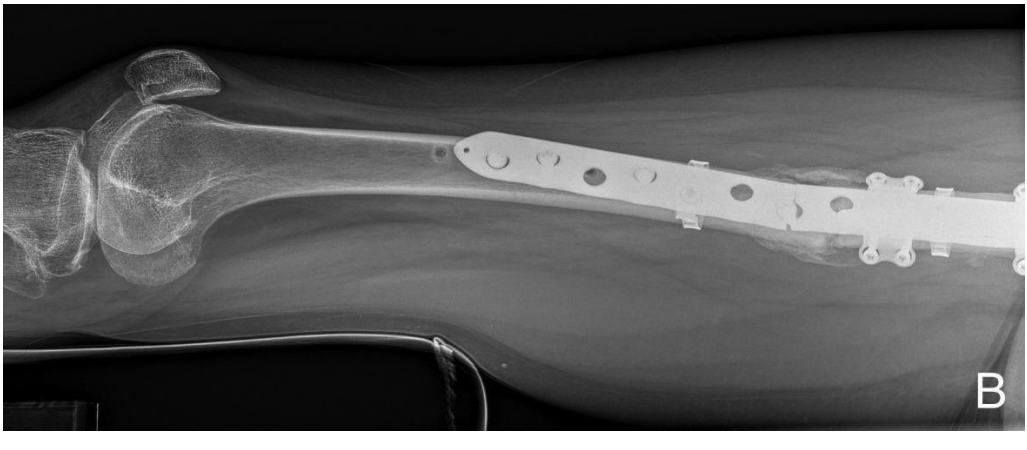

Figure 3
(A-B) Preoperative X rays of left side periprosthetic femoral shaft fracture on 2020.06.25.

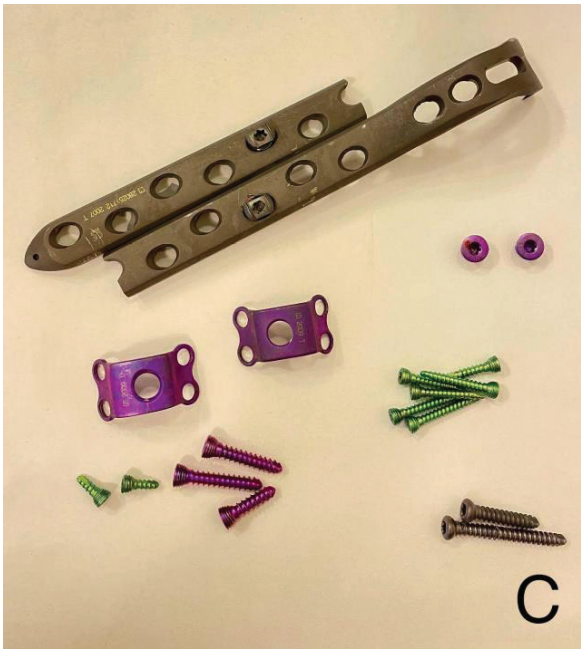

Figure 3 (C)
Implants that were removed due to the break in the LCP femoral hook plate

Figure 4 (A, B)
Postoperative X ray after cadaver bone allograft implantation and a new hook plate application

Figure 5 (A, B)
Subluxation of the left radiocarpal joint taken on 2020.10.13. Conservative therapy was recommended

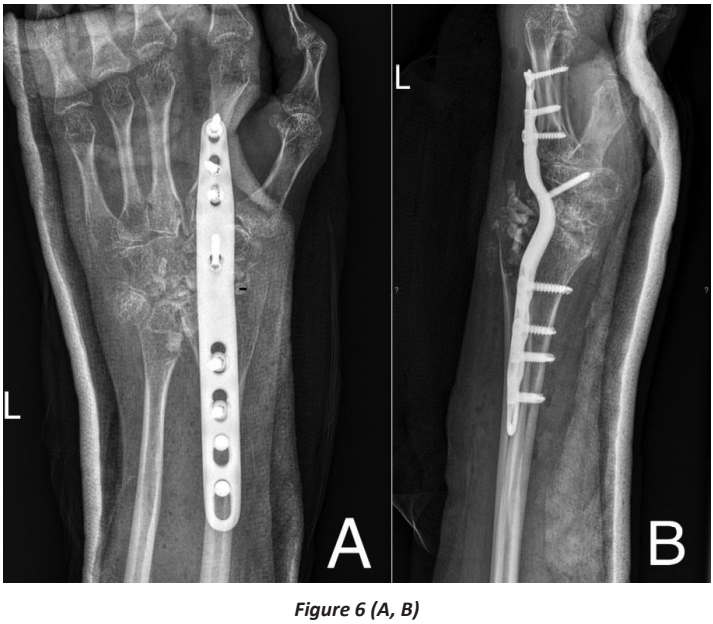

Figure 6 (A, B)
Postoperative X ray after left side radiocarpal arthrodesis and extensor tendon reconstruction

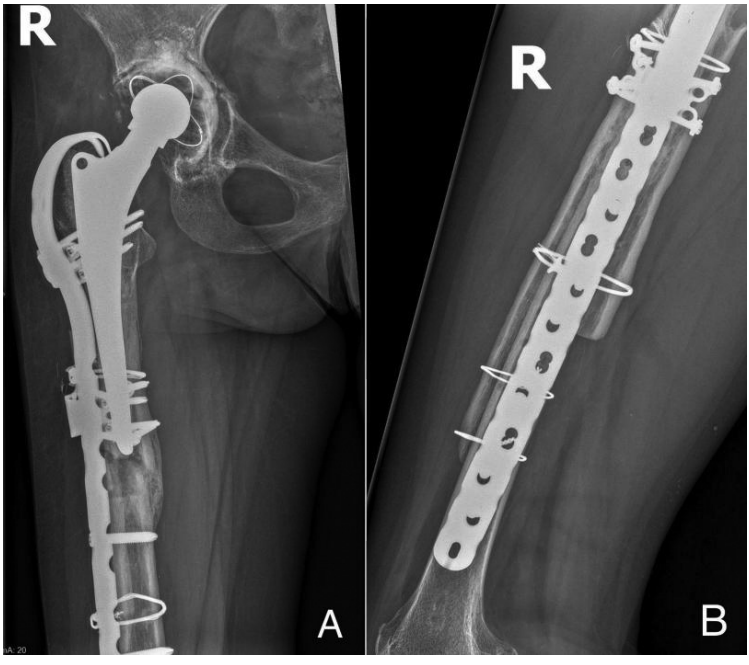

Figure 7 (A, B)
Right side FHP osteosynthesis after 15 months postoperative. X rays were taken in September 2021.

Figure 7 (C, D)
X ray of the left side radiocarpal arthrodesis after 10 months

DISCUSSION

While immunosuppressive therapy provides benefits in the treatment of autoimmune diseases, the well-known side effects can lead to serious consequences, especially osteoporosis (2). While complications of immunosuppressive therapy have been well understood and managed in older patients, the complications and its treatment of juvenile rheumatoid arthritis seems to be vague and unsettling, especially when the patients have had the disease for a longer period of time (3). Not only do the young patients have to struggle with complications from taking immunosuppressants in itself, pregnancy while under immunosuppression also exacerbates the patient's condition; the alteration of the patients osteobiology, osteoporosis (1).

In our case report, the patient had had a history of 30 years of immunosuppression at the age of 38, and received multiple surgeries over the course of more than ten years. Because of her advanced RA, she received three large total joint arthroplasties in her 20s. Also the fact that she gave birth accelerated her change in osteobiology, leaving her with brittle bone structure similar to an elderly patient. This led to a cascade of periprosthetic fractures, leading to multiple challenging surgical interventions. The challenges here that must be dealt with are numerous strategies.

Because of the advanced osteoporosis, she was put on an early treatment regime. *Sunyecz* reviewed that in compliant patients the use of calcium and vitamin D therapy decreases the risk of osteoporotic fractures (13). The patient also took alendronate, which the American College of Rheumatology recommends against glucocorticoid induced osteoporosis. Because of the patients' multiple re-surgeries, Teriparatide was also introduced in November 2019. Although the effectiveness of teriparatide is moderate with a 7% increase in premenopausal women with glucocorticoid use when compared to alendronate, its adverse effect cannot be ignored (8). While literature reviews that teriparatide increases the risk of osteosarcoma in rodents, it has not been shown to increase the risk in humans (15). In humans, hypercalcemia after subcutaneous administration and urinary calcium excretion seems to be the most common complications, in our case the patient presented with palpitations and tachycardia, which could have been caused by ionic disturbances caused by multiple drug interactions. After discontinuation, the side effects resided, and to our surprise the patient later did not suffer from further periprosthetic fracture complications. According to *Lane et al.*, even in glucocorticoid-induced osteoporosis, the effects of teriparatide continue up to 6 to 12 months, which may have been the cause of successful postoperative course in our patient as well (5).

In the initial periprosthetic fracture treatment in October 2019, the application of the FHP resulted in a periprosthetic fracture and the destruction of the titanium plate. In our initial treatment, an autograft collected from the patient's own pelvis was applied, which unfortunately resulted in the previously mentioned complication. Perhaps in an advanced osteoporotic patient with glucocorticoid use, the autograft was also osteoporotic in nature, which did not accelerate the ossification process, as expected (14). Literatures mostly focus only on the decrease in bone mass in the hip and spine, and not on the pelvis, it difficult to project the effectiveness of autograft application in patients with glucocorticoid, let alone premenopausal women. Allograft implantations can be indicated in case of Type B3 Vancouver periprosthetic fractures, especially in young and active patients (10). While *Hui et al*. suggests that in Vancouver type B1 or C fractures, the union rates are similar with or without strut allografting, our case report indicates otherwise (6). As unfortunate as it is, this specific case provides a rare perspective on the effectiveness of multiple osteoporotic medications and surgical techniques.

During the follow ups, we restricted the weight bearing of the patient's operated limb (15 kg during the first week, plus 5 kg per week), and introduced partial weight bearing as part of the patients rehabilitation program. As a general rule, most literature provides positive insight on immediate weight bearing during postoperative rehabilitation. They mostly analyzed cases in elderly patients

without long term glucocorticoid use (11, 12). One other important factor that should be taken into consideration is also the weight of the patient. According to *Keenan et al.*, immediate weight bearing had no noticeable effect on reoperation risks in patients with lateral locked plate fixation of periprosthetic distal femoral fractures, although these apply to those older patients and not patients with histories of long term glucocorticoid use (4). No differences in functional outcomes were noted in a randomized control study by *Paulsson et al.* (9). In cases of those with obesity, postoperative complications of THP are noticeably increased, which should be a consideration factor when introducing weight bearing exercises in rehabilitation (7). While we proceeded with caution, the first FHP did in fact break not right after the surgery, but gradually. We might be able to suspect that the outcome would have been similar even if we started immediate weight bearing. However, considering the fact that our patient had a rare history of long term glucocorticoid use, alendronate and teriparatide application, the osteobiological changes cannot be simply applied in the general rule of periprosthetic fracture treatment in the elderly. In our latest attempt, we reconsidered the biological changes of the patient by utilizing an allograft to stabilize the periprosthetic fracture both mechanically and osteogenetically, which lead to successful results.

On another note, the subluxation of the radiocarpal joint was most likely caused by the compensatory stress caused by use of walkers while restricted weight bearing, or from an imbalance in the flexor and extensor tendons. In our intraoperative assessment, the extensor tendons were ruptured, and the latter may be a more plausible cause. Nevertheless, if the rupture of the extensor tendons were caused by the excess stress still remains a possible mechanism of injury as well. Cases have been reported that excessive and multiple steroid uses cause spontaneous ruptures of extensor tendons (16).

CONCLUSION

Even in young patients, long term immunosuppression leads to drastic changes in osteobiology, and the surgical treatment of complicated fractures should be planned considering the altered osteobiology. The timing of administration of parathyroid hormone analogues could enhance the strength of the bone structure temporarily, but should be used with caution and medication alone may not be enough to treat periprosthetic fractures in patients with long term glucocorticoid use. In cases of treating young pre-menopausal women with a long history of immunosuppression, multidisciplinary perioperative planning is necessary to ensure a successful postoperative course.

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Arthroscopic treatment of femoral trochlear notch fracture caused by intra-articular dislocation of the patella
Case report

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ABSTRACT

This case report presents a traumatic intra-articular patellar dislocation – associated intercondylar fracture of the distal femur – and the consequent arthroscope assisted reduction and percutaneous screw fixation. To the best of our knowledge, this is the first case in which the arthroscope assisted operative reduction and percutaneous screw fixation of the fracture fragment has been demonstrated. Our patient was a 55-year-old female who was treated by the aforementioned method which concluded with excellent results.

Keywords: ***Arthroscopy; Dislocations; Femoral fractures; Patella;***

INTRODUCTION

Intra-articular or inferior dislocation of the patella is a well-documented yet rare clinical condition, in which the majority of cases require open reduction. The reported case is a unique intercondylar distal femur impaction fracture caused by a Type I intra-articular dislocation of the patella. This rare injury was managed using arthroscope assisted fracture reduction and percutaneous screw fixation

CASE HISTORY

A 55-year-old Caucasian female with moderate osteoarthritis slipped in her bathroom and landed directly onto her hyperflexed right knee. She was unable to bear weight on the injured knee locked in 90 degrees of flexion. The patella was closed-reduced in the emergency department using the hyperflexion maneuver. There was palpable joint effusion and limited range of motion however, active knee extension was possible without any palpable gap of the extensor mechanism. Plain radiographs confirmed an impaction of the femoral trochlea (*fig. 1*). Computer tomography was utilized for the exact location and the extent of the intra-articular fracture (*fig. 2*). The wedging of the proximal pole of the patella had caused an osteochondral fracture of the femoral trochlear notch measuring 25 mm × 15 mm x 20 mm. The consequent magnetic resonance imaging identified a partial quadriceps tendon tear on the lateral portion (*fig. 3*). The patient was then taken to the operating theatre in which, under general anesthesia, an arthroscopy was performed. During the operation, blood was rinsed out from the joint and the fracture was visually identified. In consideration of the lateral femoral condyle, a 2.2 mm wire was hammered behind the fracture in which the position of the wire was controlled using fluoroscopy. Next, the impacted fracture was tilted back to the anatomic position and the reposition was checked by the camera (*fig. 4*). Following these procedures, the fracture fragment was fixed in which a 5.0 mm diameter and 60mm long cannulated partially threaded titanium screw (ASNIS III, Stryker® Trauma Selzach AG, Switzerland) was inserted using the previously inserted wire as its guide. There were no additional injuries in the joint. Following the operation, conventional radiographs and CT scans were performed (*fig. 5–7*). Remarkably, there was no need for immobilization of the joint. Full weight bearing was allowed following six weeks convalescence. Following rehabilitative physiotherapy during the 12 months follow-up, the knee was asymptomatic and had regained full range of movement.

Figure 1
Plain lateral and AP view X-rays obtained at the time of admission

Figure 2

Computed tomography images in three different plains; showing the impaction femoral trochlear notch fracture

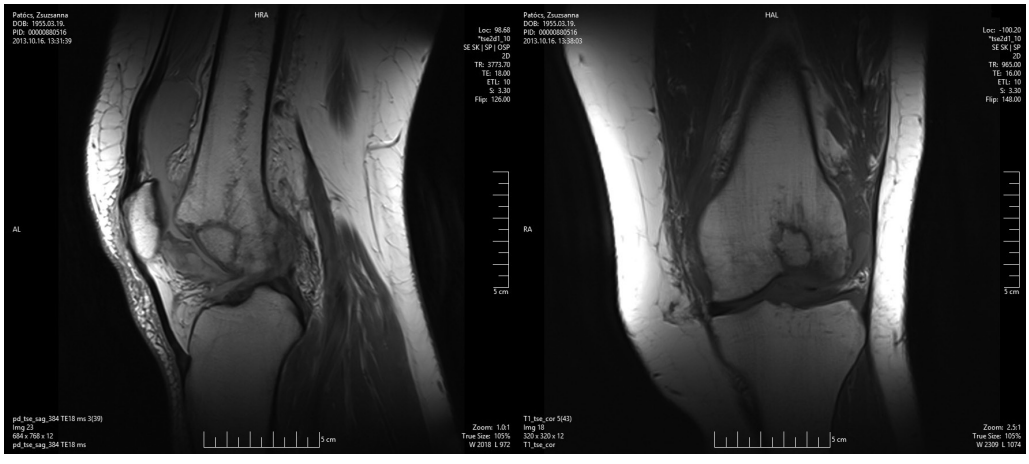

Figure 3

Pre-operative MR images

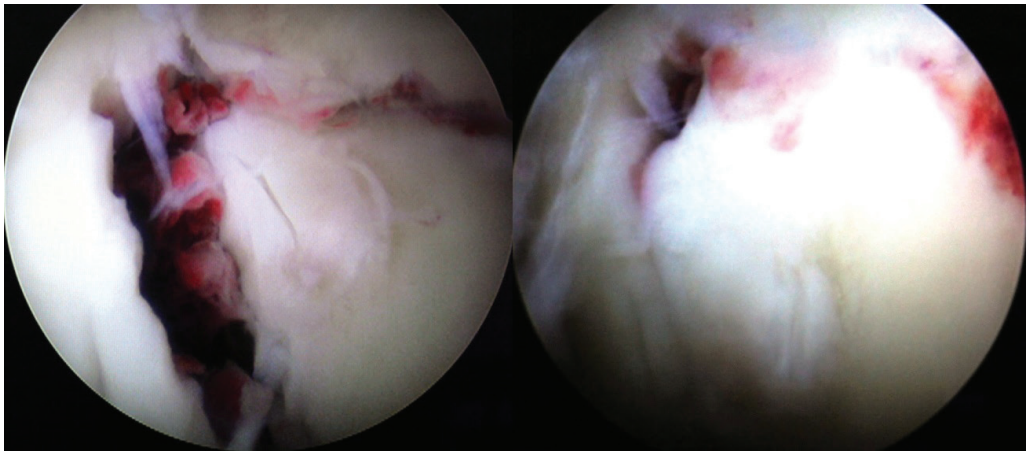

Figure 4

View of the impaction fracture and the fracture after reduction during arthroscopy

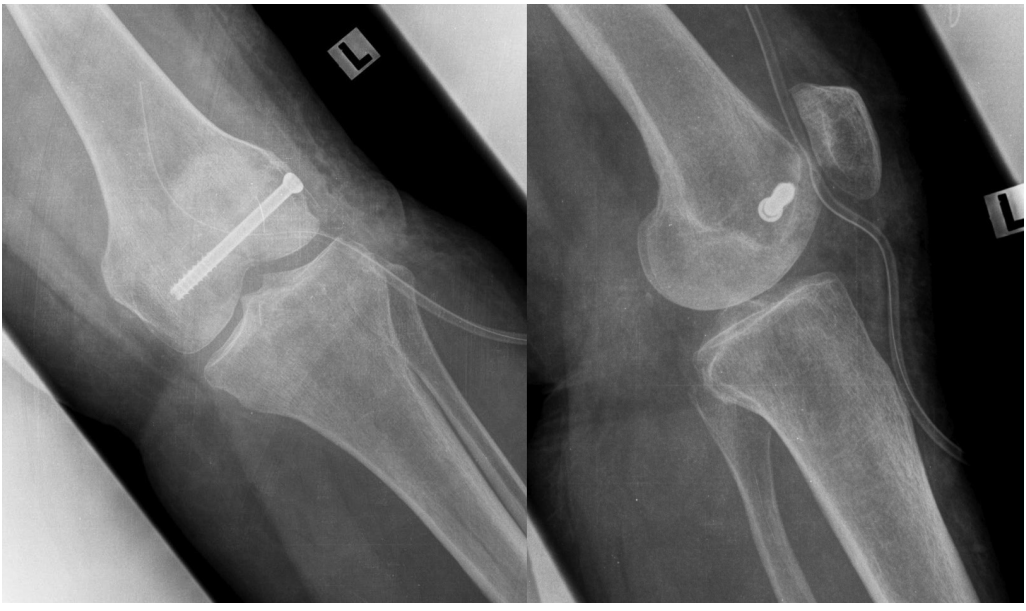

Figure 5
Post-operative plain lateral and AP view X-rays

Figure 6
Post-operative computed tomography images in three different plains; showing the anatomic reduction and screw fixation

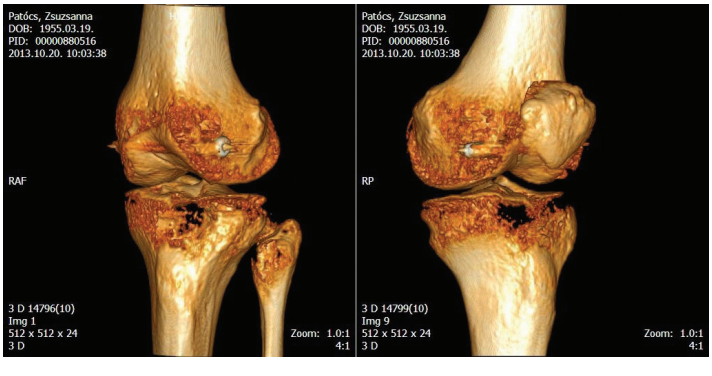

Figure 7
Post-operative three dimensional computed tomography images

DISCUSSION

The first case of intra-articular dislocation of the patella was reported by *Midelfart* in 1887 (13). Only 47 cases of this rare traumatic condition have been reported in published literature. Banks classified the inferior patellar dislocation into two types; the rare degenerate Type II and the common Type I injuries (1, 5, 11, 17, 18). Type I dislocations are usually present among adolescents (14, 17). The horizontal type of dislocation occurs when the victim falls down onto the over-flexed knee and the proximal pole of the patella wedges into the femoral trochlear notch (6, 7, 17, 19, 20). Our case patient had dislocated in the aforementioned way, however, this is the first case in which the wedging caused an impaction fracture of the femoral trochlear notch. Most of these cases require an open reduction as a primary procedure (3, 4, 8, 9, 12, 15, 16), only the cases with incomplete patellar rotation can be treated conservatively (3, 10, 12, 14). Distinctly, only three authors reported an osteochondral fracture of the lateral femoral condyle (2, 6, 18). Two of these authors treated the fracture during open surgery (6, 18). There is only one report regarding the importance of arthroscopy during the treatment of the inferior patellar dislocation. Barlow et al. reported a case referencing an 88-year-old female, in which the recurrent inferior patellar dislocations caused an impaction fracture of the lateral femoral condyle. During arthroscopy, the superior pole of the patella was trimmed and the ridge on the lateral femoral condyle was smoothed using a fine burr (2). Interestingly, the impaction fracture of the femoral trochlear notch caused by the superior pole of the patella during its inferior dislocation has not been previously described. In our report, we presented an arthroscopically assisted percutaneous screw fixation treatment regarding this type of injury. To assure the finest treatment of these fractures requires a correct diagnosis using a CT scan and a precise reduction and fixation. The best means to reach this area is through the use of arthroscopic guided surgery. Under arthroscopic control, we can reduce the fracture without causing further damage to the joint and visualize additional intra-articular damage. During closed reduction of the patellar dislocation, the intra-articular injuries are easy to miss.

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