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Structure of long bone fractures of lower limbs at a car injury

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The most traumatized body region in road traffic accidents is the lower extremities, however, the structure of fractures has not been adequately studied. Objective: to study the structure of long bones fractures of the lower extremities in various non-lethal car injuries. Material and methods. The research material was 116 reports of primary forensic medical examinations of victims with fractures of the femur and/or shin bones resulting from a car injury. When studying the frequency of damage to various areas of the body and the frequency of fractures of long bones of the lower extremities, it was taken into account that 28 victims with polytrauma had multiple injuries, and thus 116 patients revealed 232 injuries of various areas of the body and 138 fractures of long bones of the lower legs. Research methods — retrospective analysis, descriptive statistics. Results. The main contingent of those injuries in the car accident was car drivers (8.5%) and pedestrians (47.3 %) aged 31–50 years. In the general group, the shin (37.9 %), thigh (21.6 %), head (13.8 %) were most injured areas, in the group of car drivers — neck, thigh, chest, shin, in the group of passengers — head, shin and thigh; pedestrians — shin, thigh, head. Due to the predominance of anterior (41.4 %) and anterolateral collisions of a moving car in the group as a whole, in cases of the of pedestrians injuries as well as in cases of in-cabin injuries, the presence of bumper fractures of the lower leg bones, as well as fractures of the femur of various localization, was observed. Conclusions. According to the initial forensic medical examination, a collision of a moving car with a pedestrian (78.4 %) and a collision of moving vehicles (21.6 %) were observed in the structure of non-lethal car accidents. In this case, diaphyseal fractures of the femur (29.8 %) and the shin bones (47.1 %) in the general group and in the group of pedestrians (20.4 and 40.7 %, respectively) predominated. Fractures of the femur of various localization were most often detected also in the in-cabin injuries (50.0 % of the total number of fractures in drivers and passengers). Key words: road traffic injury, femoral fractures, fractures of shin bones.

Найбільш вразливою зоною в разі дорожньо-транспортної пригоди (ДТП) є нижні кінцівки, проте структура переломів їхніх довгих кісток досліджена недостатньо. Мета: вивчити структуру переломів довгих кісток нижніх кінцівок у різних учасників нелетальної автомобільної травми. Методи: проаналізовано 116 актів первинних судово-медичних експертиз постраждалих із переломами стегнової кістки та/або кісток гомілки, отриманих унаслідок ДТП. Через те, що у 28 постраждалих із політравмою були множинні ушкодження, у 116 осіб виявлено 232 ураження різних ділянок тіла та 138 переломів довгих кісток нижніх кінцівок. Проведено ретроспективний аналіз, використано методи описової статистики. Результати: основний контингент постраждалих унаслідок ДТП — водії легкових автомобілів (8,5 %) і пішоходи (47,3 %) у віці 31–50 років. Загалом найчастіше травмовано гомілку (37,9 %), стегно (21,6 %), голову (13,8 %); у групі водіїв авто — шию, стегно, грудну клітку, гомілку; у групі пасажирів — голову, гомілку та стегно; у пішоходів — гомілку, стегно, голову. У результаті переважання переднього (41,4 %) і передньобокowego (32,8 %) зіткнень рухомого автомобіля загалом по групі, у разі пішоходної, а також внутріньосалонної травм, була характерною наявність бамперних переломів кісток гомілки, стегнової кістки різної локалізації. Висновки: у структурі нелетальної автотравми за даними первинної судово-медичної експертизи спостерігали зіткнення рухомого автомобіля з пішоходом (78,4 %) або рухомих транспортних засобів (21,6 %). При цьому переважали діафізарні переломи стегнової кістки (29,8 %) і кісток гомілки (47,1 %) загалом у групі та серед пішоходів (20,4 і 40,7 % відповідно). Переломи стегнової кістки різної локалізації найчастіше виявлені в разі внутріньосалонної травми (50,0 % від загальної кількості переломів у водіїв і пасажирів). Ключові слова: дорожньо-транспортна травма, переломи стегнової кістки, переломи кісток гомілки.

Key words: road traffic injury, femoral fractures, fractures of shin bones

Introduction

Over the years, road traffic accidents (RTA) remain a constant endemic phenomenon and a heavy economic and medical-social burden for many countries of the world. According to the report of the World Health Organization (WHO) in 2018, 1.35 million lethal (fatal) RTA were recorded in 2016, which resulted in road traffic injury taking the 8th place among causes of death in the general population and the 1 place — in children and young people aged 5 to 29 years [1]. In high-income countries, in 2016, deaths from road accidents between the ages of 15 and 49 reached 9.5 % (9.0–9.9), amounting to approximately 255 million DALYs (Disability-adjusted life year) [2]. Given the potentially lost years of life, the socio-economic losses of society due to fatal accidents exceed similar indicators for malignant diseases, heart diseases and cerebrovascular diseases [3].

In Ukraine, 4 687 fatal RTA (76 % of men, 24 % of women) were recorded in 2016, according to WHO, their number was 6 089; per 100 000 of the population — 13.7 deaths from road traffic injuries, which exceeds the average in Europe (10.4 per 100 000 of the population) and the USA (12.4 per 100 000 of the population) [1]. In Ukraine, mortality of pedestrians (42 %), passengers (18 %) and drivers (16 %) of 4-wheeled vehicles occurs the most in RTA. A different structure of fatal RTA is observed in highly developed countries. In the United Kingdom and the USA, the percentage of mortality among pedestrians is 24 and 15 %, respectively; for 4-wheeled vehicles: among passengers 14 and 17 %, respectively; among drivers — 33 and 47 %, respectively [1].

Epidemiology and risk factors for fatal RTA are studied comprehensively at both the national level and the WHO. At the same time, the structure of non-lethal road traffic injuries is less known. It is been reported that, regardless of the type of RTA (collision of vehicles, collision of a vehicle and a pedestrian, collision of a vehicle with a fixed obstacle) and its participants (pedestrian, driver and/or passenger of a car/motorcycle/scooter/bicycle), the lower limbs are most often injured [4–6]. However, the structure of lower limb injuries in various types of injured in non-fatal RTA has not been sufficiently studied.

Objective: to study the structure of lower limb fractures in various participants in non-lethal car injuries.

Material and methods

The research material — 116 reports of primary forensic medical examinations of victims with fractures of the femur and/or lower leg bones resulting

from a non-lethal car accident. In all cases, an expert assessment of the nature of traumatic injuries was carried out at the Kharkov Regional Bureau of Forensic Medical Examination (KRBFME) for a period not exceeding month after an injury. Reports of primary forensic medical examinations were selected by random sampling for the period February–June 2018.

Inclusion criteria — isolated fractures of the femur or lower leg bones; non-lethal polytrauma with fractures of long bones of the lower extremities as a leading injury received by drivers, passengers of vehicles, pedestrians as a result of a collision with a car.

Exclusion criteria — non-lethal polytrauma, in which fractures of the long bones of the lower extremities were a concomitant injury; car accident in which the forensic medical examination was carried out in terms exceeding month; fractures of long bones of the lower extremities obtained as a result of other mechanisms (except for car injury), fatal car injury.

All victims of road accidents were selected in group 1 «car injury» (n = 116, 100 %); there were also selected: for group 2 — drivers of a four-wheeled (passenger car) vehicle (n = 11, 9.5 %); for group 3 — drivers of 2-wheeled (bicycle, scooter) vehicles (n = 4, 3.4 %); for group 4 — passengers of the front seat of 4-wheeled vehicles (n = 6, 5.2 %); for group 5 — rear-seat passengers of 4-wheeled vehicles (n = 1, 0.9 %); for group 6 — passengers of 2-wheeled (bicycle, motorcycle) vehicles (n = 3, 2.6 %); for group 7 — pedestrians (n = 91, 78.4 %).

When classifying injuries, resulted from car injury, into isolated fractures of long bones of the lower extremities, multiple and combined injuries, we conditionally did not take into account injuries of the integumentary system (abrasions, superficial bruised wounds, subcutaneous hematomas), qualified as light bodily injuries (according to «Rules of forensic determination of the severity of injuries», approved by Ministry of Health of Ukraine Order No.6 dated 01.17.1995). Also, mild and moderate brain concussion, superficial neck injuries, bone fractures and dislocations of the joints of the upper extremities, bruises of the chest and abdomen, non-penetrating fractures of the ribs, fractures of the pelvic bones without damaging internal organs were taken into account.

In the study of the frequency of damage to various areas of the body and the frequency of fractures to long bones of the lower extremities, it was taken into account that, among 19 patients with multiple injuries of the locomotor system, in 2 patients injuries of the lower extremities in combination with dislocation of the joint of the upper limb were defined; in 4 — in combination with damage to the upper limb;

in 2 — a fracture of the pelvic bones and 2 fractures of the bones in one segment of the lower limb; in 2 — a fracture of the pelvic bones and damage to 2 segments of the lower extremities; 1 — bone fractures of 3 segments of the lower extremities; in 8 — bone fractures of 2 segments of the lower extremities. In the group of victims with combined trauma in the 1st case, damage was defined in 2 segments of the upper limb and 3 segments of the lower extremities; in 4 — fractures of the pelvic bones and 2 segments of the lower extremities; in 4 — damage to 2 segments of the lower extremities. Thus, in 116 victims of a car accident, 232 injuries of various areas of the body and 138 fractures of long bones of the lower extremities were recorded.

Research methods — retrospective analysis, descriptive statistics.

Results and discussion

The average age of victims of a car accident was (42.8 ± 24.3) years (10–81 years), a slight predominance of men was observed (54.3 %). The main contingent of victims was car drivers (8.5 %) and pedestrians (47.3 %) in the age group of 31–50 years old, and almost one third (24.2 %) of pedestrians were older 51 years. It should be noted that, in the general group 1, «the number of men: the number of women» ratio did not exceed 1.2 : 1, in the group of car drivers it reached 4.5 : 1, and in the group of pedestrians it was 0.98 : 1 (table 1).

Car accident was the result of 2 types of RTA: collision of a moving car with a pedestrian (78.4 %) and collision of moving vehicles (21.6 %). RTA prevailed in the city (92.2 %); pedestrian collisions in other settlements occurred in 6.0 % of cases, collision of moving vehicles on the roads — in 1.7 %.

According to the nature of the injuries received, as expected, combined damage prevailed (71.5 %). Isolated fractures of long bones of the lower extremities and multiple injuries of locomotor system were observed much less frequently with approximately the same frequency: 12.1 % and 16.4 %, respectively. For pedestrians, a similar distribution of the frequency of isolated and multiple damage to the locomotor system was noted. A slightly different picture was observed with in-cabin injury. If we take for 100 % the number of victims in the passenger compartment ($n = 18$), we can see the prevalence of multiple injuries over isolated fractures of long bones of the lower extremities: 33 % and 17 %, respectively (table 2).

The most frequently injured areas of the body in the victims in car accidents were: shin (37.9 %), thigh (21.6 %) and the head (12.5 %). The least injured were the forearm and the foot (1.3 % each), the wrist (1.7 %) (table 3). The frequency of injuries of various areas of the body in various groups of participants in an accident was as follows: in case of in-cabin injury ($n = 18$, 100 %), thigh injuries (for drivers — 38.9 %; for passengers — 33.3 %), shin injuries (33.3 and 38.9 %, respectively), head injuries (38.9 and 27.8 %, respectively) and neck superficial injuries (27.8 % each) were characteristic. In addition, car drivers were distinguished by injuries to the chest (33.3 %) and abdomen (22.2 %). In pedestrians ($n = 91$, 100 %), the shin was mostly damaged (73.6 %); injuries of the thigh area were noted in 35.2 % of cases, heads in 14.3 % and pelvis in 12.1 %. Injuries of the upper extremities, chest and abdomen were noted less frequently: 8.8, 4.4 and 6.6 %, respectively. Thus, among injuries of various areas of the body, during an car injury, fractures of long bones of the lower extremities took a leading place both in general group

Table 1

Distribution by gender and age of injured in car accidents

The characteristic	The groupe of victims						
	1 n = 116; 100 %	2 n = 11; 9.5 %	3 n = 4; 3.4 %	4 n = 6; 5.2 %	5 n = 1; 0.9 %	6 n = 3; 2.6 %	7 n = 91; 78.4 %
Gender:							
male	63; 54.3 %	9; 7.8 %	3; 2.5 %	4; 3.4 %	—	2; 1.7 %	45; 38.8 %
female	53; 45.7 %	2; 1.7 %	1; 0.9 %	2; 1.7 %	1; 0.9 %	1; 0.9 %	46; 39.7 %
Age (years):							
10–20	4; 3.4 %	—	—	—	1; 0.9 %	1; 0.9 %	2; 1.7 %
21–30	12; 10.3 %	—	3; 2.5 %	1; 0.9 %	—	2; 1.7 %	6; 5.2 %
31–40	43; 37.2 %	7; 6.0 %	1; 0.9 %	4; 3.4 %	—	—	31; 26.6 %
41–50	28; 24.1 %	3; 2.5 %	—	1; 0.9 %	—	—	24; 20.7 %
51–60	15; 12.9 %	1; 0.9 %	—	—	—	—	14; 12.1 %
> 61	14; 12.1 %	—	—	—	—	—	14; 12.1 %

1 (59.5 %) and in the groups of drivers, car passengers (72.2 % each) and especially pedestrians (108.8 %), where damage was observed in two segments (thigh and shin or both shins) (table 3).

In the structure of fractures of long bones of the lower extremities in the general group 1, shaft fractures of the femur (29.8 %) and shin bones (47.1 %) prevailed. Those fractures were a leading injury in the group of pedestrians (20.4 and 40.7 %, respectively). In addition, femur fractures were «leaders» in case of in-cabin injury: for drivers and passengers of cars (n = 18, 100 %), their total percentage was 50.0 % (table 4).

This nature of the damage corresponds to the mechanism of car injury, in which the anterior (41.4 %) and anterolateral (32.8 %) collisions of a moving car with a pedestrian prevailed. As a result of the collision, the frontal parts of the car collide with the lower limbs of the pedestrian with the formation of bum-

per fractures of the shin bones. Due to the impact below the level of the center of mass of a person, a torque arises, as a result of which the head, upper limbs and upper half of the pedestrian's body deviate towards the car, and the lower limbs are shifted up and along the vehicle. Often, in this phase, a second blow of the car's hood on the pedestrian's hips occurs [7, 8]. Fractures of the diaphysis of the femur and tibia, injuries of the knee joint and the distal tibia also correspond to injuries during in-cabin injury [9]. Fracture of the acetabulum with a central dislocation of the femur is a typical injury to a driver of a car in a frontal collision [10].

The structure of RTA to a certain extent depends on the economic, social, cultural characteristics of the studied region. So, automobile injuries lead in the developed countries of Europe and North America, and motorcycle and bicycle injuries — in the countries of Africa and Southeast Asia [11, 12].

The nature of damage to the musculoskeletal system in various injured in car accidents

Table 2

Parameters	Nature of car injury (n = 116; 100 %)							
	isolated fractures of femur/ lower leg bones		multiple injury		polytrauma		total	
	abs.	%	abs.	%	abs.	%	abs.	%
Car injury:	14	12.1	19	16.4	83	71.5	116	100.0
– drivers of 4-wheeled vehicles;	1	0.9	3	2.6	7	6.0	11	9.5
– drivers of 2-wheeled vehicles;	1	0.9	2	1.7	1	0.9	4	3.4
– front-seat passengers of 4-wheeled vehicles;	2	1.7	2	1.7	2	1.7	6	5.2
– rear-seat passengers of 4-wheeled vehicles;	—	—	1	0.9	—	—	1	0.9
– passengers of 2-wheeled vehicles;	—	—	1	0.9	2	1.7	3	2.6
– pedestrians	10	8.6	10	8.6	71	61.2	91	78.4

The structure of damage to various areas of the body in victims in a car accident

Table 3

Injured segment	The group of victims						
	1 (n = 116)	2 (n = 11)	3 (n = 4)	4 (n = 6)	5 (n = 1)	6 (n = 3)	7 (n = 91)
Head	29; 12.5 %	7; 3.0 %	1; 0.4 %	4; 1.7 %	1; 0.4 %	1; 0.4 %	15; 6.5 %
Neck	1; 4.7 %	5; 2.2 %	1; 0.4 %	4; 1.7 %	—	—	1; 0.4 %
Shoulder	8; 3.4 %	—	1; 0.4 %	1; 0.4 %	—	—	6; 2.6 %
Forearm	3; 1.3 %	—	1; 0.4 %	—	—	—	2; 0.9 %
Wrist	4; 1.7 %	1; 0.4 %	1; 0.4 %	—	—	—	2; 0.9 %
Chest	12; 5.2 %	6; 2.6 %	1; 0.4 %	1; 0.4 %	—	—	4; 1.7 %
Abdomen	11; 4.7 %	4; 1.7 %	—	1; 0.4 %	—	—	6; 2.6 %
Pelvis	13; 5.7 %	2; 0.9 %	—	—	—	—	11; 4.7 %
Thigh	50; 21.6 %	7; 3.0 %	4; 1.7 %	5; 2.2 %	1; 0.4 %	1; 0.4 %	32; 13.8 %
Shin	88; 37.9 %	6; 2.6 %	4; 1.7 %	6; 2.6 %	1; 0.4 %	4; 1.7 %	67; 28.9 %
Foot	3; 1.3 %	—	1; 0.4 %	—	—	—	2; 0.9 %
Total	232; 100.0 %	38; 16.4 %	15; 6.5 %	22; 9.5 %	3; 1.2 %	6; 2.6 %	148; 63.8 %

Table 4

The structure of fractures of long bones of the lower extremities in various injured in car accidents

The nature of the lower limb injury	The group of victims						
	1 (n = 116)	2 (n = 11)	3 (n = 4)	4 (n = 6)	5 (n = 1)	6 (n = 3)	7 (n = 91)
Fracture of the acetabulum with a central dislocation of the thigh	2; 1.4 %	2; 1.4 %	—	—	—	—	—
Medial femoral neck fracture	2; 1.4 %	—	—	—	—	—	2; 1.4 %
Transtrochanteric fracture of the femur	1; 0.7 %	—	—	—	—	—	1; 0.7 %
Shaft fracture of the femur	41; 29.8 %	4; 2.9 %	—	4; 2.9 %	1; 0.7 %	1; 0.7 %	—
Fracture of the distal femur epimetaphysis	4; 2.9 %	1; 0.7 %	1; 0.7 %	1; 0.7 %	—	—	1; 0.7 %
Fracture of the proximal tibia epimetaphysis	11; 8.0 %	1; 0.7 %	1; 0.7 %	2; 1.4 %	—	1; 0.7 %	6; 4.3 %
Diaphyseal fracture of the lower leg bones	65; 47.1 %	1; 0.7 %	2; 1.4 %	3; 2.3 %	1; 0.7 %	2; 1.4 %	56; 40.7 %
Double diaphyseal fracture of the lower leg bones	1; 0.7 %	—	—	—	—	—	1; 0.7 %
Fracture of the inner / outer ankle	7; 5.1 %	3; 2.3 %	1; 0.7 %	1; 0.7 %	—	—	2; 1.4 %
Fracture of both ankles	4; 2.9 %	1; 0.7 %	—	—	—	1; 0.7 %	2; 1.4 %
Total	138; 100.0 %	13; 9.4 %	8; 5.8 %	11; 8.0 %	2; 1.4 %	5; 3.6 %	99; 71.7 %

In this regard, the victims of non-lethal car injuries are active (drivers) and passive (passengers, pedestrians) road users of almost all age periods with a predominance of people of working age and some prevalence of men [13]. Road traffic injury involving 2-wheeled vehicles is seasonal (with an increase in the number of RTA in the spring and summer [14]), its victims are mostly young males (20–39 years old), in which, in addition to the lower extremities, injuries of the head, shoulder girdle and upper limbs are recorded with high frequency [15, 16]. The frequency of non-fatal and, especially, fatal motorcycle injuries, regardless of the region (developed or developing countries), is significantly higher in people with low socio-economic status (unemployed, illiterate, literate at the initial level, low-skilled workers) [17–19].

Fatal outcomes at the age of 65–74 years are uncharacteristic for RTA, although the level of hospitalization of older victims increases [6, 20]. Among the risk factors affecting the gender distribution of RTA victims, it is worth noting the risky behavior of male vehicle drivers with less frequent use of seat belts and frequent use of a mobile phone compared to women [21]. Pregnant women also fall into the same risk group and avoid using seat belts to prevent fetal damage [22]. In RTA outside the city, men participated 4 times more often than in urban accidents [23].

Road traffic injuries are the most common cause of fractures in human bones [24, 25], and fractures of long bones of the lower extremities, regardless of the circumstances of RTA, are the most frequently damaged areas of the human body [2, 5, 6, 12, 26]. Isolated fractures of the femur or shin bones are rare

when vehicles collide with each other or hit a pedestrian at a low (30–40 km/h) speed. With an increase in the speed of vehicles involved in RTA, the severity of the injury and the number of skeleton fractures increase accordingly. In non-lethal polytrauma, fractures of the femur and shin bones with fractures with the pelvic bones fractures, fractures of the long bones of the upper extremities are most often recorded [25–28]. Closed fractures of long bones of the lower extremities are more typical for drivers and passengers of automobiles [25], while a motorcycle injury is distinguished by the predominance of open multi-fragmented fractures of limb bones [27]. About 40 % of victims with polytrauma and multiple bone fractures exceeded speed [25], moreover, at a car speed of 50 km/h, the risk of a fatal collision with a pedestrian is 26 %, at a speed of 58 km/h — 50 and 82 % — at 70 km/h [28]. At the same time, a decrease in vehicle speed from 40 km/h to 30 km/h reduces the risk of collision with a pedestrian by 28 % [29].

Conclusions

In the structure of non-lethal road traffic injury according to the initial forensic medical examination, the most common types of accidents were a collision of a moving car with a pedestrian (78.4 %) and a collision of moving vehicles (21.6 %).

According to the initial forensic medical examination, the main contingent of victims of car injuries was pedestrians, 47.3 % of them were 31–50 years old and 24.2 % were older 51 years. In case of an internal cabin injury (n = 18), car drivers (n = 10) aged 31–50 years prevailed. For pedestrians, the gender

distribution was almost the same with the ratio of the number of men: the number of women was 0.98 : 1. Car drivers were dominantly men, in a ratio of 4.5 : 1.

In injured from car injuries combined damage prevailed (71.5 %); isolated fractures of long bones of the lower extremities and multiple injuries were observed with almost the same frequency in the general group (12.1 and 16.4 %, respectively) and in the group of pedestrians (n = 91, 11.6 % each). On cases of in-cabin injuries, multiple injuries prevailed (17.0 and 33.0 %, respectively).

In the structure of fractures of long bones of the lower extremities, diaphyseal fractures of the femur (29.8 %) and shin bones (47.1 %) prevailed in the general group and in the group of pedestrians (20.4 and 40.7 %, respectively). Fractures of the femur of various localization were most often observed in the in-cabin injury (50.0 % of the total number of fractures in drivers and passengers).

Conflict of interest. The author declare the absence of conflict of interest.

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