

# Forensic Medical Characteristics of Damage in Falling from Height

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**Abstract** The results of forensic medical examination of 82 corpses, persons who died as a result of falls from a height, were studied and analyzed. Among the dead were 64 men and 18 women. The height of the falls varied from several to tens of meters. The aggregate of injuries in persons affected by falls from a height are characterized by severity and are characterized by the formation of the most frequent (80.5%) combined trauma (CT) of more than two parts of the body. Injuries of the chest and chest cavity organs (90.2%), abdominal organs (80.4%), traumatic brain injury (TBI) (68.5%) and spinal cord injury SCI (30.5%) prevail in the composition of CT during falls from a height. Injuries to the limb bones and their structure were detected in 30.1%, and injuries to the pelvic bones and their structure – in 20.2% of cases. The severity and massiveness of CT in the victims were the direct cause of death at the pre-hospital stage and in the early period (1-3 days) of the hospital stage from severe TBI, massive blood loss and traumatic shock. The massiveness of the ST covering more than 2 parts of the body was due to the height of the fall (from 4-5 and 6-8 storey buildings) and frequent landings falling in a horizontal position. These data can be taken into account for forensic diagnostics and differential diagnosis of blunt trauma, in the conditions of non-obvious circumstances of damage. The nature and location of injuries that occur when falling from a height can be important in the process of organizing and providing emergency and specialized medical care to victims.

**Keywords** Falls from height, Combined trauma, Diagnostics, Mechanism, Forensic medical examination

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## 1. Actuality of the Problem

Due to the rapid growth of cities and the increase in the number of storeys of buildings, the number of mechanical injuries from falling from a height around the world has increased dramatically. For this reason, the medical and social aspects of this trauma constantly attract the attention of researchers of various medical specialties [1] In the structure of blunt mechanical trauma, injuries resulting from falling from a height are second only to road traffic injuries and account for 20 to 40% of all blunt injuries [2]. The circumstances of the fall from a height are very diverse. The most frequent falls are observed from functioning buildings (80-90%), relatively rarely from structures under construction (about 10%), and significantly rarely from trees, mountains, or in closed spaces – a well, a mine. A lot of deaths related to falls occur in the construction industry [3,4,5]. When falling from a height, victims usually

experience severe CT - multiple injuries with injuries to the bones of the skeleton and internal organs. However, the severity and nature of CT falls depend on the height, type and direction of the fall, as well as the nature of the landing surface and the age of the victims [6,7,8]. The mortality rate from ST in specialized clinics is 18.8-36.0%, of which 50-60% died at the pre-hospital stage [9].

Forensic diagnostics and differential diagnostics of injuries associated with falls from a height continue to be the most complex due to the wide variety of types of falls, mechanisms of their formation, as well as polymorphism of damage to organs and tissues [10,11]. These data dictate the need to further study the biomechanics of this injury to solve forensic problems and regularly analyze the nature and volume of CT to improve the quality and effectiveness of medical care for victims with CT at the pre-hospital and hospital stages.

## 2. The Purpose of the Study

To study the structure and nature of injuries in persons who died as a result of falls from a height.

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### 3. Materials and Methods of Research

The results of the forensic medical examination of 82 corpses and persons who died as a result of falls from a height were studied and analyzed. The victims were mostly aged between 16 and 66 years (80). In two cases, the victims were aged 80 and 84. Among the dead men -64, women -18. The height of the falls varied from several to tens of meters. Circumstances of falls: falls from Windows and roofs of 4-5 and 6-8 storey buildings-78, falls from a pole-1, from a carousel-1, from a walnut tree-1. According to the materials of the preliminary investigation, in all cases there was a free fall without preliminary acceleration (passive fall). In 48 cases, the victims died at the scene of the injury, in the remaining 34 cases-in hospitals on 1-3 days.

### 4. Results and Discussions

**Table 1.** General characteristics of injuries in victims of falls from a height

N n/n	Structure and nature of damage	Frequency of occurrence
1.	TBI	5
2.	CT of the head, chest and abdomen	20
3.	CT chest and abdomen	8
4.	CT of the head, chest, abdomen and limbs	6
5.	CT of the head, spine, chest and abdomen.	6
6.	CT of the chest, abdomen and limbs	6
7.	CT of the head, chest, abdomen, pelvis and extremities	5
8.	CT of the spine, chest and abdomen	4
9.	CT of the head, spine, chest, abdomen, pelvis and extremities	4
10.	CT of the head, spine, chest, abdomen and limbs	3
11.	CT of the head, chest, abdomen and pelvis	2
12.	CT of the head, chest, pelvis and extremities.	2
13.	CT chest, abdomen and pelvis	2
14.	CT of the head, chest and limbs	1
15.	CT of the spine, chest, abdomen, pelvis and extremities	1
16.	CT of the chest, abdomen, pelvis and extremities	1
17.	CT head and spine	1
18.	CT of the head, spine and chest	1
19.	CT of the abdomen, pelvis and limbs	1
20.	CT of the spine and chest	1
21.	CT of the spine, chest and extremities	1
22.	Fractures of the bones of the right forearm and right thigh, complication of pulmonary embolism	1
Total		82

The totality of injuries in persons affected by falls from a height differ in severity and is characterized by the formation of the most common (66 cases out of 82) CT of more than

two parts of the body. Isolated TBI it was detected in 5 cases and CT of two body parts was detected in 11 cases (see table 1).

The table shows that in 68.5% of cases (56 out of 82 observations), victims of falls from a height have severe TBI, which is often accompanied by multiple fractures of the bones of the arch and base of the skull (36 out of 56 cases). TBI in almost all cases (52 out of 56 cases) was combined with trauma to more than 2 parts of the body: chest and abdomen (20), chest, abdomen and extremities (6), spine, chest and abdomen (6), chest, abdomen, pelvis and extremities (6), spine, chest, abdomen, pelvis and extremities (4), etc. Combined TBI in most cases occurred as local primary and local secondary injuries.

In the composition of CT, vertebral-spinal injury (VSI) was observed in 30.5% of cases (25 out of 82). Psmt was often combined with trauma to the head, chest, abdomen and extremities (6), chest and abdomen (7), head, chest, abdomen, pelvis and extremities (6). VSI often covered 2 or more parts of the spine and was characterized by localization: cervical-occipital trauma (C1-C2)-4, lower cervical (C3 - C7)-7, upper thoracic (T1 - T4)-4, lower thoracic - 9, lumbar - L1 - L2 (3), L3-L5 (5). In 15 cases (out of 25), compression fractures of the vertebrae were noted, rotation-7, distraction fractures-3. In 3 cases, there was a complete separation of the spinal cord in the cervical (2) and thoracic (1) divisions. VSI as separate injuries can be observed in any variant of landing falls, but compression fractures of the spine were the results of falls on the legs.

St of the chest and chest cavity were detected in 74 cases (90.2%), St of the abdomen was detected in 69 cases (80.4%). In the structure of chest injuries, rib fractures were noted in 51 cases, including right - 13, left - 16, and bilateral - 22. Lung injuries were also the most characteristic of falls from height, which we observed in 69 cases (80.4%). Traumatization of the lungs was characterized by bruises of this organ and morphologically expressed mainly by massive hemorrhages in their parenchyma, which were mainly localized in the root area of both lungs, and sometimes there were tissue tears. In a number of cases, bruises of the heart were detected, sometimes with tissue tears and hemorrhage in the mediastinal region.

In the structure OF St of the abdomen, liver damage in the form of subcapsular hemorrhage, parenchymal hemorrhages and ruptures was noted in 56 cases, hemorrhages in the intestinal wall and mesentery-52 (out of 69). In addition, hemorrhages were detected in the diaphragm (8), kidneys (9), and spleen (7). The formation of a large volume of damage to the chest, chest cavity, and abdominal organs was due to both the height of the falls and the frequent horizontal positions of the victims' bodies at the time of landing.

H. Haddat (1984) established the relationship between the nature of damage caused by direct free fall and the height of the fall. Depending on the height of the fall, he identified 5 groups of damage, namely: for falling from a height of growth, from a height of 4-5 meters, 5-13 meters, 13-24 meters and more than 24 meters. From the author's point of

view, as the height of the fall increases, the number of damaged body parts increases, while the number of head injuries decreases, and the number of chest and abdomen injuries increases. The location, nature and extent of damage depends on the height of the fall and the position of the body at the time of landing. According to the author, as the height of the fall increases, the value of the body position during landing gradually decreases and the probability of fatal outcomes increases to 90% of the ST [12].

Data on injuries to limb bones during falls are shown in table 2.

**Table 2.** Fractures of the bones of the extremities in falls from a height

№ n/n	Limb bone injuries		
		on right	on left
1.	Fractures of the humerus	5	-
2.	Forearm fractures	5	7
3.	Femur fractures	5	7
4.	Fractures of the shin bones	-	6
5.	Calcaneus fractures	2	2
6.	Fractures of the bones of the hand and phalanges	2	-
	Total	19	22

Injuries to limb bones were detected in 25 cases (30.1%). The table shows that fractures of the forearm, femur, right humerus, and left Shin bones were relatively more frequent. These bone fractures were most often diaphyseal and often comminuted with dislocations, epiphyseal and intra-articular fractures were observed in the tibia and wrist joints (typical fractures) relatively less often.

Pelvic injuries were reported in 18 cases (20.2%). They were characterized by fractures, often comminuted, of the iliac (often on the right) and sacral bones, a complete rupture of the symphysis and ligaments of the sacroiliac joint, and sometimes a fracture of the structure of the hip joint. These data indicated the formation of damage to the pelvic structure mainly when falling on the buttocks.

The nature of the volume and localization of local primary and remote damage in a free fall from a height depend on the landing options. It is established that injuries to various parts of the head mainly occur as local primary injuries when falling from a height and landing on the head. At the same time, the head is often damaged and the hands, as at the moment of landing, the victims expose them for self-defense. Injuries to the femur and lower leg bones occur mainly when landing on the feet as distant injuries, and injuries to the feet and ankle joints – as primary local injuries. At the same time, injuries to the spine, chest, chest cavity, abdomen, and pelvis as separate injuries can be observed in various landing options. Landing a person falling from a height in a horizontal position leads to the formation of more severe and diverse primary local injuries to the chest and abdomen in the form of tears and splinters. In this case, the damage is localized mainly on the side of the organ that was facing the impact surface [3].

The primary causes of death of victims at the trauma sites were: gross anatomical trauma of more than 2 parts of the body, severe TBI, massive blood loss, cervical-occipital trauma (COT), in some cases – cardiac tamponade and bilateral hemo-pneumothorax. In the earlier period of CT (1-3 days), the death of victims in hospitals occurred as a result of edema and dislocation of the brain, ascending edema of the spinal cord, traumatic and hemorrhagic shock, pulmonary edema, fat embolism of the brain and lung vessels.

The variety of options for combining injuries and disorders that occur in the body during CT as a result of falls from a height requires the search for modern methods of early diagnosis and rational methods of treatment aimed at reducing mortality and disability [13]. ST accompanied with TBI has a low-symptomatic (atypical) course associated with traumatic (hemorrhagic) shock and appears to be the most dangerous conditions. The covered damage to the abdominal organs in the composition of CT is about 54-62%, in which the liver and spleen are more often damaged, the mortality rate reaches from 23% to 41% [14].

In forensic terms, cases of CT, regardless of its outcome, require justification of the mechanical and thanatogenesis of injuries. Morphological and morphometric indicators of internal organ damage can be used to justify the mechanogenesis of trauma and for differential diagnosis of various types of blunt mechanical trauma.

## 5. Conclusions

Falling from a height is one of the most frequently observed types of blunt trauma. The totality of injuries in persons affected by falls from a height differ in severity and is characterized by the formation of the most common (80.5%) CT more than two parts of the body. Injuries to the chest and chest cavity organs (90.2%), abdominal organs (80.4), TBI (68.5%) and VSI (30.5%) predominate in the composition of CT when falling from a height. Injuries to the bones of the extremities and their structure were detected in 30.1%, injuries to the pelvic bones and their structure -20.2% of cases. The severity and massiveness of CT in the victims were the direct cause of death at the pre-hospital stage and in the early period (1-3 days) of the hospital stage from severe TBI, massive blood loss and traumatic shock. The massiveness of the ST covering more than 2 parts of the body was due to the height of the fall (from 4-5 and 6-8 storey buildings) and frequent landings falling in a horizontal position. These data can be taken into account for forensic diagnostics and differential diagnosis of blunt trauma, in the conditions of non-obvious circumstances of damage. The nature and location of injuries that occur when falling from a height can be important in the process of organizing and providing emergency and specialized medical care to victims. Forensic medical examination of corpses of persons who died as a result of a fall from a height requires further improvement to establish and justify the mechano-and

thanatogenesis of ST.

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