

# Epidemiology of Non-Morbid Vertebro-Medullary Trauma Following Road Accidents in the Forensic Casuistry of Bihor County, Romania

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## Abstract

**Introduction:** Vertebro-medullary trauma and spinal cord injuries are a traumatic pathology commonly encountered in road accidents. The severity of the posttraumatic consequences is given by the magnitude of the meningo-medullary injuries and it is directly proportional to them.

**Materials and Methods:** A retrospective study on living persons of Bihor County was conducted at the Bihor County Forensic Service, Romania. It consisted of examining forensic documents regarding vertebro-medullary trauma caused by road accidents from the Bihor County Forensic Service archive during 2013-2015. After classifying the descriptive parameters, the obtained data was statistically analyzed and the final results were presented using tables and graphs.

**Results and Discussions:** A quarter of the road accidents occurred in Bihor County during 2013-2015 lead to vertebro-medullary trauma. Mostly, these road accidents occurred in the urban environment, during summer, on Mondays and Sundays, the victims being young male adults. The most exposed category of road traffic participants to spinal trauma is represented by passengers of four-wheeled vehicles (more often driver and the passenger on the right front place) followed by pedestrians. The vertebro-medullary injuries frequently involved the cervical segment, followed by the thoracic and lumbosacral segments, the spine having more frequently a unique lesion. The most noticed mechanism of lesions encountered is hyperextension/hyperflexia. Only one third of the study group had lesions of low intensity, the other cases being of medium or high severity with less or more severe neurological and vegetative symptoms associated.

**Conclusions:** Vertebro-medullary trauma is a major cause of tetraparesis and paraplegia, representing a public health issue. Correct and prompt diagnosis of spinal cord injuries is essential for a favorable prognosis. It is necessary to improve the measures of preventing road accidents.

**Keywords:** Road accident; Spine; Spinal cord injuries; Epidemiology

## Introduction

Annually, over 10,000 severe road accidents occur in Romania and 20,000 light road accidents. According to the statistical data provided by the Romanian Police, about 2,000 people lose their lives, 8,000 are seriously injured and 20,000 have mild lesions [1]. Thus, our country occupies, unfortunately, one of the leading positions in Europe in terms of mortality due to road accidents [2].

Injuries produced in road accidents are often complex and affect more or less different organ systems. Vertebro-medullary trauma and spinal cord injuries are a traumatic pathology commonly found as consequence of road accidents [3-7]. The circumstances of producing vertebro-medullary trauma are various and globally differ depending on the country's lifestyle, socio-demographic and political conditions [3-5,8]. According to a study published by Guang-Zhi, et al. [3], road accidents are the most common cause of vertebro-medullary trauma in developed countries from Europe, North America, Sub-Saharan Africa,

and Asia, followed by injuries produced by falling [3]. The circumstances of producing vertebro-medullary trauma are various: road accidents and sports accidents (horseback riding, winter sports, recreational sports) (affecting especially the adult population aged between 20 and 50 years), low or high falling (domestic accidents, work accidents), hitting (frequently affected people over 70) [3-9]. Active bumping with various blunt objects and firearm injuries occur regardless of age and often affect the population in geographic regions with armed conflicts [3,8-10].

Due to its complex morpho-functional structure, the spine fulfills three main functions: static, dynamic and spinal cord protection [11,12]. In road accidents, it can suffer complex traumatic injuries, affecting different segments and resulting in losing its ability to complete its functions. Depending on the cause and the anatomical region involved, the lesions may have different degrees of severity: from ligament injuries (sprains, luxations) to spinal cord injuries [4,12-15]. The severity of the posttraumatic consequences is given by the magnitude of the meningo-medullary injuries, with which are directly proportional [12,13,16]. Preexisting conditions such as

degenerative diseases of the spine, osteoporosis, systemic diseases, neoplastic diseases etc. can be an aggravating factor in their evolution [3,12].

The victim of a road accident can be any road user and may be the occupant of a vehicle (driver, passenger), pedestrian, bicyclist, motorcyclist, teamster. Each category of road users presents particularities regarding the type of traumatic vertebro-medullary injuries and the causing mechanism, which is often an indirect, combined one [9,12,13,16].

The post-traumatic injuries can endanger the life of the victim and can irreversibly affect the quality of the victim's life, both by themselves and by the complications that may occur immediately or after several days, weeks or months. Complications may be both neurological and vegetative, following spinal cord injuries. They consist of temporary or permanent disorders of reflex activity, sensitivity and motility (sensory deficit, motor deficit or bladder/bowel dysfunction) with tetraplegia or paraplegia and septic disorders due to prolonged immobilization of the patient. The most frequent septic complications are bronchopneumonia or even multiple organ failure, which may lead to victim's death [4,17,18].

It is vital for the patient a correct and prompt diagnose of the spinal cord injuries regardless of their topographic location, mobilization, transport or incorrect treatment of the victim at the site of the road accident because it may lead to spinal cord injuries or to worsening of the pre-existing ones [7,12,16].

## Materials and Methods

At the Bihor County Forensic Service, a retrospective study on the living persons of Bihor County, Romania was conducted. The study consisted of examining the forensic documents from the Bihor County Forensic Service archive during 2013-2015. For each case of living person who was diagnosed with vertebro-medullary trauma as a consequence of a road accident, a record of the following parameters was compiled: time distribution, sex, age, home environment, the month and the day when the accident took place, the quality of the road user involved, the causing mechanism of the lesion, the type and location of the spine and spinal cord injuries, the unique or multiple nature of the injuries, associated injuries, pre-existing conditions, the number of days of medical care given to assess the severity of trauma injuries and the legal framing of the deed. After classifying the descriptive parameters, the obtained data was statistically analysed and the results were expressed using tables and graphics.

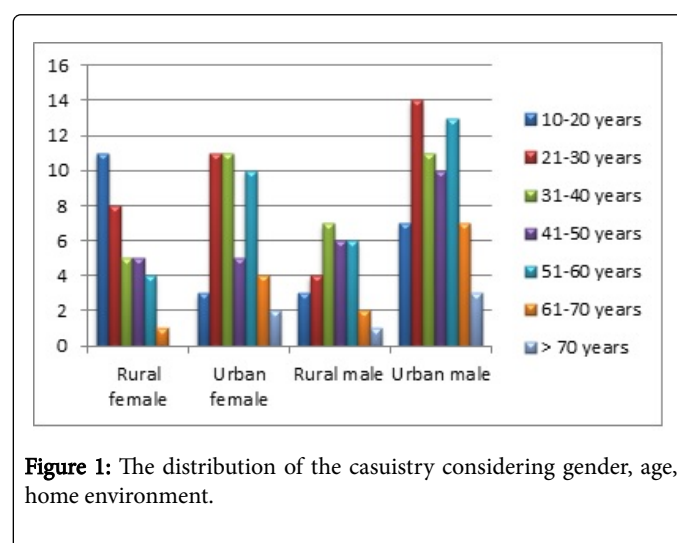
## Results and Discussions

During the 1<sup>st</sup> January 2013 to the 31<sup>st</sup> December 2015, 767 forensic cases of living persons, victims of road accidents were recorded at the Bihor County Forensic Service, Romania. Out of these, 175 cases (22.8%) presented spinal cord injuries. Case distribution is relatively homogeneous over the time span, with no major differences: a maximum of 25% (68 cases) in 2014 and a minimum of 20% (49 cases) in 2015, 23.1% (58 cases) in 2013.

The distribution of the casuistry considering gender, age, home environment shows that most of the victims were males (56%), adults aged between 21-50 years (55.42%) (21.1% aged between 21-30 years) from urban areas (63.4%) (Figure 1). Regarding gender distribution, the ratio male: Female is in favor of men, 56% vs 44%, sex ratio 1.27: 1, with a relatively small difference of number of cases, confirming the

data from literature (Figure 1). Recent epidemiological studies on vertebro-medullary injuries show that victims are both men and women, more frequently men, men having a higher risk of injury, with small or large percentage differences depending on the socio-economic and demographic conditions of each geographical region [3-7].

Considering age group distribution, the age group 21-50 years is followed by the age group 51-60 years (18.9%), the age group 10 - 20 years (14.3%), the age group 61-70 years (8%), the last place as frequency being occupied by the age group over 70 (3.4%) (Figure 1). Thus, the results of our study confirm the results of other studies which concluded that adults aged between 20-50 years have the highest risk of vertebro-medullary injuries, mostly due to car accidents [3,5-7,9]. The home environment of the victims of road accidents with spine injuries is clearly in favor of the urban environment (63.4%) compared to the rural environment (36.6%).



**Figure 1:** The distribution of the casuistry considering gender, age, home environment.

The victim's age is an important parameter because it helps classifying the mechanisms of producing vertebro-medullary injuries: in young and adults aged between 20-50 years most vertebro medullary injuries occur due to road and sports accidents (horseback riding, winter sports, recreational sports) and in people over 70 years vertebro medullary injuries occur due to low falls, high falls, hitting [3,5-9].

Regarding case distribution by season, it can be noticed that most road accidents occur during summer (43%), with a peak in August (15.78%), followed by winter (26%), spring (19 %) and autumn (12%), with a minimum in September (3.15%). Mondays and Sundays are the days of the week with the highest incidence of road accidents which lead to spine injuries (23.15% and 20.36%), while Wednesdays and Tuesdays have the lowest incidence (0.7% and 0.8%).

Depending on the quality of the person involved in traffic, the most exposed to spinal trauma are the occupants of vehicles (62.8%), followed by pedestrians (26.3%), cyclists (4.6%), motorcyclists (4%) and carrier (2.3%) (Figure 2). Among the occupants of the vehicles, the passengers mostly occupying the right-front place and the drivers occupy leading positions (35.4% and 27.4%).

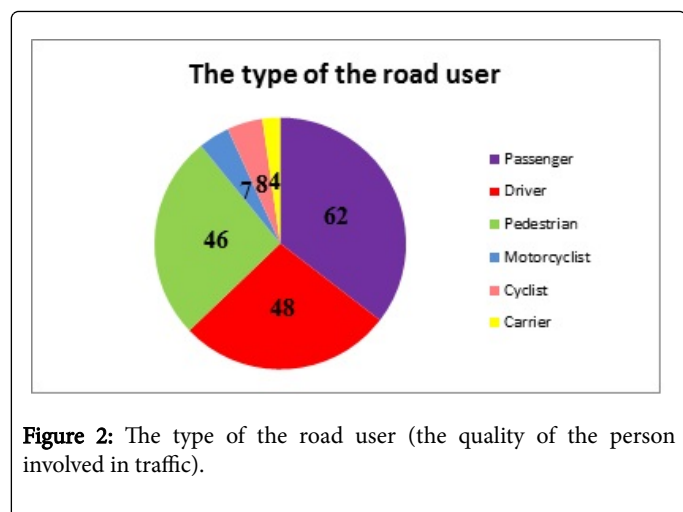


Figure 2: The type of the road user (the quality of the person involved in traffic).

The spinal cord injuries suffered by occupants of the vehicles (driver, passengers) occur due to sudden acceleration-deceleration phenomena of the axial skeleton of the vehicle during rear or front collision with other vehicles or obstacles outside the road. As other road users are concerned (pedestrian, bicyclist, motorcyclist or carrier), spinal cord injuries occur during road accidents when the victims are hit or hanged by a moving vehicle followed by the victim's fall on irregular, tough surfaces. The most frequent mechanisms of causing spinal cord injuries were the most simple ones (69.14%) such as: Hyperflexia, hyperextension, torsion, twisting/rotation, elongation, whiplash, lateral hyperflexia, axial load and compression and frequently an association of these [13-16]. The most common mechanisms are hyperflexia, hyperextension. The most affected category is the driver (25.75%) and the right-front passengers (29.14%). The complex mechanisms of hitting-discarded-falling, hitting-compression-crushing were found in pedestrians, cyclists, motorcyclists (28.57%) out of which pedestrians were the most affected (15.42%). In carriers, the vertebro-medullary injuries were caused by falling on the head from the carriage (2.29%) (Figure 3).

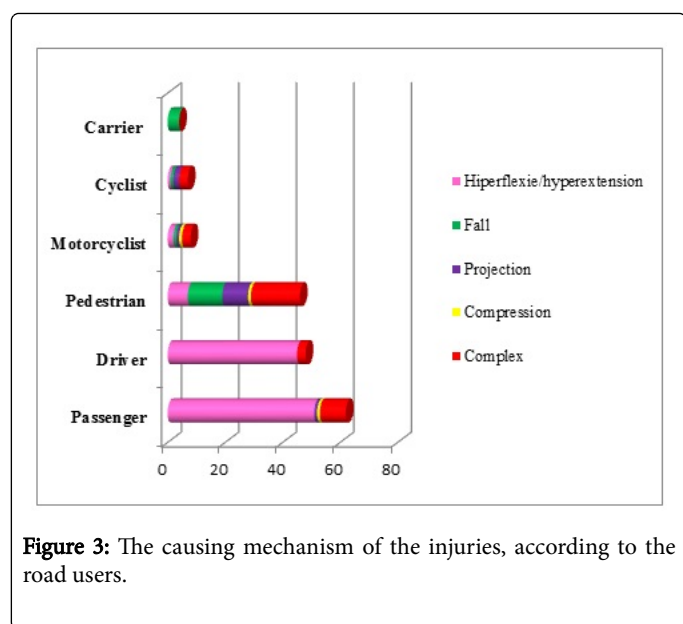


Figure 3: The causing mechanism of the injuries, according to the road users.

In 73.15% of the cases, the radian trauma affected only one vertebra and in 26.85% of the cases there were complex spinal cord injuries with multiple lesions (frequently affected two or even three vertebrae), usually associating thoracic injuries with lumbar and sacral injuries. Regarding the topography of spinal cord injuries caused by road accidents in the living person, we have the following distribution: mostly were located in the cervical segment (44.57%), followed by thoracic (21.14%) and lumbosacral segments (7.42%). No posttraumatic injuries in the coccyx segment were identified in the study group. The distribution of lesions on spine segments is as it follows: C5-C6 segment (29.71%), C3-C4 (7.42%), C7-C8 (4%), C1-C2 (3.43%), thoracic segment T1-T10 (21.14%), thoracic-lumbar segment T11-L2 (1.72%), and lumbosacral segment L3-S1 (12%), sacral segment S2-S5 (5.14%) (Figure 4). The cervical segment of the spine is more vulnerable to the action of traumatic agents due to its increased mobility, but also due to its exposure to the energy released by the forces active on the head and neck [4,12].

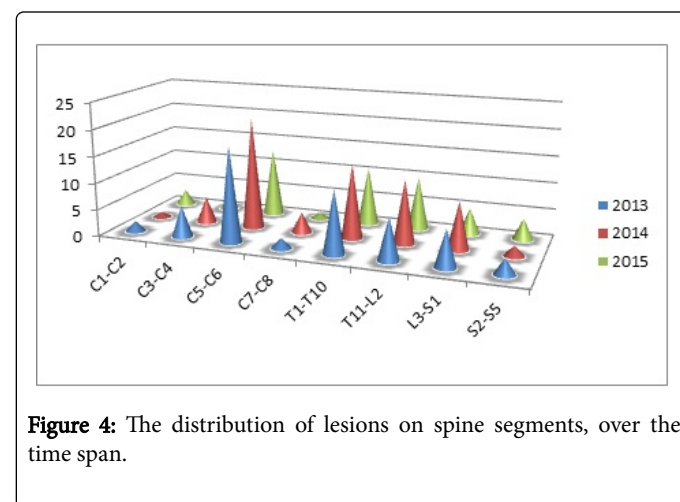
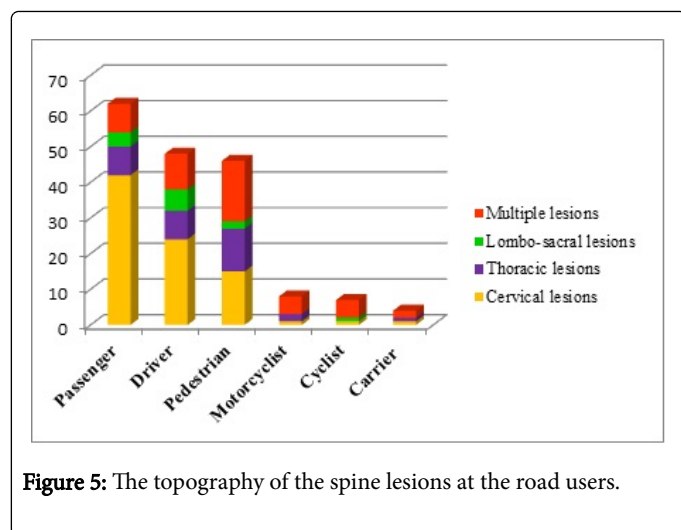


Figure 4: The distribution of lesions on spine segments, over the time span.

The topography of the spine lesions depends on the quality of the traffic participants and is as it follows: the passengers of the vehicles (62 cases) have more frequently cervical spinal cord injuries (24%), followed by thoracic (4.57%) and lumbosacral injuries (2.29%); multiple locations of the spinal cord injuries were identified in 4.57% of the cases. Drivers (48 cases) presented spinal cord injuries (13.71%), thoracic (4.57%), lumbosacral injuries (3.43%); multiple locations of the spinal cord injuries were found in 5.71% of the cases.

Pedestrians (46 cases) presented complex polytrauma with multifocal lesions and multiple lesions of the spinal cord (9.71%), followed by cervical (8.57%), thoracic (6.86%) and lumbosacral spinal cord injuries (1.14%). Cyclists, motorcyclists and carriers (19 cases) often presented complex polytrauma with multifocal lesions and multiple spinal cord injuries (6.86%), the other cases presenting cervical and thoracic spinal cord injuries (4%). Polytrauma with multiple lesions associated to cervical, thoracic or lumbosacral spinal cord injuries have been recorded to a large number of pedestrians (9.71%), cyclists (2.85%), motorcyclists (2.86%) and carriers (1.14%) (Figure 5).



**Figure 5:** The topography of the spine lesions at the road users.

60.57% of the vertebro-medullary injuries cases were traumatic injuries such as vertebral body fractures/vertebral arch fractures, luxations, while 39.43% of the cases presented disco-ligamental lesions (luxations and sprains). 28% of the cases presented spinal cord injuries associated with neurological and vegetative symptoms, out of which 13.3% presented severe dilacerations of the spinal cord and neurological syndromes. The myelic fractures with the most severe consequences were those with cervical topography.

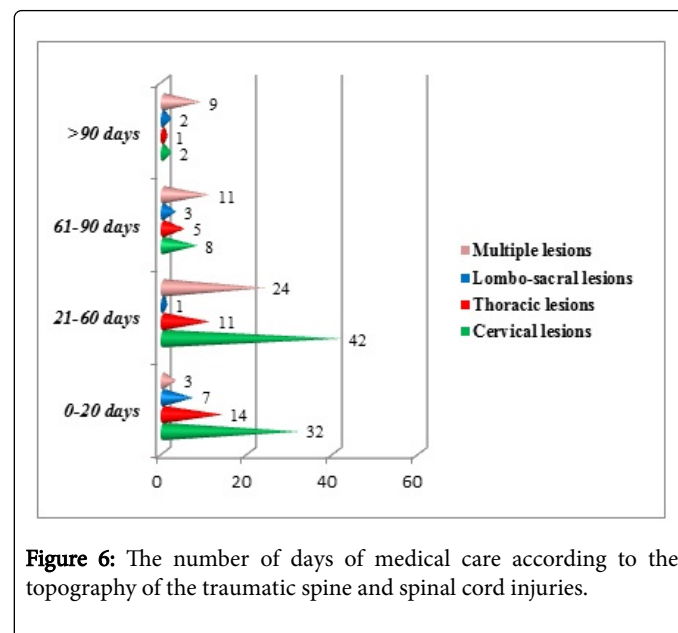
Regarding road accidents produced to the living persons, a relatively large number of spinal cord injuries is associated with other traumatic injuries, depending on the intensity and the strength of the impact, the quality of the road user and on a number of unpredictable factors. Thus, depending on the topography of vertebro-medullary injuries, the following association of topographic lesions on the study group can be observed: cervical spinal cord injuries were associated with cranio-cerebral and cranio-facial trauma (47.43%); thoracic spinal cord injuries were associated with upper limb fractures (32.7%), costal fractures and lesions of the thoracoabdominal internal organs (34.61%); lesions of the lumbosacral spinal cord were associated with lower limb and/or pelvic fractures (73.33%), sometimes accompanied by lesions of the abdominal and pelvic internal organs (13.33%).

Preexistent personal pathology of spinal trauma consists of: obesity (34%), hypertension (26%), diabetes mellitus (22%), ischemic heart disease (17%), osteoporosis (16%), scoliosis and kyphosis (5%), spondylarthrosis (8%), rheumatoid arthritis (3%), the rest of 9% being epilepsy, hearing loss, mental retardation. Metabolic diseases and osteoporosis are contributing factors to spine fractures and also aggravating factors to their evolution, especially concerning lumbar-thoracic spine, thus confirming recent studies from the literature [19].

The direct criteria for assessing the severity of a trauma is the number of days of medical care mentioned in the New Penal Code [16,20]. This is the number of days estimated from the forensic point of view to evaluate the severity of lesions or the post-traumatic diseases [16]. Thus, on our study group, mild vertebro-medullary injuries, which required up to 20 days of medical care, were observed in 32% of the cases, most of them consisting of type I or II ligament injuries, mostly affecting the cervical spine, and isolated fractures of the transverse, spinous or articular apophyses without myelic injuries in the thoracic-lombar spine. 60% of the cases presented medium and high gravity lesions with spinal cord injuries (mostly fractures) of

different complexity, some associated with ligament injuries, neurological and vegetative symptoms of various degrees, requiring 20-90 days of medical care (Art. 193 New Penal Code-hitting or other violence)[20].

In 8% of the cases over 90 days of medical care were given due to their high gravity with medullary dilaceration and severe neurological injuries (Art. 194 New Penal Code- Body injuries)[20]. 24% of the analyzed cases had an adaptive disability in different percentages, 28% had different degrees of disability (6.28% grade I, 8.57% grade II, 15.42% grade III), 14.85% had an infirmity, 22.86% had a severe and permanent esthetic damage. The cases of disability and some cases of invalidity depending on the topography of the spinal cord injuries were found with tetraparesis, often associated with sphincter disorders, complete or incomplete paraplegia with spasticity or sensitivity/sphincter disorders or disturbances of walking, Brown Sequard syndrome, and disturbances of the vegetative functions (Figure 6).



**Figure 6:** The number of days of medical care according to the topography of the traumatic spine and spinal cord injuries.

## Conclusions

Vertebro-medullary trauma is a major cause of tetraparesis and paraplegia and also a public health issue [3]. Correct and prompt diagnosis of spinal cord injuries is essential for a favorable prognosis. Improving the prevention measures of road accidents by school and university road education programs, promoting walking or cycling, improving road infrastructure and the technical condition of the car park, road safety expertise and judicial practice are required [2]. Speed adjustment to traffic conditions, preventative driving, wearing seatbelts, statutory pedestrian crossing and overrun are some of the basic rules that can significantly reduce the frequency of road accidents and the number of victims with vertebro-medullary injuries.

## Declaration of Conflicting Interests

The authors declared no potential conflicts of interest.

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