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DEPARTMENT OF FORENSIC MEDICINE AND
DEONTOLOGY

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Forensic characteristics of injuries
in case of falling from different heights

ABSTRACT

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The dissertation consists of 130 computer pages. The bibliography includes 67 literary sources.

The dissertation was discussed and directed for defense by an extended departmental council of the Department of Forensic Medicine and Deontology of the Ministry of Health, Medical University - Plovdiv, held on 21.01.2026.

The dissertation is scheduled for defense before a scientific jury consisting of:

External members:

Prof. Dr. Julian Rumenov Ananiev, MD

Assoc. Prof. Dr. Viliam Viktorov Dokov, MD

Assoc. Prof. Dr. Biser Aleksandrov Makelov, MD

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Prof. Dr. Vesselin Todorov Belovezhov, MD

Prof. Dr. Slavi Dimitrov Delchev, MD

Reserve members:

Prof. Dr. Ivan Petkov Novakov, MD

Assoc. Prof. Dr. Teodora Georgieva Kiryakova, MD

The final jury meeting will be held on 18.05.2026 at 11 am in the Second Auditorium of the Auditorium Complex, Medical University – Plovdiv.

The materials for the defense are available at the Scientific Department of MU-Plovdiv, 15 A Vasil Aprilov Blvd. and are published on the website of MU – Plovdiv – www.mu-plovdiv.bg

I .Introduction

A fall from a height can be defined as the movement of the body to a lower level than the level at which it is located, under the influence of gravity, due to inattention, imbalance or volitional actions of oneself or another person. The kinetic energy obtained during a fall from a height leads to multiple traumatic injuries and death, affecting the entire body.

Falls from height rank among the top causes of injury-related mortality, along with road traffic accidents. They account for a high percentage of injuries associated with hard blunt objects. The main cases of this type of injury are related to accidents or suicide, which lead to disability or death. Falls from height are more common in cities and are among the three most common causes of death due to trauma. Fatal outcomes are more common in adults than in children. Falls from height are the most common cause of death in occupational accidents in Bulgaria. There are many factors that influence the outcome of falls from height – age, gender, characteristics of the surface on which the body falls, angle of fall, height of fall, manner of landing and first contact of the body.

Historically, there have been some cases of falls from great heights that were not fatal. Stewardess Vesna Vulovic survived a fall from a height of 10,160 meters when she was thrown out of the plane (JAT Flight 364) on January 26, 1972, after an explosion. She suffered broken bones and was in a coma for 27 days. During World War II, pilots Nick Alkimaïd, Alan Magee and I. Chisov fell from over 6,000 meters and survived the fall.

In forensic practice, there are not isolated cases in which, based on the characteristics of the traumatic injuries found during the autopsy, the expert experiences significant difficulties in determining the manner of death. The latter is a legal concept, but the forensic finding assists in its definition. There are significant difficulties in determining the medico-legal assessment of injuries resulting from falls from a height, accidents, suicides and murders.

II. Aim and objectives

AIM

Based on the results published by other authors and their analysis, the lack of sufficient materials and studies, in this work we set the following goals:

1. To obtain an objective forensic characterization of traumatic injuries occurring in falls <3 meters in height of fall.
2. To obtain an objective forensic characterization of traumatic injuries occurring in falls from 3 to 9 meters in height of fall.
3. To obtain an objective forensic characterization of traumatic injuries occurring in falls >9 meters in height of fall.

MAIN TASKS

We have set the following tasks for the implementation:

1. To study the characteristics of traumatic injuries on the bodies of deceased persons, as a result of a fall from a height of <3 m. To compare the results obtained with the known ones described in foreign and Bulgarian studies so far
2. To study the characteristics of traumatic injuries on the bodies of deceased persons, as a result of a fall from a height of 3 to 9 meters. To compare the results obtained with the known ones described in foreign and Bulgarian studies so far
3. To investigate the characteristics of traumatic injuries on the bodies of deceased persons, as a result of falling from a height of >9 meters. To compare the obtained results with the known ones described in foreign and Bulgarian studies to date
4. To analyze the obtained results and the presence of static significance between the characteristics of the bodily injuries and the respective heights.

III. Material and methods

1. MATERIALS

The statistical study includes:

1. Corpses of persons over 18 years of age who died as a result of a fall from a height, who were the subject of research at the Department of Forensic Medicine at the University Hospital "St. George" EAD, Plovdiv for the period 2017 - 2021.

All studies were conducted with bodies of individuals with complete bone development.

2. METHODS

2.1. Statistical survey

Статистическа карта при фатални падания от височина										Корем																					
№										№																					
Паспортни и биометрични данни										Тяло и вид																					
1. Пол		Мъжки				Женски				1. Увреждания на кожата		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да											
2. Възраст		18-34 години				35-54 години				55-99 години		Не		Не		Не		Не		Не											
3. Височина на тяло (см.)										2. Увреждания на меките тъкани		Да		Не		Да		Не		Да											
Обстоятелства около падането										3. Увреждания на костите																					
1. Височина на падането		<3 метра		>3 и <9 метра		>9 метра				Счуване на всички пръсти		Да		Не		Да		Не		Да											
2. Място, от което е паднало тялото										4. Увреждания на крайните пръсти		Контузия на Черен дроб		Да		Разкъсване на Черен дроб		Да		Разкъсване на Черен дроб		Да									
3. Род на смъртта		Нештетен случай		Самубийство		Убийство				Контузия на бял дроб		Да		Разкъсване на бял дроб		Да		Да		Да											
Травматични увреждания										Таз																					
1. Увреждания на кожата		Окълзвания		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да		Не		1. Увреждания на кожата		Окълзвания		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да			
2. Увреждания на меките тъкани		Да				Не				2. Увреждания на меките тъкани		Да		Не		2. Увреждания на костите		Да		Не		Да		Не		Да					
3. Увреждания на костите		Счуване на черепна основа		Да		Счуване на черепна основа		Да		Счуване на шийни пръстени		Да		Не		3. Увреждания на костите		Да		Не		Да		Не		Да					
4. Вътрешни увреждания		Мозъчна контузия		Да		Субдурален хематом		Да		Субарахноидален хематом		Да		Епендурален хематом		Да		1. Увреждания на кожата		Окълзвания		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да	
Гръден кош										Горни крайници																					
1. Увреждания на кожата		Окълзвания		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да		Не		2. Увреждания на меките тъкани		Да		Не		Да		Не		Да		Не			
2. Увреждания на меките тъкани		Да				Не				3. Увреждания на костите		Да		Не		3. Увреждания на костите		Да		Не		Да		Не		Да					
3. Увреждания на костите		Счуване на ребра		Да		Счуване на ребра		Да		Счуване на гърдна кост		Да		Счуване на гърдни пръстени		Да		1. Увреждания на кожата		Окълзвания		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да	
4. Увреждания на вътрешни органи		Контузия на бял дроб		Да		Разкъсване на бял дроб		Да		Сърце		Да		Аорта		Да		2. Увреждания на меките тъкани		Да		Не		Да		Не		Да			
										Долини крайници																					
1. Увреждания на кожата		Окълзвания		Да		Кривоизсъдими		Да		Разкъсано-контузни рани		Да		Не		3. Увреждания на костите		Да		Не		Да		Не		Да		Не			
2. Увреждания на меките тъкани		Да				Не				3. Увреждания на костите		Да		Не		3. Увреждания на костите		Да		Не		Да		Не		Да					

2.2. Methods used

2.2.1 Survey method – this method of collecting primary information gives us information about the circumstances surrounding the occurrence of the accident. It is presented in the forensic medical examinations carried out in the Department of Forensic Medicine at the University Hospital “St. George” EAD, Plovdiv in the section “Preliminary information”. The data presented are provided by the examination of the forensic medical examiner in the examination of the MP, the investigating police officer or witness statements.

2.2.2 Descriptive method (descriptive) – all qualitative (categorical) signs are described through their frequency distribution, taking into account the error of the relative share.

2.2.3 Graphical analysis – for the construction of illustrative graphs.

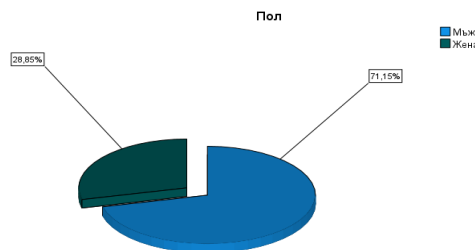
IV. Results

The results are based on a thorough analysis of the available data on deaths from falls from a height in the Department of Forensic Medicine for the period 2017-2021. 104 cases were analyzed. The results were processed and distributed into several categories, with all traumatic injuries being considered in relation to the target groups of the study, namely depending on the height of the fall (≤ 3 meters, from 3 to 9 meters and ≥ 9 meters).

I. General data:

Gender			
	Number of cases	Percentage ratio	Percentage of validity
Male	74	71,2	71,2
Female	30	28,8	28,8
All	104	100,0	100,0

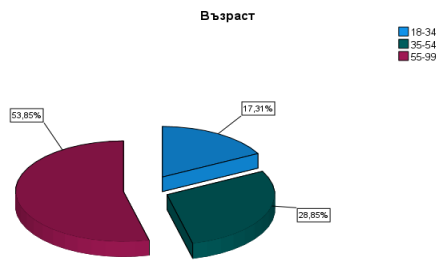
It is evident from the presented results that the majority of cases involved male victims – 74 (71.2%). In 28.8% or 30 cases, there were female victims.



2. Frequency distribution depending on age group:

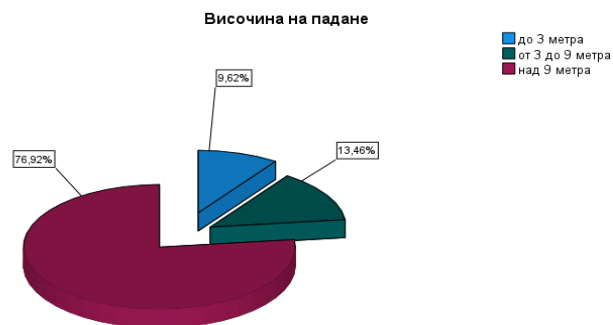
Age			
	Number of cases	Percentage ratio	Percentage of validity
18-34	18	17,3	17,3
35-54	30	28,8	28,8
55-99	56	53,8	53,8
All	104	100,0	100,0

The age distribution shows that the largest percentage of incidents occurred in people aged 55-99 years (53.8%), followed by those aged 35-54 years (28.8%) and the smallest number of victims was between 18-34 years (17.3%).



3. Frequency distribution versus drop height

Hight of falling			
	Number of cases	Percentage ratio	Percentage of validity
to 3 m	10	9,6	9,6
from 3 to 9 m	14	13,5	13,5
over 9 m	80	76,9	76,9
All	104	100,0	100,0

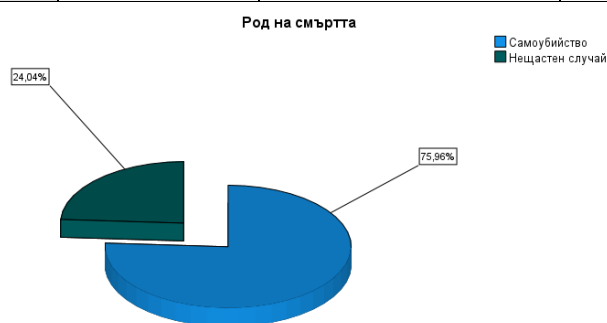


As can be seen from the results obtained, cases of falls from a height of over 9 meters are predominant in the total number of cases, accounting for 76.9% or 80 cases. Next are falls from a height of between 3 and 9 meters – 13.4% or 14 cases, and the smallest number is falls from a height of up to 3 meters – 9.6% or 10 cases.

4. Frequency distribution by location of the incident:

Location			
	Number of cases	Percentage ratio	Percentage of validity
block	65	62,5	62,5

Manner of death			
	Number of cases	Percentage ratio	Percentage of validity
Suicidal	79	76,0	76,0
Accidental	25	24,0	24,0
All	104	100,0	100,0

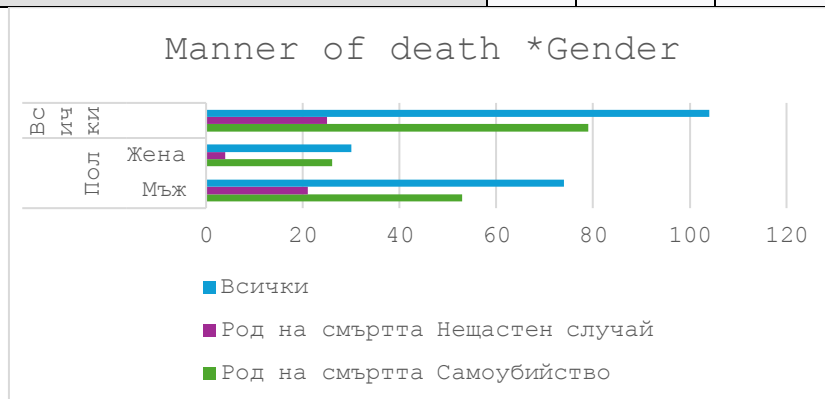


Only suicides and accidents are commented on, as there is no data on homicides by falling from a height in the cases examined. Suicides account for 76%, and accidents account for 24% of all.

6. Distribution by cause of death:

Cause of death			
	Number of cases	Percentage ratio	Percentage of validity
Traumatic brain injury, Thoracic trauma, Abdominal trauma	10	9,6	9,6
Multitrauma	13	12,5	12,5
Blood loss	17	16,3	16,3
Traumatic brain injury	18	17,3	17,3
Thoracic trauma, Abdominal trauma	9	8,7	8,7
Vertebral trauma	10	9,6	9,6
Fat embolism	3	2,9	2,9

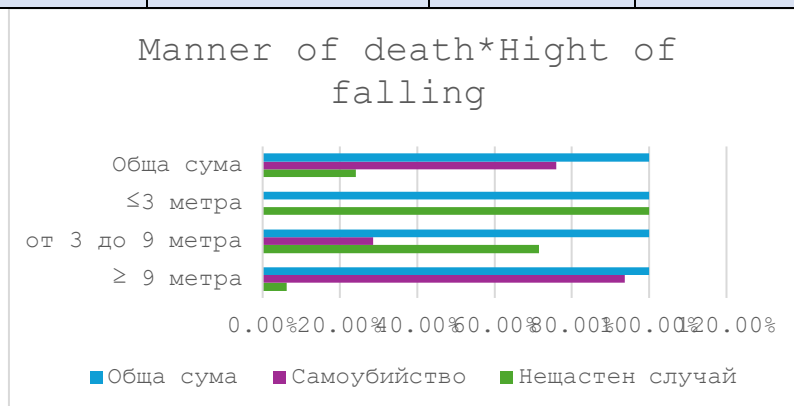
		Gender		
		Male	Female	All
Manner of death	Suicidal	53	26	79
	Accidental	21	4	25
All		74	30	104



The data shows that of the suicide cases studied, 53 were male and 26 were female. In accidents involving falls from a height, males predominated with 21 victims and 4 were female.

8. Distribution according to fall height and type of death:

Manner of death	≥ 9 m	from 3 to 9 m	≤3 m	Total
Accidental	6,25%	71,43%	100,00%	24,04%
Suicidal	93,75%	28,57%	0,00%	75,96%
All	100,00%	100,00%	100,00%	100,00%

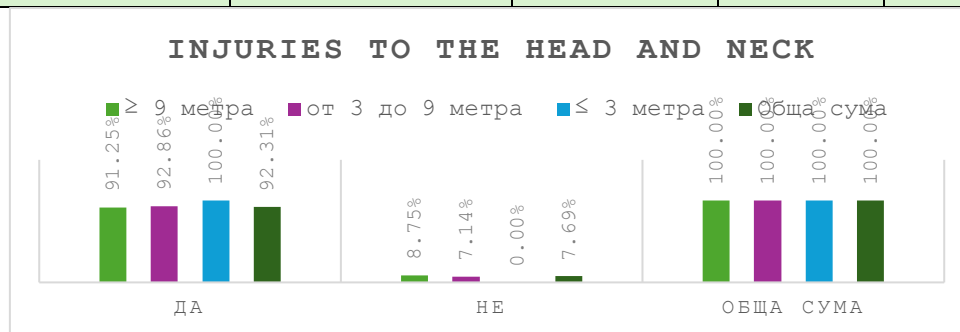


The distribution according to the height of the fall shows that when falling from a height of more than 9 meters, 6.25% are accidents, and 93.75% are suicides. When falling from a height between 3 and 9 meters, 71.43% are accidents and 28.57% are suicides. When falling from one's own height or a height less than 3 meters, all 100% of the subjects were injured in accidents.

II. Head and Neck.

1. Skin lesions of the head and neck:

Injuries to the head and neck	≥ 9 m	from 3 to 9 m	≤ 3 m	Total
yes	91,25%	92,86%	100,00%	92,31%
no	8,75%	7,14%	0,00%	7,69%
Total	100,00%	100,00%	100,00%	100,00%

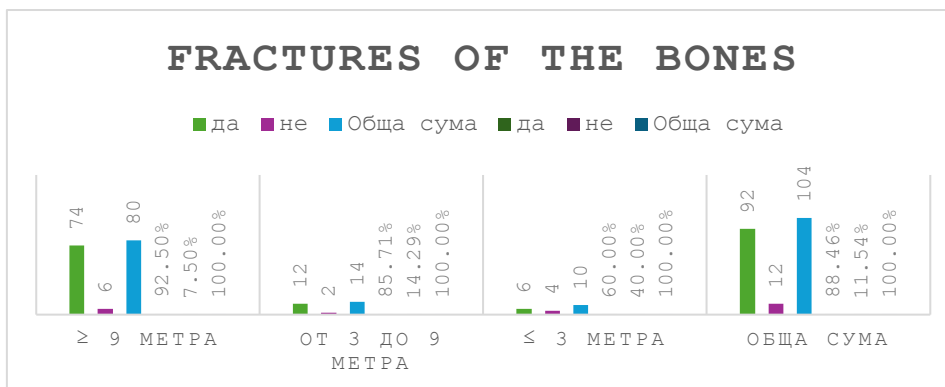


Head and neck skin injuries from falls of more than 9 meters are found in 91.25%. From heights between 3 and 9 meters, they are found again in a high percentage – 92.86%, and from falls of 3 meters or less, they occur in 100%.

III. Chest.

1. Distribution according to the presence of fractures of the chest bones when falling from different heights:

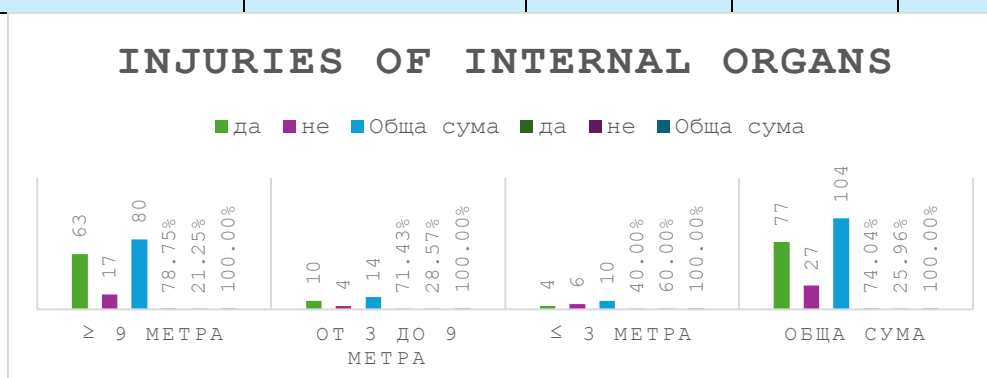
Fractures of the bones	≥ 9 m	from 3 to 9 m	≤ 3 m	Total
yes	74	12	6	92
no	6	2	4	12
Total	80	14	10	104
yes	92,50%	85,71%	60,00%	88,46%
no	7,50%	14,29%	40,00%	11,54%
Total	100,00%	100,00%	100,00%	100,00%



In general, when examining the fracture of the bones of the chest, it is found that in a predominant percentage of cases, one or more of the bone fractures listed below are found for all three height groups.

4. Distribution according to the presence of damage to internal organs when falling from different heights:

Injuries of internal organs	≥ 9 m	from 3 to 9 m	≤ 3 m	Total
yes	63	10	4	77
no	17	4	6	27
Total	80	14	10	104
yes	78,75%	71,43%	40,00%	74,04%
no	21,25%	28,57%	60,00%	25,96%
Total	100,00%	100,00%	100,00%	100,00%



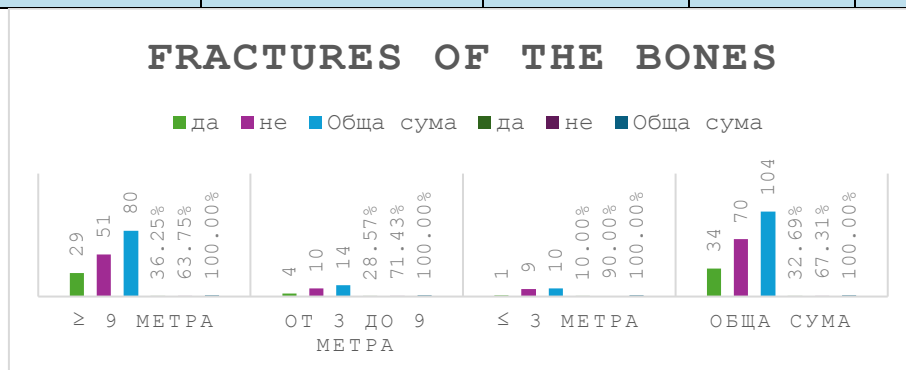
When studying the most generalized cases of injuries to internal organs in the chest, it was found that in a predominant percentage of cases, when falling from a height of more than 9 and between 3 and 9 meters, internal organ injuries occur in almost 79% and 72%, respectively. When falling from one's own height or a

height below 3 meters, there are 40% in which internal organ injuries are observed.

VI. Upper Limbs.

1. Distribution according to the presence of damage to the bones of the upper limbs when falling from different heights:

Fractures of the bones	≥ 9 m	from 3 to 9 m	≤ 3 m	Total
yes	29	4	1	34
no	51	10	9	70
Total	80	14	10	104
yes	36,25%	28,57%	10,00%	32,69%
no	63,75%	71,43%	90,00%	67,31%
Total	100,00%	100,00%	100,00%	100,00%



Injuries to the bones of the upper extremities are found in 36.25% of falls from a height of over 9 meters, 28.57% of falls from a height of between 3 and 9 meters, and 10% of falls from a height of less than 3 meters.

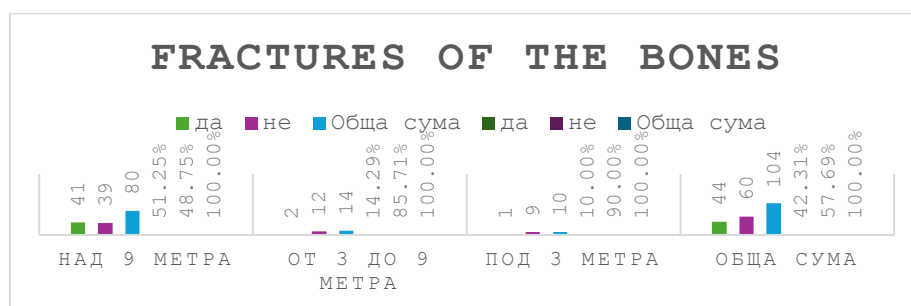
VII. Lower Limbs.

1. Distribution according to the presence of damage to the bones of the lower limbs when falling from different heights:

Fractures of the bones	≥ 9 m	from 3 to 9 m	≤ 3 m	Total
yes	41	2	1	44
no	39	12	9	60

Total	80	14	10	104
yes	51,25%	14,29%	10,00%	42,31%
no	48,75%	85,71%	90,00%	57,69%
Total	100,00%	100,00%	100,00%	100,00%

In general, fractures of the bones of the lower extremities occur mainly in falls from great heights - over 9 meters (51.25%). In falls from heights between 3 and 9 meters, only 2 cases (14.29%) were found, and only 1 (10%) in falls from heights below 3 meters.



V. Discussion

104 cases of deaths from falls from different heights were processed, whose autopsies were performed in the Department of Forensic Medicine at the University Hospital "St. George" EAD, Plovdiv for a period of 5 years - from 2017 to 2021.

1. General data

1.1. Gender distribution

The results of the statistics prepared based on the statistical map show a significantly higher percentage in favor of the male gender - 71.2%, compared to the female gender - 28.8%. The established percentage ratio coincides with that of İbrahim Eray Çakı et al. in 2020 that men are more frequent victims of falls from a height.

1.2. Age distribution

The cases were divided into three age groups – 18-34; 35 – 54; 55- 99, and it is striking that the average age for men is 56 years, and for women 58 years.

The most cases fall precisely in the third age group – 55-99 years. The results presented in the dissertation work confirm other well-known statements presented in the literature.

1.3. Distribution by fall location

One of the indicators studied is the place of fall. It is striking that a significant percentage of cases fell from a block of flats (residential building, balcony, mezzanine) – 62.5% of all, which once again confirms the data proven by İbrahim Eray Çakı et al. in 2020. In second place is the fall from a hospital – 9%, with 100% of these falls being suicides and 6% from construction, with 100% of such falls being accidents.

1.4. Distribution by fall height

One of the most important factors affecting mortality is the height of the fall. The results presented in this dissertation are presented in three groups – below 3 meters; between 3 and 9 meters and above 9 meters. The results show that the largest percentage of cases – 76.9% are in falls from above 9 meters, 13.5% are in falls from 3 to 9 meters and 9.6% - below 3 meters.

1.5. Distribution by manner of death

In the studied cases, two types of type of death are observed – suicide and accidents. In the 104 cases examined, no murders were found by falling from a height. A higher percentage are suicides – 76%, and accidents – 24%.

In the study that was carried out, 6 main groups were distinguished, divided by anatomical features: head and neck, chest, abdomen, pelvis, upper and lower extremities. Each of the described groups contains subgroups showing traumatic

injuries to the skin, soft tissues, bones and internal organs in the corresponding areas. All described groups and subgroups of traumatic injuries were examined according to the three groups of fall heights considered in the dissertation work – under 3 meters, between 3 and 9 meters and over 9 meters.

2. Traumatic injuries from falls below 3 meters.

2.1. Abrasions:

Bruises on the head are found in 70% of cases, on the chest in 30%, on the abdomen in 10%, no bruises are found on the pelvis, and on the upper and lower limbs in 30% of cases, respectively. These data from the study coincide with the literature data, according to which bruises are found in all cases when falling from a height below 3 meters. In a relatively large percentage of cases, about 40%, one or two bruises are found in one or several regions of the body. In about 60%, multiple bruises are found on the head, body and limbs (Abder-Rahman, H. et al., 2018).

2.2. Bruises:

Bruises on the head and neck when falling from a height of less than 3 meters are found in 50% of cases; bruises on the chest are found in 30%, bruises on the abdomen are found in 10%, on the pelvis in 20%, and on the upper and lower limbs in 50% and 10% of cases, respectively. Studies on the presence of bruises when falling from a height of <3 m. show that in a relatively large percentage of cases (about 30%) no such bruises are found during the forensic autopsy of the corpse. In the largest percentage (about 65%) one or two bruises occur and only in about 5% multiple bruises on the body are found. (Abder-Rahman, H. et al., 2018).

2.3. Laceration wounds:

Laceration wounds of the head and neck are observed in 50% of cases, on the abdomen -10%, the chest and pelvis, as well as the upper limbs are not detected. The study of a number of authors on the presence of laceration wounds on the head, chest, abdomen and limbs shows an absence of such in 85% of cases. One or two wounds occur in 14% of cases and only in about 1% of cases are multiple laceration wounds present. (Abder-Rahman, H. et al., 2018). The present study confirms these results.

2.4. Soft tissue injuries

Soft tissue injuries of the head, represented by contusions and ruptures of the soft cranial membranes, were found in 100% of cases, which does not coincide with the literature data, in which 32% of contusions and 6% of ruptures of the soft cranial membranes were found. In soft tissue injuries, 5% of contusions of the pectoral muscles and 0% of their ruptures were found (Abder-Rahman, H. et al., 2018). In the present study, 40% of cases were found to have soft tissue injuries

of the chest. Contusion and ruptures of the abdominal muscles are not detected in falls below 3 meters in height, which coincides with the results of the dissertation work, in which no injuries to the soft tissues of the abdominal wall were also detected. Injuries to the soft tissues of the pelvis are detected in 10%. No soft tissue injuries were detected on the upper and lower extremities.

2.5. Skull Fracture

A skull fracture is found in 40% of cases, and a skull base fracture is found in 60% of cases. Studies conducted by a number of scientists on skull fractures show that the presence of skull fractures is found at a minimum fall height of ≤ 1.5 meters. Some authors present a distribution of skull fractures as skull base and skull roof, with the distribution between them being almost equal. (Rowbotham, S. K. et al. (2018)). Other authors point out that in the cases they studied, isolated skull base fractures were not observed. However, combined fractures of facial and cranial bones occur in about 5% of cases (Abder-Rahman, H. et al., 2018).

2.6. Vertebral fractures

Fractures of the cervical vertebrae occur in 40%, of the thoracic vertebrae in 10% and of the lumbar vertebrae in 10%, which values, when compared with those of foreign authors, show the following values – cervical vertebrae 2.3%, without injuries to the thoracic and lumbar vertebrae (Abder-Rahman, H. et al., 2018). These data convincingly differ from those obtained in the present study.

2.7. Rib Fracture

Fracture of the ribs on the left and right when falling from a height of less than 3 meters occurs in 40%. These results do not match those obtained in the study of Abder-Rahman, H. et al., 2018, according to which rib fractures when falling from such a height occur in 7.3% of cases.

2.8. Sternum Fracture

Fracture of the sternum when falling from a height of less than 3 meters is found in 20% of the studied cases. Such fractures are not found in the literature, which shows a discrepancy with the results of the present study (Abder-Rahman, H. et al., 2018).

2.9. Clavicle fracture

Clavicle fractures from falls from this height were not found in the studied cases. These data fully correspond to data from foreign studies, which show that such trauma also does not occur (Abder-Rahman, H. et al., 2018).

2.10. Scapula fracture

Scapula fractures occur in 10% of falls from a height of less than 3 meters, which is a small percentage of traumatic injuries to the bones of the chest.

2.11. Pelvic fractures

According to the literature, pelvic fractures are found in about 6% of cases (Abder-Rahman, H. et al., 2018), which corresponds to the percentage obtained in the present study, in which 10% had pelvic bone fractures.

2.12. Fractures of the bones of the limbs

When examining the limbs, the division into five groups is as follows - no fracture (0/4); there is a fracture of one limb (1/4); fracture of two limbs (2/4); fracture of three limbs (3/4) and fracture of all four limbs (4/4). In falls from a height of less than 3 meters, there are no fractures of the limbs (79%), fractures of one limb (19%) and fractures of both limbs (2%). (Abder-Rahman, H. et al., 2018). In this study, the following percentages of fractures of the bones of the limbs are established: upper left - 10%, upper right - 10%, lower right 10% and lower left 0%.

2.13. Brain contusions

Brain contusions are found in 50% of cases. Contusions from falls from a height of less than 3 meters or one's own height are described in 25% of cases, and lacerations in only 0.8% of cases (Abder-Rahman, H. et al., 2018).

2.14. Subdural hemorrhage

Subdural hemorrhages are found in 30% of cases. They have not been studied in the available literature on the subject.

2.15. Subarachnoid hemorrhage

Subarachnoid hemorrhages are found in 40% of cases, which is the highest percentage of intracranial injuries. They have not been the subject of research in the available literature on the subject.

2.16. Epidural hemorrhages

Epidural hemorrhages are found in 10% of cases, which is the least common type of intracranial injury in falls from a height of less than 3 meters. They have not been the subject of research in the available literature on the subject.

2.17. Heart damage

The heart damage represented by contusions and lacerations in the present study shows 10%, which somewhat coincides with the results established by foreign authors, according to whom heart contusions are not observed when falling from a height below 3 meters (Abder-Rahman, H. et al., 2018).

2.18. Aortic damage

Similar to heart damage, aortic damage when falling from this height was not observed in the present study. No lacerations of the thoracic or abdominal aorta have been described in the literature either.

2.19. Lung injuries

Lung contusions when falling from a height of less than 3 meters are relatively rare. Contusions of the right lung occur in 20%, and of the left lung in 30%. These data do not correspond to foreign literature, according to which contusions occur in 4.1% (Abder-Rahman, H. et al., 2018). Lung lacerations are less common than contusions, with the results here showing that right lung lacerations occur in 10%, and left lung lacerations in 10%. These results are closer to foreign studies, according to which lacerations occur in 0.8% (Abder-Rahman, H. et al., 2018).

2.20. Liver injuries

The authors report cases of falls from a height of less than 3 meters with the presence of liver contusion in 2.4% (Abder-Rahman, H. et al., 2018). These values do not fully correspond to those obtained from the present study, according to which contusions in these falls from a height were found in 10%, and ruptures were not found.

2.21. Spleen injuries

In the present study, contusions and ruptures of the spleen were not found in falls from a height of less than 3 meters. According to foreign authors, contusions and ruptures of the spleen are not found in falls from such a height, which also confirms our results.

2.22. Mesenteric injury

Mesenteric rupture in the present study was found in 10% of cases, while the authors of the literature review did not report contusions and lacerations (Abder-Rahman, H. et al., 2018).

2.23. Kidney injuries

Foreign author teams did not report kidney injuries – contusions and lacerations when falling from a height of less than 3 meters or from one's own height (Abder-Rahman, H. et al., 2018). In the present study, no cases of kidney lacerations were found when falling from this height, and contusions were found in 10% of the left kidney and 30% of the right kidney, which does not coincide with the small percentage of contusions found by foreign authors.

3. Traumatic injuries to the body, when falling from a height of 3 to 9 meters.

3.1. Bruises:

Bruises on the head are found in 42.86% of cases, on the chest in 28.57%, on the abdomen 7.14%, no bruises are found on the pelvis, and on the upper and lower limbs, respectively, in 50% of cases. These data from the study do not match the literature data, according to which in all cases there are bruises on the head, body and limbs (Abder-Rahman, H. et al., 2018).

3.2. Bruises:

Bruises on the head and neck when falling from a height between 3 and 9 meters are found in 35.71% of cases; on the chest they are found in 7.14%, bruises on the abdomen are found in 57.14%, on the pelvis in 7.14%, and on the upper and lower limbs in 21.43% and 14.29% of cases, respectively. These conclusions are again in contradiction with the literature data, according to which bruises on the head, body and limbs are present in all cases.

3.3. Laceration wounds:

Laceration wounds of the head and neck are observed in 42.86% of cases, on the chest, abdomen and pelvis, as well as on the upper limbs are not detected. Laceration wounds of the lower limbs on the left are detected in 1 case or 7.14%, and on the right they are not detected. The study of a number of authors on the presence of laceration wounds on the head, chest, abdomen and limbs shows an absence of such in 36% of cases. One or two wounds occur in 50% of cases and only in about 14% of cases are multiple laceration wounds present. (Abder-Rahman, H. et al., 2018). The present study confirms these results.

3.4. Soft tissue injuries

Soft tissue injuries of the head, represented by contusions and ruptures of the soft cranial membranes, were found in 92.86% of cases, which coincides with the literature data, in which 79% of contusions and 53% of ruptures of the soft cranial membranes were found. In soft tissue injuries, 47% of contusions of the pectoral muscles and 23% of their ruptures were found. In the present study, 62.29% were found to have damage to the soft tissues of the chest. Contusion of the abdominal muscles occurs in 3%, and its rupture in 2%, which does not coincide with the results of the dissertation work, in which injuries were found in 21.43% of cases. Injuries to the soft tissues of the pelvis were found in 28.57%, and to the upper and lower extremities in 21.43% and 14.29%, respectively.

3.5. Skull fracture

A fracture of the cranial vault is found in 42.86% of cases, which approximately coincides with the data from the literature, in which fractures are present in 36% of cases. A fracture of the skull base is found in 64.29% of cases, which significantly differs from the foreign literature, in which only 30% are found.

3.6. Vertebral fracture

A fracture of the cervical vertebrae occurs in 28.57%, of the thoracic vertebrae 57.14% and of the lumbar vertebrae 42.86%, which values, when compared with foreign authors, show the following values - cervical vertebrae 8%, thoracic - 18% and lumbar 3%. These data convincingly differ from those obtained from the present study.

3.7. Rib Fracture

Fracture of the ribs on the left and right when falling from a height between 3 and 9 meters occurs in 64.29%. These results coincide with those obtained in the study by Abder-Rahman, H et al., 2018, according to which rib fractures when falling from such a height occur in 44% of cases.

3.8. Sternum Fracture

Fracture of the sternum when falling from a height between 3 and 9 meters is found in 14.29% of the studied cases. Approximately such are the data from foreign studies, according to which they occur in only 3%. (Abder-Rahman, H. et al., 2018).

3.9. Clavicle fracture

Clavicle fracture when falling from this height is found in 14.29% of the studied cases. Data from foreign studies show that such trauma occurs in only 1%. (Abder-Rahman, H. et al., 2018).

3.10. Scapula fracture

Scapula fractures occur in 14.29% of falls from a height between 3 and 9 meters, which is a small percentage of traumatic injuries to the bones of the chest.

3.11. Pelvic fractures

According to the literature, pelvic fractures are found in about 14% of cases, which corresponds to the percentage obtained in the present study, in which there are 28.57% or 4 cases with pelvic bone fractures.

3.12. Fractures of the bones of the limbs

When examining the limbs, the division into five groups is as follows - no fracture (0/4); there is a fracture of one limb (1/4); fracture of two limbs (2/4); fracture of three limbs (3/4) and fracture of all four limbs (4/4). In falls from a height of 3 to 9 meters, no fractures of the limbs are found (19%), fractures of one limb (18%) and fractures of two limbs (50%), fracture of three limbs (12%), and simultaneous fracture of all four limbs is not established. (Abder-Rahman, H. et al., 2018). The present study found the following rates of limb bone fractures: upper left – 21.43%, upper right – 14.29%, lower right and lower left 14.29% each.

3.13. Brain contusions

Brain contusions were found in 57.14% of cases, which coincides with the results obtained by foreign researchers of 44% in falls from a height between 3 and 9 meters. (Abder-Rahman, H. et al., 2018)

3.14. Subdural hemorrhage

Subdural hemorrhages were found in 35.71% of cases. They have not been studied in the available literature on the subject.

3.15. Subarachnoid hemorrhage

Subarachnoid hemorrhages were found in 57.14% of cases, which is the highest percentage of intracranial injuries. They have not been studied in the available literature on the subject.

3.16. Epidural hemorrhages

Subdural hemorrhages are found in 14.29% of cases, which is the least common type of intracranial trauma in falls from a height of between 3 and 9 meters. They have not been the subject of research in the available literature on the subject. Ruptures of brain structures are found in 20% of the literature, and in the present study such were not found.

3.17. Heart damage

Heart damage, represented by contusions and lacerations, in the present study gives a zero percentage, which somewhat coincides with the results established by foreign authors, according to which contusion of the heart is observed in 3% of cases, and lacerations in 8%.

3.18. Aortic injuries

Similar to heart injuries, aortic injuries from falls from this height were not observed in the present study. A total of 10% of thoracic or abdominal aortic tears have been described in the literature.

3.19. Lung injuries

Lung contusions when falling from a height of between 3 and 9 meters are relatively common. Contusions of the right lung occur in 64.29%, and of the left in 57.14%. These data do not correspond to foreign literature, according to which contusions of the right lung occur in 3%, and of the left in 1%. Lung lacerations are less common than contusions, with the results here showing that lacerations of the right lung occur in 21.43%, and of the left in 28.57%. These results are closer to foreign ones, according to which lacerations on the left occur in 5%, and on the right in 14%.

3.20. Liver injuries

The authors report cases of falls from a height of 3 to 9 meters with liver contusions in 24% and ruptures in 10%. These values do not fully correspond to those obtained from the present study, according to which contusions in these falls from a height were not established, and ruptures were established in 21.43%

3.21. Spleen injuries

In the present study, contusions and ruptures of the spleen in falls from a height between 3 and 9 meters were not established. According to foreign authors, contusions of the spleen in falls from such a height are established in 4% and ruptures in 2%, which somewhat confirms our results.

3.22. Mesenteric injury

Mesenteric rupture in the present study was found in 7.14% of cases, while the authors of the literature review reported contusion in 2% and lacerations in 0% of cases.

3.23. Kidney injuries

Authors reported contusion of the right kidney in 1% and of the left kidney in 2% of cases. The same authors also found lacerations of the right kidney in 3% and of the left in only 1%. In the present study, no cases of lacerations of the kidneys were found when falling from this height, and contusions were found in 21.43% for the left kidney and 42.86%, which does not coincide with the small percentage of contusions found by foreign authors.

4. Traumatic injuries from falls from a height of more than 9 meters.

4.1. Abrasions:

Studies conducted by a number of authors on cases of falls from a height of more than 9 meters have found that abrasions are present in all cases. In the largest percentage of cases (about 81%) one or two abrasions are observed in one or several regions of the body. However, a significantly smaller percentage (about 19%) have multiple abrasions on the head, body and limbs. (Abder-Rahman, H. et al., 2018). These data also coincide with those obtained in the present study, according to which abrasions on the head are found in 45% of cases, on the chest in 32.5%, on the abdomen 17.5%, on the pelvis 8.75% of abrasions are found, and on the upper right and left limbs 35% and 33.5% respectively, and the lower right and left limbs 37.5% and 43.75% respectively of cases.

4.2. Bruises:

Bruises on the head and neck when falling from a height between 3 and 9 meters are found in 38.75% of cases; bruises on the chest are found in 31.25%, bruises on the abdomen are found in 17.5%, on the pelvis in 10%, and on the upper right and left -30% and 35% and the lower right and left limbs respectively 31.25% and 33.75% of cases. These conclusions coincide with the literature data,

according to which bruises on the head, body and limbs are present in all cases, with one or two bruises occurring in about 35%, and in a relatively larger percentage - about 65%, multiple bruises on the body are found (Abder-Rahman, H. et al., 2018).

4.3. Laceration wounds:

Laceration wounds of the head and neck are observed in 45% of cases, of the chest - 1.25%, of the abdomen - 1.25% and of the pelvis - 1.25%. Laceration wounds of the upper right limb are found in 5%, and of the left - 7.5%. Laceration wounds of the lower limb on the left are found in 12.5%, and of the right in 5% of cases. The study of a number of authors on the presence of laceration wounds on the head, chest, abdomen and limbs shows the absence of such in 31% of cases. One or two wounds occur in 49% of cases and only in about 20% of cases are multiple laceration wounds present. (Abder-Rahman, H. et al., 2018). The present study confirms these results.

4.4. Soft tissue injuries

Soft tissue injuries of the head, represented by bruises and ruptures of the soft cranial membranes, were found in 71.25% of cases, which coincides with the literature data, in which 79% of contusions and 46% of ruptures of the soft cranial membranes were found (Abder-Rahman, H. et al., 2018). In soft tissue injuries, 6% of contusions of the pectoral muscles and 50% of their ruptures were found (Abder-Rahman, H. et al., 2018). In the present study, 68.75% were found to have soft tissue injuries of the chest. Abdominal muscle contusion occurred in 2%, and its rupture in 4%, which does not coincide with the results of the dissertation work, in which injuries were found in 16.25% of cases (Abder-Rahman, H. et al., 2018). Soft tissue injuries of the pelvis were found in 62.5%, and of the upper and lower extremities in 23.75% and 30%, respectively.

4.5. Skull Fracture

Skull vault fracture was found in 43.75% of cases, which approximately coincides with the data from the literature, in which fractures were found in 36% of cases (Abder-Rahman, H. et al., 2018). According to other authors, skull roof fracture was found in 29% of cases (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)), which values approximately coincide with those of other authors, as well as the present study. Skull base fracture was found in 45% of cases, which significantly differs from foreign literature, in which only 39% were found (Abder-Rahman, H. et al., 2018) and 27% according to other author groups (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)).

4.6. Vertebral fractures

Cervical vertebrae fractures occur in 32.5%, thoracic vertebrae fractures in 38.75%, and lumbar vertebrae fractures in 27.5%, which values, when compared

with foreign authors, show the following values- cervical vertebrae 10%, thoracic vertebrae - 21%, and lumbar vertebrae 3% (Abder-Rahman, H. et al., 2018). These data differ from those obtained in the present study.

4.7. Rib fractures

Fractures of the ribs on the left and right when falling from a height of more than 9 meters occur in 85% and 82.5%. These results coincide with those obtained in the study by Abder-Rahman, H. et al., 2018, according to which rib fractures when falling from such a height occur in 54% of cases. According to other authors, 41% of cases with rib fractures are found in falls from a height of more than 9 meters (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)).

4.8. Fracture of the sternum

Fracture of the sternum when falling from a height of more than 9 meters was found in 32.5% of the studied cases. This is approximately the same as the data from foreign studies, according to which it occurs in only 8% (Abder-Rahman, H. et al., 2018), and according to other authors in 14% of cases (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)). These data are convincingly different from those obtained in the present study.

4.9. Clavicle fracture

Clavicle fracture when falling from this height is found in 30% of the studied cases. Data from foreign studies show that such trauma occurs in only 2%. (Abder-Rahman, H. et al., 2018). For this indicator, there is again a relatively large discrepancy in the obtained values.

4.10. Scapular fracture

Scapular fractures occur in 5% of falls from a height of more than 9 meters, which is a small percentage of traumatic injuries to the bones of the chest.

4.11. Pelvic fractures

According to the literature, pelvic fractures are found in about 18% of cases (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)), which coincides with the result obtained by other authors – 18% (Abder-Rahman, H. et al., 2018). These results do not coincide with the percentage obtained in the present study, in which 68.75% with pelvic bone fractures are present.

4.12. Fractures of the bones of the limbs

When examining the limbs, the division into five groups is as follows - no fracture (0/4); there is a fracture of one limb (1/4); fracture of two limbs (2/4); fracture of three limbs (3/4) and fracture of all four limbs (4/4). In falls from a height of more than 9 meters, no fractures of the limbs are found (7%), fractures of one limb (15%) and fractures of two limbs (51%), fracture of three limbs (24%),

and simultaneous fracture of all four limbs is not established. (Abder-Rahman, H. et al., 2018). Other authors reported that in 21% of cases, fractures of the lower extremities were observed, and in 15% of cases, fractures of the upper extremities (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)). In the present study, the following percentages of fractures of the limb bones were found - upper left - 26.25%, upper right - 20%, lower right - 38.75% and lower left 30%.

4.13. Brain contusions

Brain contusions were found in 38.75% of cases, which coincides with the results obtained by foreign researchers 17% in falls from a height of more than 9 meters. (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)). According to studies by author teams, brain contusions occur in 46% of cases, and lacerations only in 23% of cases. (Abder-Rahman, H. et al., 2018).

4.14. Subdural hemorrhage

Subdural hemorrhages are found in 10% of cases. Subdural hemorrhage occurs in 16% of cases (Çakı, İ. E., et al., 2021), which coincides with the data in the dissertation.

4.15. Subarachnoid hemorrhage

Subarachnoid hemorrhages are found in 41.25% of cases, which is the highest percentage of intracranial injuries. Other authors report the presence of subarachnoid hemorrhage in 37% of cases, which corresponds to the above-cited results (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)).

4.16. Epidural hemorrhages

Epidural hemorrhages are not found in falls from a height of more than 9 meters. According to foreign author teams, they are found in about 9% of cases, which coincides with the present study (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)). Ruptures of brain structures are found in 20% of the literature, and in the present study, such were not found.

4.17. Heart injuries

Heart injuries, represented by contusions and lacerations, in the present study give 41.25%, which does not coincide with the results established by foreign authors, according to which contusion of the heart is observed in 4% of cases, and lacerations in 13% (Abder-Rahman, H. et al., 2018).

4.18. Aortic injuries

Similar to heart injury, aortic injury when falling from this height is observed in 30% of the present study. A total of 7% of lacerations of the thoracic or abdominal aorta are described in the literature (Abder-Rahman, H. et al., 2018).

4.19. Lung injuries

Lung contusions when falling from a height of more than 9 meters are relatively common. Contusions of the right lung occur in 65%, and of the left lung in 65%. These data do not correspond to foreign literature, according to which contusions of the right lung occur in 5%, and of the left lung in 2%. Lung lacerations are less common than contusions, with the results here showing that lacerations of the right lung occur in 52.50%, and of the left lung in 43.75%. These results differ from foreign studies, according to which lacerations on the left occur in 7%, and on the right in 18% (Abder-Rahman, H. et al., 2018). Lung ruptures, according to other authors, are found in 18% of cases (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)).

4.20. Liver injuries

The authors reported cases of falls from a height of more than 9 meters with liver contusion in 4% and ruptures in 27% (Abder-Rahman, H. et al., 2018). These values somewhat correspond to those obtained from the present study, according to which contusions in these falls from a height were found in 5% and ruptures were found in 53.75%. According to other authors, the liver ruptures in 14% of cases (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)).

4.21. Spleen injuries

In this study, contusions were found in 3.75% and splenic ruptures in 43.75% of falls from a height of over 9 meters. According to foreign authors, splenic contusions were found in 2% and ruptures in 10% of falls from such a height, which does not match our results (Abder-Rahman, H. et al., 2018). According to other authors, the spleen ruptures in 9% of cases, which again does not match the results obtained in this study (Çakı, İ. E., Karadayı, B., & Çetin, G. (2021)).

4.22. Mesenteric injury

Mesenteric rupture in the present study was found in 7.14% of cases, while the authors of the literature review reported contusion in 10% and ruptures in 3% of cases (Abder-Rahman, H. et al., 2018), which coincides with the data from the literature.

4.23. Kidney injuries

Authors report right kidney contusion in 13% and left kidney in 6% of cases. The same authors also found right kidney ruptures in 7% and left kidney in only 2% (Abder-Rahman, H. et al., 2018). In the present study, when falling from this height, cases of right kidney ruptures were found in 2.50% and left kidney ruptures in 6.25%, and contusions were found in 27.50% for the left kidney and 21.25%, which does not coincide with the small percentage of contusions found by foreign authors.

The results obtained from the study fully correspond to those presented in the results obtained by other authors. They indicate the presence of a high percentage of polytrauma, presented and expressed differently in individual cases.

VIII. Conclusion

This dissertation is dedicated to the analysis of traumatic injuries in those who died as a result of falling from different heights, examined in the Department of Forensic Medicine at the University Hospital "St. George" EAD - Plovdiv for the period 2017–2021. The results obtained were compared with data from the Bulgarian and foreign scientific literature, which allowed a number of significant problems related to this type of trauma to be outlined.

One of the main practical difficulties in cases of falls from a height remains determining the approximate height of the fall, as well as distinguishing injuries from those caused by impact with hard blunt objects, including road traffic accidents and physical violence. These issues have direct relevance for the correct forensic interpretation and for determining the manner of death.

Falls from height, including from one's own height, should be considered not only as an isolated forensic problem, but as a complex multidisciplinary phenomenon, often associated with the presence of a helpless or unconscious state of the injured persons. In this sense, a detailed analysis of the nature and distribution of traumatic injuries is essential for clarifying the mechanism and etiology of the trauma.

The analysis of the literature sources showed that there is a lack of sufficiently systematized and in-depth scientific information dedicated entirely to injuries from falls from a height. This necessitates further targeted research in this direction, as well as the development of practically applicable criteria and algorithms for work both in clinical practice and in forensic structures.

From the conducted study of forensic cases for the period under review, the general conclusion can be drawn that at present there are no unified criteria for a comprehensive assessment of injuries from falls from a height. It was found that in falls from a significant height (over 9 meters) external bodily injuries often do not reflect the actual severity of internal traumatic findings. In contrast, in falls from a height between 3 and 9 meters, injuries caused by a direct impact on a hard blunt object, most often the ground, are more often observed than typical findings of pronounced inertial trauma.

It is this group of cases, which is mostly related to accidents, that requires particularly careful and thorough forensic analysis. Only through a detailed assessment of all identified injuries can a reasoned answer be given to the question of whether the injury is the result of a fall from a height or another type of traumatic impact, including beating.

IX. Contributions

1. Contributions of a cognitive nature

1.1. A thorough and analytical literature review has been carried out on the types of traumatic injuries in falls from different heights, based on contemporary Bulgarian and foreign scientific sources.

1.2. A detailed analysis of the published statistical studies related to traumatic injuries in falls from different heights has been carried out, covering data from Bulgarian and international literature.

1.3. A systematized and detailed discussion of the main types of traumatic injuries in falls from different heights has been made, examining the most common injuries and possible predictors of falls from a height.

2. Contributions of a scientifically applied and original nature

2.1. A comprehensive and detailed analysis of traumatic injuries accompanying falls from different heights was conducted, based on forensic cases from the Plovdiv region for the period 2017–2021.

2. A practically applicable option for working in cases related to falls from height and/or from one's own height was developed, including cases with suspected falls from height.

2.3. For the first time in the Bulgarian forensic literature, a systematized and detailed analysis of traumatic injuries from falls from different heights was conducted, based on real forensic material.

3. Confirmatory Contributions

3.1. The study confirms the need for detailed and systematic forensic autopsy of deceased persons due to falls from a height, with a description of the identified injuries according to the algorithm proposed in this dissertation.

3.2. The results obtained regarding the nature and distribution of traumatic injuries largely confirm the data published in the Bulgarian and foreign literary sources used.

3.3. Assessment scales have been developed for an approximate assessment of the approximate height of the fall based on typical traumatic injuries identified during the forensic examination and autopsy.