BALNEO RESEARCH Balneo and PRM Research Journal
English Edition
e ISSN 2734 - 8458 p ISSN 2734 - 844X ROMANIAN ASSOCIATION OF BALNEOLOGY

Research article

Severity of the neurological deficit of high spinal cord lesions assessed according to etiology

Radu Fodor [1], Lavinia Davidescu [2,*], Florica Voiță-Mekeres [3], Cornel Dragos Cheregi [4], Gheorghe Szilagyi [4], Ioana Vîlceanu [3], Darius Davidescu [1], Felicia Manole [4]

Citation: Fodor R., Davidescu L., Voiță-Mekeres F., Cheregi C.D., Szilagyi G., Vîlceanu I., Davidescu D., Manole F. - Severity of the neurological deficit of high spinal cord lesions assessed according to etiology
Balneo and PRM Research Journal ***2024****, 15(3): 724*

Academic Editor(s):
Constantin Munteanu

Reviewer Officer:
Viorela Bembea

Production Officer:
Camil Filimon

Received: 25.07.2024
Published: 25.09.2024

Reviewers:
Mihai Hoteteu
Elena Valentina Ionescu

Publisher's Note: Balneo and PRM Research Journal stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1 Doctoral School of Biomedical Sciences, Faculty of Medicine and Pharmacy, University of Oradea, Oradea, Romania; dr.radu.fodor@gmail.com (R.F), darius.davidescu96@gmai.com (D.D.);
2 Department of Medical Disciplines, Faculty of Medicine and Pharmacy, University of Oradea, Oradea, Romania; lavinia.davidescu@yahoo.com (L.D.);
3 Department of Morphological Disciplines, Faculty of Medicine and Pharmacy, University of Oradea, Oradea, Romania; mekeres_florina@yahoo.com (F.V.M), vilceanuioana@yahoo.com (V.I.);
4 Department of Surgical Disciplines, Faculty of Medicine and Pharmacy, University of Oradea, Oradea, Romania; cheregicorneldragos@gmail.com(C.D.C.), gyuri.dr.sz@gmail.com(G.S.), fmanole@uoradea.ro (F.M.)

* Correspondence: lavinia.davidescu@yahoo.com(L.D.)

Abstract: Spinal cord injury (SCI) represents a major health problem, having significant consequences on motor and sensory function, as well as on the quality of life of affected patients. The objective of this study is to assess the severity of high post-traumatic spinal cord injuries depending on the age and gender of the patients and the manner of their etiology. We used useful tools for evaluating and classifying the severity of spinal cord injuries: ASIA classification, MAS and MTS score. This is a retrospective observational study included a number of 146 patients with various high spinal cord injuries whose diagnosis was confirmed by imaging. The mean age of the cohort was 42.97 ± 15.9 years, with a range of 18 to 83 years. The severity of the ASIA score was inversely proportional to the age of the patients. Patients with ASIA A were younger than those with ASIA D. Regarding the etiology of the trauma, most patients, 39.7%, were traumatized following a road accident. The etiology of trauma has a significant influence on the severity of spinal cord injury. Accidents are the leading cause of injury, followed by falls and diving trauma. There is a correlation between the ASIA score and muscle tone/spasticity, which may influence the therapeutic approach and patient management.

Keywords: spinal cord injury, high spinal cord lesions, neurological deficit, scales

1. Introduction

Spinal cord injury (SCI) represents a major health problem, having significant consequences on motor and sensory function, as well as on the quality of life of affected patients. Understanding the complexity and variety of spinal cord injuries is essential to develop appropriate management strategies and to improve patient prognosis and quality of life. There are approximately 12,500 spinal cord injuries in the US annually, with a global incidence ranging from 133,000 to 226,000 cases annually [1]. The cost associated with caring for patients with spinal cord injury is substantial, with estimates of the average lifetime cost for direct care ranging from $1.5 million to $4.7 million [2], [3]. These injuries can be the result of traumatic accidents, falls or other events that involve a traumatic force applied to the spine. The demographics of spinal cord injury

patients have expanded over time, however, men still account for 80% of new spinal cord injury patients[2], [4].

Primary SCI occurs due to local deformation of the spine, for example, by direct compression. Secondary SCI occurs after a primary injury and involves cascades of biochemical and cellular processes, including electrolyte disturbances, free radical production, edema, ischemia, and inflammation. Secondary SCI has several phases: acute, subacute and chronic. Scarring is thought to be the critical component of permanent disability because it prevents axonal regeneration. Otherwise, axons might regenerate, but their growth is blocked. However, this notion has been challenged and there are even suggestions that astrocyte scar formation could aid regeneration. In the chronic phase, the healing process is completed [5], [6].

Patients with SCI can present numerous comorbidities or complications. Urinary incontinence is significantly associated with the severity of spinal cord injury according to the ASIA score. Patients with more severe spinal cord injuries are at increased risk of urinary incontinence, while patients with less severe ASIA scores have a lower prevalence of this condition. The presence of neurogenic bladder and neurogenic colon is correlated with the severity of spinal cord injury, as expressed by the ASIA score. These findings highlight the impact of trauma on bladder and digestive system functioning[7].

The Frankel scale was used to classify SCI, but it had considerable limitations such as not specifying the level of SCI and did not define the difference between "useful motor" and "useless motor" scores, leading to subjective scoring [8]. The American Spinal Injury Association (ASIA) Impairment Scale replaced the modified Frankel scale and became the international gold standard for SCI assessment. Since its inception, the AIS has been revised several times as its authors continue to refine the steps of the neurological examination and the details of the classifications. These revisions improved the reproducibility of the AIS and allowed a better understanding of the therapeutic implications and implications of the scale [9]. Among his notable contributions, international standards for neurological classification of spinal cord injury helped identify key muscle groups and sensory points that improved practitioners' accuracy in identifying neurological levels of injury. In addition, it was a reproducible classification with detailed descriptions of each sensory and motor grade. This allowed the precise characterization of incomplete and complete SCI[10], [11].

The Modified Ashworth Scale (MAS) is a clinical assessment tool used to assess spasticity in people with neurological conditions, particularly those with conditions affecting the central nervous system, such as stroke or SCI[12]. The Modified Tardieu Scale (MTS) is a clinical tool that presents good-to-excellent reliability in evaluating motor aspects of spasticity [13].

The objective of this retrospective study is to evaluate the severity of high post-traumatic spinal cord injuries depending on the age and gender of the patients and the manner of their production. We used useful tools for evaluating and classifying the severity of spinal cord injuries: ASIA classification, MAS and MTS score.

2. Materials and Methods

2.1. Participants

This is a retrospective observational study. All patients who were hospitalized with high spinal cord injuries in the Băile Felix Medical Rehabilitation Clinical Hospital, Romania, during the period 2016-2022, were included in this study.

The study involved adult patients, over 18 years of age, who were hospitalized for various high spinal cord injuries. In order to establish the diagnosis, patients with suspected spinal cord injury underwent chest MRI. Patients whose diagnosis was not confirmed by MRI were excluded from this study.

The final database included a number of 146 patients with various high spinal cord injuries whose diagnosis was confirmed by imaging. The mean age of the cohort was 42.97 ± 15.9 years, with a range of 18 to 83 years.

2.2. Instruments

(a) ASIA involves performing a standardized examination consisting of a myotome-based motor examination, dermatome-based sensory examination, and an anorectal examination. Based on the results of these examinations, the degree and level of the injury is assessed. Sensory examination assesses 28 specific dermatomes bilaterally for light touch (generally a cotton ball) and pinch (generally a clean safety pin) sensation. Each examination component is recorded for each dermatome and laterality. A grade of 0 indicates absent sensation, 1 indicates impaired or altered sensation, and 2 indicates normal sensation. A normal unilateral sensory examination consists of 28 dermatomes, each with 2/2 points for light touch and 2/2 points for tip, resulting in a total of 112 points. A total score of 224 bilaterally is a completely normal sensory examination. Inability to distinguish the sensation of pinching from light touch is technically classified as 0 [9]–[11].

(b) MAS helps healthcare professionals quantify the degree of muscle tone and spasticity in specific muscle groups. It provides a standardized framework for assessing spasticity and monitoring its progression or response to treatment over time. This presents 6 points, scored between 0 and 4 (0 = no increase in muscle tone, 1 = slight increase in muscle tone, 1+ = slight increase in muscle tone, manifested as a seizure, followed by minimal resistance during the rest (more less than half) of the range of motion, 2 = marked increase in muscle tone throughout most of the range of motion, but the affected parts are still easy to move, 3 = considerable increase in muscle tone, passive movement difficult, and 4 = affected parts rigid in flexion or extension) [9], [12].

(c) MTS is a clinical tool for assessing muscle spasticity in patients with neurological conditions. It quantifies spasticity by assessing the quality of the muscle response at specified speeds and the angle at which the muscle response occurs [10]. Specific limb positions, alignment positions, and procedures are described. Passive range of motion measures are described as R2; the angle of muscle reaction ("grip") is described as R1; and the difference between the two measures (R2-R1) are used to help differentiate spasticity and soft tissue restrictions [10]. The MTS evaluates muscle spasticity, and the responses were rated with 0 points in patients without resistance during passive movement up to 5 points where the joint is immobile [13].

2.3. Statistical analysis

Continuous variables were presented as mean and standard deviation, while categorical variables as absolute and relative frequency. We performed descriptive and inferential statistical analysis in order to analyze the general characteristics of the studied batch.

The results of the Shapiro-Wilk test showed a Gaussian distribution of the continuous variables, which is why we continued the statistical analysis using parametric tests.

The Student T-test or the One-way ANOVA test was used to evaluate continuous variables, and the Chi-square or Fisher-Freeman-Halton test was used to evaluate categorical variables.

Statistical analysis was performed using IBM SPSS Statistics v26.0 (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp), and a p-value of 0.05 was considered as the threshold of statistical significance.

3. Results

The studied group was composed of 146 patients, of whom 87.6% (n=128) were male and 12.3% (n=18) female. The mean age of the cohort was 42.97 ± 15.9 years, with a range of 18 to 83 years. The mean age of female patients was 48.11 ± 18.3 years, and that of male patients was 42.25 ± 15.5 years (Figure 1). These differences were not statistically significant (T-test, p=0.145)

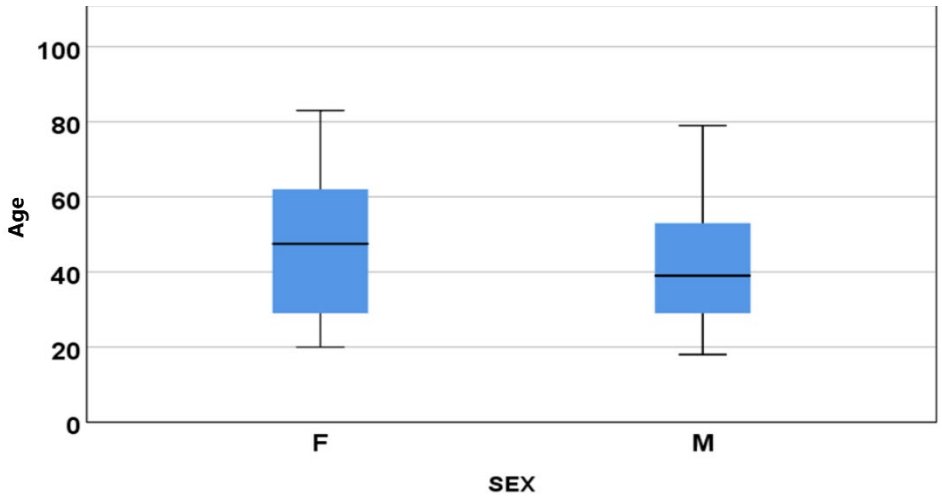

Figure 1. Age boxplot.

Regarding the age of patients stratified by ASIA score, a statistically significant difference is observed (ANOVA test, p<0.001, Table 1). It is noted that the severity of the ASIA score was inversely proportional to the age of the patients. Patients with ASIA A were younger than those with ASIA D (Figure 2).

Table 1 Average age according to ASIA classification

ASIA	Age (years)
A	36,58 ± 11,9
B	37 ± 14,8
C	46,7 ± 16,8
D	49,07 ± 15,2

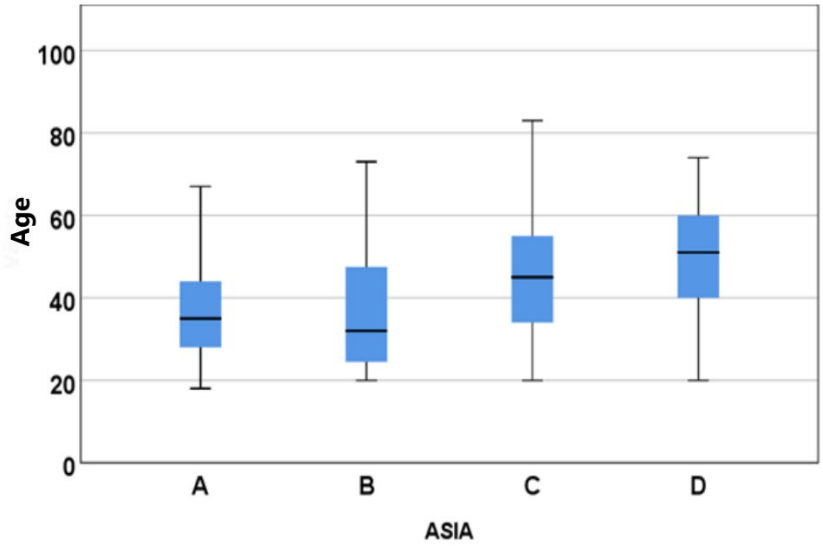

Figure 2. Boxplot of age stratified by ASIA score

Table 2 shows the general characteristics of the studied group, such as age, sex, etiology of the trauma and the environment of origin. These characteristics were stratified by ASIA score.

Table 2 General characteristics by ASIA Score

			ASIA A	ASIA B	ASIA C	ASIA D	P
Age		42,97 ± 15.9	36 ± 11,9	37 ± 14,9	46,7 ± 16,9	49,07 ± 15,2	<0,001[a]
Sex	Male	128 (87,7%)	22 (17,2%)	34 (26,6%)	37 (28,9%)	35 (27,3%)	0,730[b]
	Female	18 (22,3%)	4 (22,4%)	5 (27,8%)	3 (16,7%)	6 (33,3%)	
Etiology of trauma	road accident	58 (39,7%)	16 (27,5%)	12 (20,7%)	16 (27,6%)	14 (24,1%)	
	fall from a height	50 (34,2%)	4 (8%)	10 (20%)	15 (30%)	21 (42%)	0,008[b]
	Plunge into the water	38 (26%)	6 (15,8%)	17 (44,7%)	9 (23,7%)	6 (18,8%)	
Provenience	Urban	76 (52,1%)	17 (65,4%)	16 (41%)	22 (55%)	21 (51,2%)	0,475[b]
	Rural	70 (47,9%)	9 (34,6%)	23 (59%)	18 (45%)	20 (48,8%)	

[a] mean ± standard deviation, ANOVA test; [b] absolute (relative) frequency, Chi-square test.

Most patients are men, and the distribution of the ASIA score among the male gender was as follows: A-17.2%, B-26.6%, C-28.9% and D-27.3% (Figure 3). A similar distribution was also present in the female sex, A-22.4%, B-27.8%, C-16.7% and D-33.3% ($\chi 2(1, N = 146) = 1.298$; $p=0.730$; Chi-square test).

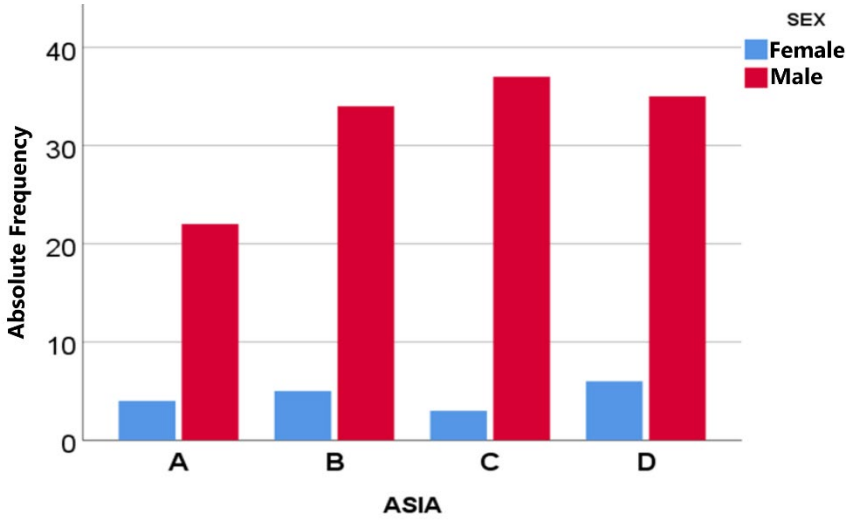

Figure 3. ASIA score distribution by gender

Regarding the etiology of the trauma, most patients, 58 (39.7%) were traumatized following an accident, and of these 16 (27.5%) obtained an ASIA A score, 12 (20.7%) ASIA B, 16 (27.6%) ASIA C and 14 (24.1%) score D. The second most frequent cause of trauma was the fall, being present in 50 patients (34.2%). Of these, 4 (8%) scored ASIA A, 10 (20%) ASIA B, 15 (30%) ASIA C and 21 (42%) ASIA D. Dive trauma was present in 38 (26%) of patients. Among them, 6 (15.8%) scored ASIA A, 17 (44.7%) ASIA B, 9 (23.7%) ASIA C and 6 (18.8%) ASIA D (Figure 4). Statistically significant differences in the ASIA score are observed according to the etiology of the trauma (χ2(6, N =146) = 26.732; p=0.008; Chi-square test).

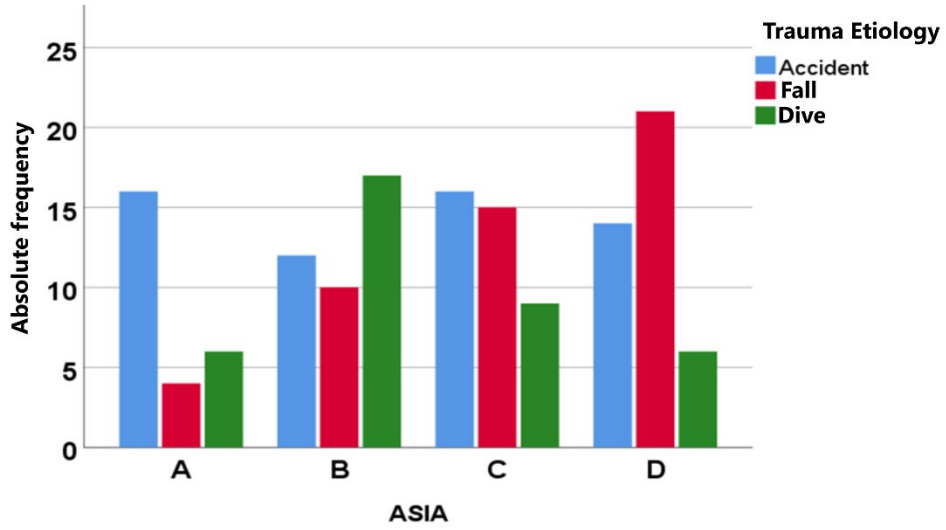

Figure 4 ASIA score distribution by etiology of trauma

The distribution of patients according to the area of origin was approximately equal, 76 (52.1%) of the patients came from the urban area and 70 (47.9%) from the rural area. The distribution of the ASIA score according to the environment of origin did not show significant differences (χ2(3, N =146) = 2.503; p=0.475; Chi-square test; Figure 5).

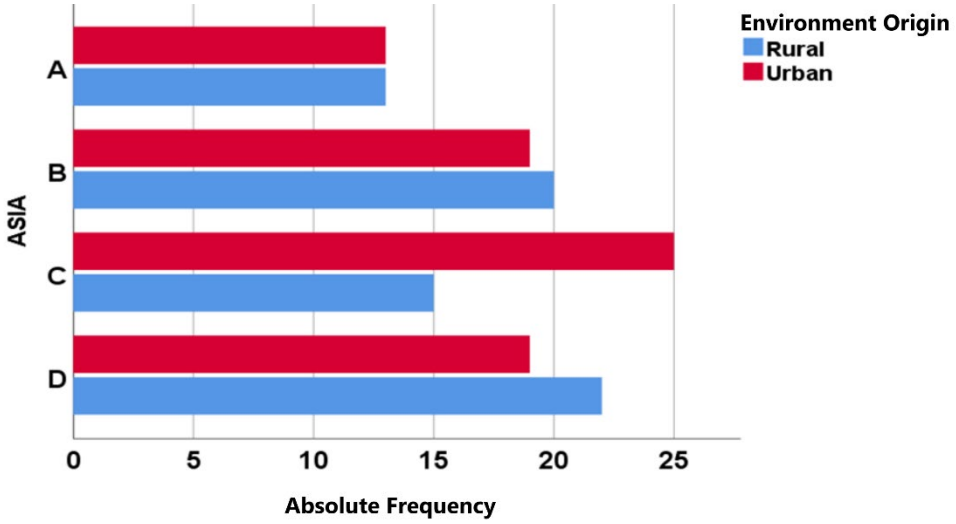

Figure 5. Distribution of the ASIA score by medium of origin

In Table 3 we can see that the distribution of bedsores on the ASIA score showed an increased frequency of bedsores correlated with the severity of the trauma. Among patients with bedsores, 40.9% were classified in ASIA-A, while in patients without bedsores only 13.7% were classified in ASIA-A. The association of bedsores with the severity of the trauma is statistically significant ($\chi 2(3, N = 146) = 12.145$; p=0.007; Chi-square test).

Table 3. Clinical characteristics in the studied group

			ASIA A	ASIA B	ASIA C	ASIA D	P
Bedsores	**Yes**	22 (15,1%)	9 (40,9%)	7 (31,8%)	4 (18,2%)	2 (9,1%)	0,007[a]
	No	124 (84,9%)	17 (13,7%)	32 (25,8%)	36 (29%)	39 (31,5%)	
Urinary incontinence	**Yes**	83 (56,8%)	16 (19,3%)	31 (37,3%)	23 (27,7%)	13 (15,6%)	<0,001[a]
	No	63 (43,2%)	10 (15,8%)	8 (12,7%)	17 (26,9%)	28 (44,4%)	
MAS	**0**	2 (1,4%)	2 (100%)	0	0	0	0,001[b]
	1	29 (19,9%)	2 (6,9%)	5 (17,2%)	5 (17,2%)	17 (58,6%)	
	2	67 (45,9%)	10 (14,9%)	20 (29,8%)	23 (34,3%)	14 (20,9%)	
	3	35 (24%)	7 (20,0%)	9 (25,7%)	11 (31,4%)	8 (22,8%)	
	4	13 (8,9%)	5 (38,5%)	5 (38,5%)	1 (7,7%)	2 (15,4%)	
MTS	**0**	2 (1,4%)	2 (100%)	0	0		0,001[b]
	1	29 (19,9%)	2 (6,9%)	5 (17,2%)	5 (17,2%)	17 (58,6%)	
	2	66 (45,2%)	9 (13,3%)	20 (30,3%)	23 (34,8%)	14 (21,2%)	
	3	35 (24%)	7 (20%)	9 (25,7%)	11 (31,4%)	8 (22,9%)	
	4	13 (8,9%)	5 (38,5%)	5 (38,5%)	1 (7,7%)	2 (15,4%)	
Duration since accident (years)		4,98 ± 5,5	4,03 ± 3,5	4,25 ± 4,06	5,9 ± 7,1	5,39 ± 5,9	0,433
Professional activity	**no**	131 (89,7%)	23 (17,6%)	35 (26,7%)	38 (29%)	35 (26,7%)	0,552
	yes	15 (10,3%)	3 (20%)	4 (26,7%)	2 (13,3%)	6 (40%)	
Neurogenic bladder	**No**	24 (16,4%)	0	0	7 (29,2%)	17 (70,8%)	<0,001[b]
	Yes	122 (83,6%)	26 (21,3%)	39 (32%)	33 (27%)	24 (19,7%)	
	No	43 (29,5%)	1 (2,3%)	5 (11,6%)	16 (37,2%)	21 (48,8%)	<0,001[b]

Neurogenic colon	**Yes**	103 (70,5%)	25 (24,3%)	34 (33%)	24 (23,3%)	20 (19,4%)	
Risk of falling	**0**	5 (3,4%)	0	0	1 (20%)	4 (80%)	<0,001[b]
	1	45 (30,8%)	2 (4,4%)	4 (8,9%)	13 (28,9%)	26 (57,8%)	
	2	96 (65,8%)	24 (25%)	35 (36,5%)	26 (27,1%)	11 (11,5%)	
Dependence	**1**	11 (7,5%)	0	0	1 (9,1%)	10 (90,9%)	<0,001[b]
	2	50 (34,2%)	2 (4%)	6 (12%)	19 (38%)	23 (46%)	
	3	53 (36,3%)	9 (17%)	18 (34%)	19 (35,8%)	7 (13,2%)	
	4	32 (21,9%)	15 (46,9%)	15 (46,9%)	1 (3,1%)	1 (3,1%)	

[a] Absolute (relative) frequency, Chi-square test; [b] Absolute (relative) frequency, Fisher-Freeman Halton test;

[c] mean ± standard deviation, ANOVA test

The distribution of urinary incontinence also showed a statistically significant association with the severity of the trauma ($\chi2(3, N =146) = 18.952$; $p<0.001$; Chi-square test).

According to the ASHWORTH classification, 2% (1.4%) of patients have a score of 0; 29 (19.9%) patients have a score of 1; 67 (45.9%) patients a score of 2; 35 (24%) patients score 3 and 14 (8.9%) patients a score 4. The ASWORTH classification differs significantly for patients in the ASIA categories ($\chi2(12, N =146) = 32.863$; $p=0.001$; Fisher-Freeman-Halton test).

The same pattern was also found in the Tardieu score distribution after ASIA classification, the differences were statistically significant ($\chi2(3, N =146) = 33.577$; $p=0.001$; Fisher-Freeman-Halton test).

Regarding age of injury, no significant differences in duration since accident were observed between ASIA scores ($F(3, 142) = [0.919]$, $p = 0.433$). There was no association between ASIA classification and professional activity ($\chi2(3, N =146) = 2.098$; $p=0.552$; Chi-square test, Figure 6).

The presence of neurogenic bladder and neurogenic colon was associated according to the ASIA score with the severity of the trauma ($\chi2(3, N =146) = 31.512$; $p<0.001$; respectively ($\chi2(3, N =146) = 24.888$; $p<0.001$; the Fisher-Freeman-Halton test).

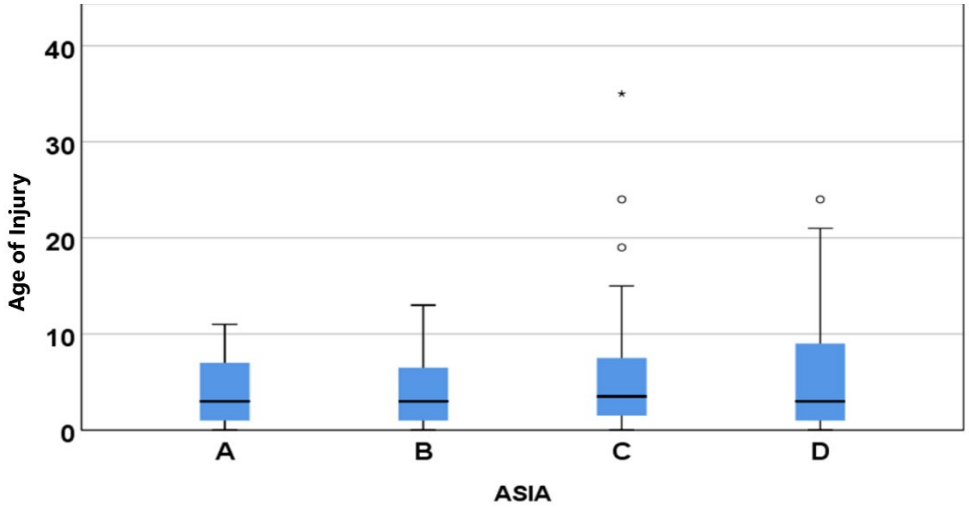

Figure 6. Boxplot of duration since accident stratified by ASIA score

4. Discussion

The ASIA classification has a crucial role in understanding the degree of impairment and predicting functional outcomes for people with spinal cord injury. In addition to the classification of the injury, the ASIA classification involves identifying the neurological level of the injury and determining the complexity of the injury. The neurological level refers to the lowest segment of the spinal cord with intact sensory and motor function on both sides of the body. This level serves as a reference point for assessing the severity and distribution of the injury. By using the ASIA classification system, healthcare professionals can effectively communicate the severity of a spinal cord injury, compare outcomes across patients, and develop appropriate treatment plans. It serves as a valuable tool for determining prognosis, rehabilitation strategies and research studies focused on spinal cord injuries [11].

The study revealed a statistically significant difference in the age of patients stratified by ASIA score. In the study, it was observed that the severity of the ASIA score was inversely proportional to the age of the patients. This means that patients with a more severe ASIA score (eg, ASIA A, indicating a complete spinal cord injury) were younger than those with a less severe ASIA score (eg, ASIA D, indicating normal neurological function).

This association between the severity of the ASIA score and the age of the patients is in accordance with the results reported in previous studies in the literature. Typically, younger patients have a higher prevalence of severe spinal injuries and therefore a more severe ASIA score[14], [15].

It is important to note that this relationship between age and severity of the ASIA score may be influenced by other factors, such as mechanism of injury, associated comorbidities, and time since injury. Thus, the results of the study show a correlation, but not necessarily a direct causal relationship between age and the severity of the spinal cord injury.

As in the literature, in our study we also observed significant discrepancies in the frequency and severity of high spinal cord injuries between sexes. Men have a higher proportion of high spinal cord injuries compared to women[2], [4]. This difference can be attributed, in part, to physiological and behavioral differences between the sexes, such as differences in muscle size and strength, level of physical activity, and type of activities performed [16], [17].

In our study we observed a quasi-equal distribution of the severity of spinal cord lesions according to the ASIA score between the two sexes. Comparing these results with the literature, it can be seen that the distribution of the severity of high spinal cord injuries between the sexes may be influenced by individual factors and the circumstances in which the injuries occurred. In the study by Scivoletto et al., female patients had a lower frequency of trauma and complications at admission, but a higher frequency of incomplete injuries compared to males [18]. In contrast, research conducted by Furlan et al., indicated a more balanced distribution of ASIA scores between sexes, with no significant differences [19].

These discrepancies can be attributed to differences in the mechanisms of injury, the type of trauma suffered and the physiological characteristics of the sexes. Also, cultural and social differences may also influence the distribution of the severity of high spinal cord injuries between sexes, given the variability in exposure to risk factors such as road accidents or sports accidents.

The results obtained in this study demonstrate a significant association between the etiology of trauma and the severity of high spinal cord injuries, expressed by the ASIA score. The most common cause of trauma was accident, which resulted in a significant proportion of patients with ASIA A, B, C and D scores. These results are consistent with existing literature indicating that accidents are the leading cause of spinal cord injury [4], [12].

Falling was also identified as an important cause of trauma in this study, with a significant number of patients presenting with ASIA A, B, C and D scores. This result is in agreement with previous studies that emphasize that falling can have serious consequences on the spinal cord and can lead to a variety of severity levels of spinal cord injury.

Interestingly, diving trauma was associated with a different distribution of ASIA scores. Although the proportion of patients with an ASIA D score is relatively low in this group, ASIA A and B scores are more common than in the other causes of trauma. This finding may suggest that spinal cord injuries resulting from the plunge may mainly affect the lower regions of the spinal cord.

The Ashworth classification and the Tardieu score among patients with high spinal cord injuries showed a significant variation according to the ASIA classification. The distribution of the Ashworth score showed that most patients scored 2 and 3, while scores 0 and 4 were less common. This distribution is in agreement with the existing literature, which indicates that patients with spinal cord injuries may have increased muscle tone at certain degrees and levels of the spinal cord.

The results also showed that there are significant differences in the Ashworth classification according to the ASIA classification. This suggests that the severity of spinal cord injury may influence the muscle tone and degree of spasticity exhibited by patients. Our results are consistent with previous studies that highlighted the correlation between ASIA classification and spasticity severity in patients with spinal cord injury [17], [18].

Similarly, the distribution of the Tardieu score showed a similar pattern according to the ASIA classification, and the differences were statistically significant similarly confirming information from the literature [20]–[22]. This result confirms that the ASIA classification can be a useful indicator for the assessment and classification of spasticity in patients with high spinal cord injuries.

Our results are consistent with the existing literature regarding the association between ASIA classification, Ashworth score, and Tardieu score in patients with high spinal cord injuries. Assessment and classification of muscle tone and spasticity can be important in the management and treatment of patients with spinal cord injury, and the use of standardized classifications such as ASIA can provide relevant information for therapeutic decisions.

The present study revealed a significant association between the severity of trauma and the distribution of urinary incontinence in patients with high spinal cord injuries. The distribution of urinary incontinence showed that a higher proportion of patients with ASIA A and B scores had urinary incontinence, while patients with ASIA C and D scores had a lower prevalence of urinary incontinence. These results are consistent with previous studies reporting that patients with more severe spinal cord injuries are at increased risk of urinary incontinence.

The results also showed a significant association between the presence of neurogenic bladder and neurogenic colon and the ASIA score, indicating a correlation between the

severity of the trauma and the presence of these conditions. Patients with lower ASIA scores had a higher frequency of neurogenic bladder and neurogenic colon, whereas patients with higher ASIA scores had a lower prevalence of these conditions. These findings are consistent with existing literature, which has demonstrated that severe spinal cord injury can impair bladder and digestive system function [7], [23].

Our results provide further support for the association between the severity of trauma and the manifestation of urinary incontinence, as well as the presence of neurogenic bladder and neurogenic colon among patients with high spinal cord injuries. Appropriate assessment and management of urinary incontinence and neurogenic bladder and colon conditions may be important aspects in the care and treatment of patients with spinal cord injury, and our results support the use of an individualized approach based on trauma severity and ASIA score in the management of these health problems.

5. Conclusions

The age of the patients is significantly associated with the severity of the spinal injury, according to the ASIA score. Younger patients tend to have more severe ASIA scores, while older patients have less severe ASIA scores. Men have a higher proportion of high spinal cord injuries than women, which may be attributed to physiological and behavioral differences between the sexes. The etiology of trauma has a significant influence on the severity of spinal cord injury. Accidents are the leading cause of injury, followed by falls and diving trauma. There is a correlation between the ASIA score and muscle tone/spasticity, which may influence the therapeutic approach and patient management.

Author Contributions: Conceptualization, F.R., F.V.M. and F.M.; methodology L. D, F.M.; software, D.D., C.D.C; validation, F.R., F.V.M, F.M., V.I., G.S. and D.D.; formal analysis, F.R., D.D.; investigation, F.R, G.S; resources, C.G.C., G.S, V.I..; data curation, L.D., F.M..; writing—original draft preparation, F.R., and F.V.M.; writing—review and editing, L.D., D.D., and C.D.C.; visualization, R.D., L.D., F.V.M., C.D.C., G.S., V.I., D.D., F.M.; supervision, F.V.M., L.D., F.M..; project administration, F.M, L.D.; funding acquisition, N.A. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Băile Felix Medical Rehabilitation Clinical Hospital (no. 6449/21.06.2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Please refer to suggested Data Availability Statements in section "MDPI Research Data Policies" at https://www.mdpi.com/ethics. If the study did not report any data, you might add "Not applicable" here.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. R. A. Cripps, B. B. Lee, P. Wing, E. Weerts, J. Mackay, and D. Brown, "A global map for traumatic spinal cord injury epide-miology: towards a living data repository for injury prevention," Spinal Cord, vol. 49, no. 4, pp. 493–501, 2011.
2. D. Abdullahi, A. A. Annuar, M. Mohamad, I. Aziz, and J. Sanusi, "Experimental spinal cord trauma: a review of mechani-cally induced spinal cord injury in rat models," Rev. Neurosci., vol. 28, no. 1, pp. 15–20, 2017.

3. F. Manole, P. Marian, G. M. Mekeres, and F. Voiţă-Mekereş, "Systematic review of the effect of aging on health costs," Arch. Pharm. Pract., vol. 14, no. 3–2023, pp. 58–61, 2023.
4. R. Fodor et al., "Epidemiological study on spinal cord injuries in a hospital from north-west of Romania," Pharmacophore, vol. 14, no. 1–2023, pp. 80–86, 2023.
5. Y. Tanie, N. Tanabe, T. Kuboyama, and C. Tohda, "Extracellular neuroleukin enhances neuroleukin secretion from astro-cytes and promotes axonal growth in vitro and in vivo," Front. Pharmacol., vol. 9, p. 1228, 2018.
6. Y.-H. Kim, K.-Y. Ha, and S.-I. Kim, "Spinal cord injury and related clinical trials," Clin. Orthop. Surg., vol. 9, no. 1, pp. 1–9, 2017.
7. R. Fodor et al., "Risk factors and prevention of cardiovascular dysfunctions after spinal cord injuries. A literature review," Pharmacophore, vol. 14, no. 3–2023, pp. 47–54, 2023.
8. H. Frankel et al., "The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia," Spinal Cord, vol. 7, no. 3, pp. 179–192, 1969.
9. C. F. Lascu et al., "Advantages and limitations in the evaluation of the neurological and functional deficit in patients with spinal cord injuries," Clin. Pract., vol. 13, no. 1, pp. 14–21, 2022.
10. S. C. Kirshblum et al., "International standards for neurological classification of spinal cord injury (revised 2011)," J. Spinal Cord Med., vol. 34, no. 6, pp. 535–546, 2011.
11. S. Kirshblum and W. Waring 3rd, "Updates for the International Standards for Neurological Classification of Spinal Cord Injury.," Phys. Med. Rehabil. Clin. N. Am., vol. 25, no. 3, pp. 505–17, 2014.
12. A.-B. Meseguer-Henarejos, J. Sánchez-Meca, J.-A. López-Pina, and R. Carles-Hernández, "Inter- and intra-rater reliability of the Modified Ashworth Scale: a systematic review and meta-analysis.," Eur. J. Phys. Rehabil. Med., vol. 54, no. 4, pp. 576–590, 2017.
13. X. Shu, C. McConaghy, and A. Knight, "Validity and reliability of the Modified Tardieu Scale as a spasticity outcome measure of the upper limbs in adults with neurological conditions: a systematic review and narrative analysis," BMJ Open, vol. 11, no. 12, p. e050711, 2021.
14. R. Hu, C. A. Mustard, and C. Burns, "Epidemiology of incident spinal fracture in a complete population," Spine, vol. 21, no. 4, pp. 492–499, 1996.
15. A. V. Payenok, O. G. Morozova, O. S. Payenok, I. M. Mitelman, and O. Y. Bilianskyi, "Features of estimation of muscle tone and functional state of spinal motor neurons in patients with post-stroke spasticity on a background of a pharmacological correction," Wiad Lek, vol. 72, no. 10, pp. 1939–1941, 2019.
16. R. G. Grossman et al., "Incidence and severity of acute complications after spinal cord injury," J. Neurosurg. Spine, vol. 17, no. Suppl1, pp. 119–128, 2012.
17. C. S. YOUSEFZADEH, M. Safaee, A. Alizadeh, D. M. AHMADI, O. Taghinnejadi, and L. Koochakinejad, "Epidemiology of traumatic spinal injury: a descriptive study," 2010.
18. G. Scivoletto, B. Morganti, and M. Molinari, "Sex-related differences of rehabilitation outcomes of spinal cord lesion pa-tients," Clin. Rehabil., vol. 18, no. 6, pp. 709–713, 2004.
19. J. C. Furlan, A. V. Krassioukov, and M. G. Fehlings, "The effects of gender on clinical and neurological outcomes after acute cervical spinal cord injury," J. Neurotrauma, vol. 22, no. 3, pp. 368–381, 2005.
20. M. Vural, E. Y. Yalcinkaya, E. C. Celik, B. Gunduz, A. Bozan, and B. Erhan, "Assessment of quality of life in relation to spasticity severity and socio-demographic and clinical factors among patients with spinal cord injury," J. Spinal Cord Med., vol. 43, no. 2, pp. 193–200, 2020.
21. C. Sköld, R. Levi, and Å. Seiger, "Spasticity after traumatic spinal cord injury: nature, severity, and location," Arch. Phys. Med. Rehabil., vol. 80, no. 12, pp. 1548–1557, 1999.
22. N. Murillo et al., "Decrease of spasticity with muscle vibration in patients with spinal cord injury," Clin. Neurophysiol., vol. 122, no. 6, pp. 1183–1189, 2011.
23. K. Sievert et al., "Early sacral neuromodulation prevents urinary incontinence after complete spinal cord injury," Ann. Neurol., vol. 67, no. 1, pp. 74–84, 2010.