eISSN 2287-1683
pISSN 1738-8767
Journal of Trauma and Injury
Vol. 28, No. 4, December, 2015

• Original Article •

우즈베키스탄 국립응급병원에 내원한 낙상환자들의 임상적인 특성

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- Abstract -

Features of Patients Associated with Falls from Heights Admitted to Republican Research Center of Emergency Medicine

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Purpose: study of the mutual influence of the individual anatomical regions damage in patients associated with falls from heights.

Methods: 561 medical reports of patients associated with falls from heights admitted to Republican Research Center of Emergency Medicine (RRCEM), in period of 2010-2013 yy, were analyzed retrospectively. Patient's age range was from 15 to 89. Treatment of these patients held in three stages: period of acute disorders of vital functions; relative stabilization period; stabilization of vital functions. The scope and content of medical diagnostic procedures performed on pre-hospital and intensive care stages. The severity of each injury was scored according to the AIS scale, the total severity of lesions was scored by points due to ISS. Digital material is treated by methods of mathematical statistics.

Results: Falls from heights leads to associated injuries for 4 times more than isolated trauma, and increases according to height of fall and falling surface. Patients with TBI+chest trauma, are most serious contingent that has highest mortality and complications (36.8%). TBI+musculoskeletal system trauma are characterized by high blood loss, traumatic shock and fat embolism, forming a vicious circle.

Conclusion: in patients associated with falls from heights clinical manifestations of injuries mutual aggravation syndrome will be seen. TBI leads to complication of chest trauma, delayed diagnostics of abdominal and chest trauma, aggravation of coma condition. Developing of high blood loss and fat embolism in musculoskeletal system trauma leads to shock and pulmonary embolism, which increases probability of death in the presence of abdominal or chest trauma, but abdominal trauma or chest trauma has no significant effect on the severity of the musculoskeletal system trauma. [J Trauma Inj 2015; 28: 248-255]

Key Words: Accidental fall, Injuries, Polytrauma, ISS Score

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Submitted : October 12, 2014 **Revised** : November 19, 2015 **Accepted** : December 7, 2015

This study was approved by the Ethical Committee of the Republican Scientific Center of Emergency Medicine.

I. Introduction

Nowadays multiple trauma named "polytrauma", referring to the number of lesions in one person, when one or more of them is a life-threatening.(1,2) Lately, the number of polytrauma, among which the TBI, fractures of the vertebrae, ribs, pelvis, lungs, spleen, liver, kidneys, often leading to death has dramatically increased.(3,6-8) In peacetime, polytrauma often arise as a result of motor vehicle accidents and fall from a heights. It is dominated by the severe damage of the brain and spinal cord, internal organs of the chest and abdomen, which are immediate cause of the death.(3-5) Incidence of fall comprises 30~35% of all cases of severe trauma, the number of which is permanently increasing.(3,4)

It should be noted that the character of fall from height largely depends on the height of falling. AIS (Abbreviated Injure Score) allows accurate estimation of the severity of isolated injuries, but polytrauma is not a simple sum of various lesions.(1,2) Regarding this, in 1974, S. B a ker et al. offered additional scale for evaluation the severity of polytrauma ISS (Injury Severity Score), in which leading damage score is squared, and added less severe injuries scores, author stressed the importance of the heaviest trauma and its dominant influence on the rest of the damage.(9,10) Proposed score allows predicting the outcome and choosing the adequate medical-tactical layout in the early period of severe polytrauma. However, in the early 90 s of the twentieth century, the high mortality rate among the most severe affected, and development of the terrible, life-threatening complications forced to develop a system of "damage control". This system takes into account the mutual influence of different damages on each other. Recently, the syndrome of mutual aggravation damage takes more attention.(9-11)

According to the literature, mortality in polytrauma within 3~12 hours after being injured depends on the severity of anatomic lesions (ISS) and physiological reserves of the organism, and at a later periods-depends on life-threatening complications, comorbidities and quality of medical care (APACHE).(1,2) According to experts, physiological reserves depends on the age of patient, existence of life-threatening opportunistic diseases; quality and adequacy of treatment depends on algorithm of action, accuracy in diagnostics, training of medical personnel in intensive care unit, surgery, neurosurgery, and trauma departments. All these components can be quantified in points. No any research on this issue was found.

The purpose of our research was to study the mutual influence of the individual anatomical regions damage to each other in patients associated with falls from heights.

II. Materials and Methods

561 medical reports of patients associated with fall from heights admitted to Republican Research Center of Emergency Medicine (RRCEM), in period of 2010~2013 yy, were analyzed retrospectively. RRCEM serves for the patients from Tashkent (2.4 mln people) and suburb regions (2.6 mln people) admitting with emergency pathology, and traumatic injuries. During one year RRCEM hospitalized up to 50 thousand patients, 14 thousand of them with traumatic injuries. Average age of patients associated with fall from heights is from 15 to 89 years (mean age average 37.72±2.32 years). 85.7% man and 14.3% women. 56.9% patients were delivered during first hour, 21% in 1~3 hours, 6.6% during 24 hours and 15.5% between 24 hour and 18 days after accident. 39% of patients admitted by themselves, 37% by ambulance and 24% transferred from other hospitals.

Patients associated with severe trauma from fall from heights, accepted by shock trauma unit of admission department, bypassing the admitting doctor's room. Shock trauma unit consist of emergency room and operating room with all necessary equipment for urgent diagnostics and treatment. Treatment of such patients held in three stages.

1st stage. The period of acute disturbances of vital functions lasts from 1 to 6 hours. During this period patient will be in shock trauma unit, where intensive care, resuscitation and emergency surgery eliminates acute disorders of vital functions.

2nd stage. The period of relative stabilization of

vital functions, extending from 6 to 72 hours. This period has big chance of probable developing of complications due to multiple trauma, thus treatment was held in intensive care unit. Doing delayed surgical operations in this period is very dangerous.

3rd stage. The period of stabilization of vital functions, extending from 3 to 10 days. During this period, delayed surgeries may be performed: fixation of fractures of long bones, pelvis, and vertebrae. Treatment during complete stabilization of vital functions was performed in surgical departments depending on the type of trauma.

We have assessed the scope and content of diagnostic and treatment activities carried out in the pre-hospital and emergency stages of medical care. The severity of each damage scored on a scale AIS. The total severity of injuries was scored on the ISS.

The data are processed by methods of mathematical statistics. Statistical analysis was performed using the statistical software Statistica (StatSoft, Inc). The ANOVA method was applied. The mean (M) and standard deviation (SD) were deduced. Data were analyzed by the Student t-test. We also used the Chi-square test to compare observed data. A probability value of $p<0.05$ was considered statistically significant.

III. Results

In 449 (80%) patients (mean age 37.6 years) we have noted damage of several anatomical regions (the main group), 112 (20%) patients (mean age 38.3 years) with isolated damage of one anatomical region (control group) (Table. 1).

492 (88%) patients had accidentally falling, 36 (6%), the fall was due to criminal situations and 36 (6%) patients committed suicide by falling. 15% of the patients at the time of the fall had alcohol intoxication. 72.7% were at home, 5.5% - in the workplace, 9.7% were employee, 12.1% were in other places. Fell out of the window or balcony 28.9%, patients fell from the ladder - 28.3%, from the roof of the building - 14.3%, from power poles or other high structures - 17.1% from the trees - 11.4% (Table 2).

The nature and severity of the trauma were directly dependent on the falling height and the characteristics of the landing surface. Character of trauma changes due to increasing of height: number of isolated trauma is reduced and the number of multiple trauma increases (Table 3). Such uniformity may be seen due to increasing of the surface density to which the patient has landed (Table 4).

Total amount of damaged anatomical areas of the

Table 1. Population demographics of injured patients. (percentages with 95% confidence intervals [CI])

Gender	Isolated trauma		Multiple trauma		Total	
	n	(%, 95% CI)	n	(%, 95% CI)	n	(%, 95% CI)
Male	101	(90.2, 84.7-95.7)	380	(84.6, 81.3-87.9)	481	(85.7, 82.8-88.6)
Female	11	(9.8, 4.3-15.3)	69	(15.4, 12.1-18.7)	80	(14.3, 11.4-17.2)
Total	112	(20.0, 16.7-23.3)	449	(80.0, 76.7-83.3)	561	(100)

Table 2. Mechanism of falls. (percentages with 95% confidence intervals [CI])

Falling object	Isolated trauma		Multiple trauma		Total	
	n	(%, 95% CI)	n	(%, 95% CI)	n	(%, 95% CI)
Window/Balcony	14 (2)	(12.5, 6.4-18.6)	148 (25)	(33.0, 28.6-37.4)	162	(28.9, 25.1-32.7)
Roof	18 (1)	(16.1, 9.3-22.9)	62 (7)	(13.8, 10.6-17.0)	80	(14.3, 11.4-17.2)
Tree	16 (1)	(14.3, 7.8-20.8)	48 (2)	(10.7, 7.8-13.6)	64	(11.4, 8,8-14.0)
Ladder	35	(31.3, 22.7-39.9)	124 (1)	(27.6, 23.5-31.7)	159	(28.3, 24,6-32.0)
Pole/fence	29	(25.9, 17.8-34.0)	67 (1)	(14.9, 11.6-18.2)	96	(17.1, 14.0-20.2)
Total	112 (4)	(20.0, 16.7-23.3)	449 (38)	(80.0, 76.7-83.3)	561 (42)	(100)

Note. Number of patients who had collision with other objects during falling is shown in brackets.

body in patients associated with fall from height was 1326 (Fig. 1). Most of patient had combination of two or three damaged areas.

Table 5 shows that mortality increases according to number of injured anatomical regions.

For analysis we have selected the most severe and frequent promptness dominant damages. 1st group consisted of 95 patients with traumatic brain injury (TBI) (4–5 points of AIS), combined with the musculoskeletal system trauma (MSST) (3 points of AIS). Group 2 included 19 patients with TBI (4 points of AIS) and chest trauma (ChT) (3 points of AIS). The combination of TBI and abdominal trauma (AT) was observed in 5 cases and combination of TBI+ChT+AT +MSST observed in 12 cases.

TBI was presented with severe brain contusion, fracture of the skull base to the leaking of the cerebrospinal fluid, a fracture of the cranial vault with the leaking of liquor or loss of brain substance, significant displacement (the distance between the fragments of more than 2 cm), impressions larger than 2 cm, rupture of the dura and arachnoid, intracranial hematoma less than 100 ml, intracerebral hematoma (4 points of AIS). In case of chest

Table 3. Distribution of patients due to height of the fall.

Height of fall in meters	Number of damaged areas, n (%)					
	1	2	3	4	5	6
Up to 3	75 (67.0)	143 (58.6)	47 (38.2)	11 (19.0)	1 (5.3)	-
3-6	29 (25.9)	64 (26.2)	41 (33.3)	14 (24.1)	5 (26.3)	3 (60.0)
6-9	7 (6.3)	22 (9.0)	16 (13.0)	14 (24.1)	4 (21.1)	-
More than 9	1 (0.9)	15 (6.1)	19 (15.4)	19 (32.8)	9 (47.4)	2 (40.0)
Total	112 (100)	244 (100)	123 (100)	58 (100)	19 (100)	5 (100)

Table 4. Distribution of patients due to landing surface.

Falling surface texture	Isolated trauma		Multiple trauma		Total	
	n	(%, 95% CI*)	n	(%, 95% CI)	n	(%, 95% CI)
Grass/shrubs	3	(2.7, 0-5.4)	9	(2.0, 0.7-3.3)	12	(2.1, 0.9-3.3)
Loose ground	8	(7.1, 2.3-11.9)	29	(6.5, 4.2-8.8)	37	(6.6, 4.5-8.7)
Hard ground	54	(48.2, 38.9-57.5)	186	(41.4, 36.8-46.0)	240	(42.8, 38.7-46.9)
The concrete surface	40	(35.7, 26.8-44.6)	219	(48.8, 44.2-53.4)	259	(46.2, 42.1-50.3)
Pan/Gate/Metal surface	7	(6.3, 1.8-10.8)	6	(1.3, 0.2-2.4)	13	(2.3, 1.1-3.5)
Total	112	(20.0, 16.7-23.3)	449	(80.0, 76.7-83.3)	561	(100)

* CI: confidence interval

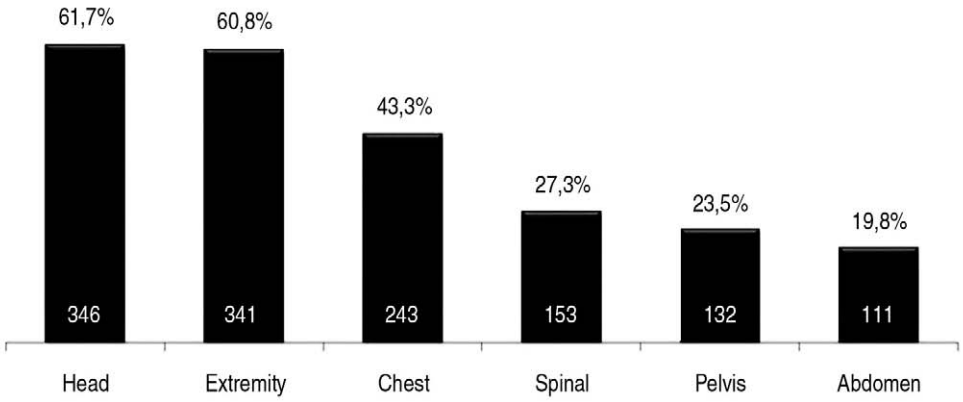

Fig. 1. Distribution of victims, depending on the number of damaged anatomical regions of the body (561 patients, damaged regions 1326).

trauma following injuries may be seen; pulmonary contusion and pulmonary rupture less than 1 lobe, unilateral hemothorax or pneumothorax, fractures of over 3 ribs on the one side and at least 3 ribs on the other side (4 points of AIS). Damage of MSST (3 points of AIS) corresponded to the open comminuted fracture of the shoulder, open comminuted fracture of the tibia, femur fracture, fractures of the hip and knee joints, multiple unstable fractures of pelvis.

Total number of multiple injured patients associated with fall from height was 449, 66 of them died (14.7%). Sampling of patients who died held out from total number of mortal cases due to multiple trauma. Sampling of survived patients (383), and patients with isolated trauma (112) held out from admitted patients' number. Injuries and complications were diagnosed by objective diagnostic methods (X-Ray, Sonography, CT etc.)

Data analysis showed that the severity of multiple injured patients significantly worse than the severity of the patients with isolated trauma of the same anatomical area that has same AIS points (Table 6).

An analysis of selected material showed that the most severe condition has patients with TBI+ChT, which confirmed by high mortality number (36.8%) (Table 7).

Table 5. Mortality of injured patients.

Number of injured regions	Number of patients		Number of deaths			
	n	(%, 95% CI*)	n	death rate, %	median age in years (range)	median ISS† (range)
1	112	(20.0, 16.7-23.3)	2	1.8	39 (34-44)	75 (75-75)
2	244	(43.5, 39.4-47.6)	17	7.0	50.2 (17-89)	53.8 (8-75)
3	123	(21.9, 18.5-25.3)	13	10.6	57.2 (19-82)	38.5 (17-75)
4	58	(10.3, 7.8-12.8)	23	39.7	44.7 (19-87)	41.1 (24-75)
5	19	(3.4, 1.9-4.9)	12	63.2	46 (15-80)	41.5 (22-75)
6	5	(0.9, 0.6-1.5)	1	20.0	19 (19)	48 (48)
Total	561	100	68	12.1	42.7 (15-89)	49.7 (8-75)

* CI: confidence interval
† ISS: injury severity score

Table 6. Comparative assessment of injured patients by ISS. (Median ISS*, range)

Injury severity	Multiple injury		Isolated injury		
	TBI†+ChT‡	TBI+MSST	TBI	ChT	MSST§
ISS	(26.16, 8-75)	(13.14, 5-75)	(11.5, 4-75)	(9.43, 4-16)	(6.24, 4-18)

* ISS: injury severity score
† TBI: traumatic brain injury
‡ ChT: chest trauma
§ MSST: musculoskeletal system trauma

Table 7. Comparative evaluation of mortality of patients depending on combination of damaged anatomical regions of the body.

Combination of damaged regions	Number of deaths		
	n (%)	Median age in years (range)	Median ISS* (range)
TBI†+ChT‡	7 (36.8)	51.9 (38-77)	47.4 (25-75)
TBI+MSST§	4 (4.2)	67.8 (46-89)	45.8 (8-75)
Isolated TBI, ChT, MSST	1 (1)	44 (44)	75 (75)

* ISS: injury severity score
† TBI: traumatic brain injury
‡ ChT: chest trauma
§ MSST: musculoskeletal system trauma

Patients with TBI combined with MSST, had more blood loss than patients with isolated TBI, ChT or MSST. This is confirmed by developing of traumatic shock in 13.7% of TBI+MSST, 3.2% fat embolism and formation of a vicious circle, which is based on circulatory, respiratory and hemic hypoxia. These conditions have a significant impact on the development of many complications in the future, especially in the lungs, kidneys and liver, leading to multiple organ failure (2.1%). In case of absence or inadequacy of shock therapy at pre-hospital and in-hospital stages condition of patients worsened. Thus some diagnostic and therapeutic methods (CT, reposition, delayed surgery, and others) had to be delayed until stabilization of patient's condition. All these conditions are the reason for high mortality of patients with combined trauma of TBI+ChT and TBI+MSST.

Mostly combined trauma affects to development of infectious complications. Thus 21% of patients with TBI+ChT had pneumonia, 10.5% had brain swelling, 31.6% polyorganic insufficiency. In combination TBI+MSST pneumonia developed in 3.2%, brain swelling 3.2%, fat ambolism 3.2%, polyorganic insufficiency in 2.1%. In patients from control group with isolated trauma severe pneumonia cases were rare: in ChT – 11.4%, in TBI – 5%. No complications of pulmonary system in MSST were observed. No death cases were observed in isolated ChT and MSST. Only one patient with isolated TBI died due to aspiration syndrome complicated with aspiration pneumonia, other patients have been successfully treated by intensive therapy.

We have also analyzed the patients with the combination of TBI+ChT+AT+MSST. Mortality in this group was 50%. Complications as pneumonia were observed in 33.3%, brain swelling 41.7%, and multiple organ failure was 33.3%.

Thus, falls from heights leads to associated injuries for 4 times more than isolated trauma. The frequency of associated injuries increases according to the falling height (6 meters or more) and falling on a hard surface. Severe TBI, ChT and MSST are frequently determined. Patients with TBI+ChT are the most serious contingent, which is confirmed by high mortality rate (36.8%). Patients with TBI+MSST at admission had a more severe blood loss than patients with isolated TBI, ChT or MSST. This is confirmed by the development of traumatic shock in 13.7% of them, fat embolism in 3.2% and the formation of a vicious circle. Among the patients with associated TBI+ChT pneumonia was observed in 21% of them, cerebral edema – 10.5%, multiple organ failure – 31.6%. In patients with TBI+MSST pneumonia occurred in 3.2%, cerebral edema – 3.2%, fat embolism – 3.2%, multiple organ failure – 2.1%. In patients associated with fall from heights clinical manifestations of mutual aggravation syndrome will be seen.

IV. Discussion

According to statistics of RRCEM, patients associated with fall from heights was 13.6% of the total number of injured patients, that maybe due to architecting of high buildings, and increasing of private constructions when there is a failure to comply with safety regulations. Proof of this is the high frequency of fallings among young and middle-aged people, employed persons and mechanism of their development: increasing of severity of the trauma is related with increasing of height and collisions with other objects during falling.

Analyzing the most common combined injury (TBI+ChT, TBI+MSST), it should be noted that the most severe injuries, with high score of AIS and ISS, has higher mortality number that is also specific for TBI+ChT. According to the literature, TBI is a part of multiple trauma, that affects directly on respiratory center and causes central respiratory insufficient.(2,12) In chest trauma peripheral respiratory disorders will be seen.(2) It may be related with lung collapsing due to hemothorax and pneumothorax, or airway obstruction, chest framing or decrease in cardiac output and an increase in resistance in the bloodstream. In our studies, these factors determined the development of acute respiratory failure in 6 patients, which could be one of the reasons of shock. One-time effect of these injuries apparently determined more severe condition of the patients and was a reason for mutual aggravation of damage. Thus, the mechanical respiratory distress (limited chest excursions and lung tissue compression by

pneumothorax or hemothorax, etc.) was accompanied by the negative impact of brain coma and development of decompensate hypoxia.(2,13,14) Considering, that brain is very sensitive to hypoxia, we can expect deepening of coma, and developing of delirium with psychomotor agitation. On the other hand, these factors contribute development of severe pneumonia, which increasing mortality, this data according our observations was 36.8%. It should be noted that patients with TBI+MSST at admission had hemorrhage, traumatic shock (13.7%) and fat embolism (3.2%). It determined the development of a vicious circle, which is based on circulatory, respiratory and hemic hypoxia.(1,2,12) It has a significant impact on the development of many subsequent complications, especially in the lungs, kidneys and liver, resulting in multiple organ failure in 2.1% of patients. These complications are aggravated by inadequate prehospital activities. Some diagnostic and therapeutic measures had to be postponed until stabilization, because of the serious condition of the patients. Totally, mortality rate in this group was 4.2%.

Mutual aggravation of injuries was evident in cases where a dominant injury of body region with a point 3 of AIS had additional minor injury of other region with point 2 of AIS, although the ratio of points on the dynamics of AIS scores was still same. Thus, in patients with TBI+ChT+AT+MSST mutual aggravation of damaged area was a reason for developing of brain swelling (41.7%), pulmonary infection (33.3%), multiple organ failure (33.3%). Proof of this is the higher incidence of pneumonia in 21% of patients with TBI+ChT than in patients with TBI+MSST – 3.2%. Our results are same with the literature, according to which the pulmonary pathology increases dramatically in multiple chest trauma.(11,14) On the other hand, abdominal trauma may be main reason that causes blood loss and develops hemodynamic disorders.(11,15) At the same time pain impulses will be decreased due to brain injury that leads to delayed diagnostics of abdominal injuries.(11,13,15)

Thus, patients associated with fall from height have clinical manifestations of syndrome of injury mutual aggravation. Condition of patients with combined TBI and ChT will be mutually aggravated.(2,14) Our results confirm the data of mutual impact of brain damage, chest and abdomen in patients associated with fall from heights. As it was mentioned before, falls from heights are characterized by high frequency of associated injuries of MSST, which could also have an impact on mutual aggravation of condition. Thus, high blood loss and fat embolism, leads to shock and pulmonary embolism, that increases a risk of death in patients with chest or abdominal trauma, but chest trauma or abdominal trauma has no significant effect on severity of MSST. Also, according to V.A. Sokolov, the condition of patients is mutually aggravated by association of chest and abdominal trauma.(2) In our observations chest trauma had no significant impact on the course of abdominal trauma, while the abdominal trauma aggravated condition of patient with chest trauma because of increased blood loss and respiratory disorders.

V. Conclusion

In patients associated with fall from heights clinical manifestations of the syndrome of mutual aggravation of injuries will be seen. In multiple injuries, TBI promotes complicated course of chest trauma, delayed diagnosis of chest and abdominal injuries, aggravating of coma. Increased blood loss and fat embolism in MSST leads to development of shock and pulmonary embolism that increases probability of death in case of chest or abdominal trauma, but chest or abdominal trauma as isolated trauma doesn't have an effect on severity of MSST.

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