

# Comparative analysis between identified injuries of victims of fall from height and other mechanisms of closed trauma

## *Análise comparativa entre as lesões identificadas em vítimas de queda de altura e de outros mecanismos de trauma fechado*

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### A B S T R A C T

**Objective:** To analyze the lesions diagnosed in victims of falls, comparing them with those diagnosed in other mechanisms of blunt trauma. **Methods:** We conducted a retrospective study of trauma protocol charts (prospectively collected) from 2008 to 2010, including victims of trauma over 13 years of age admitted to the emergency room. The severity of injuries was stratified by the Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS). Variables were compared between the group of victims of falls from height (Group 1) and the other victims of blunt trauma (Group 2). We used the Student t, chi-square and Fisher tests for comparison between groups, considering the value of  $p < 0.05$  as significant. **Results:** The series comprised 4,532 cases of blunt trauma, of which 555 (12.2%) were victims of falls from height. Severe lesions (AIS $\geq$ 3) were observed in the extremities (17.5%), in the cephalic segment (8.4%), chest (5.5%) and the abdomen (2.9%). Victims of Group 1 had significantly higher mean age, AIS in extremities / pelvis, AIS in the thoracic segment and ISS ( $p < 0.05$ ). The group 1 had significantly ( $p < 0.05$ ) higher incidence of tracheal intubation on admission, pneumothorax, hemothorax, rib fractures, chest drainage, spinal trauma, pelvic fractures, complex pelvic fractures and fractures to the upper limbs. **Conclusion:** Victims of fall from height had greater anatomic injury severity, greater frequency and severity of lesions in the thoracic segment and extremities.

**Key words:** Accidents. External Causes. Wounds and Injuries. Bone Fractures. Multiple Trauma.

### INTRODUCTION

Trauma is a major public health problem in all countries, regardless of socio-economic development. It corresponds to the third cause of death worldwide, being responsible for most deaths when considering only victims aged up to 40 years<sup>1</sup>. The social and economic impacts that trauma has are immeasurable<sup>1</sup>, thus its continued study and understanding allow not only the application of effective preventive measures, but also the rational use of resources.

In big cities, blunt trauma has become increasingly common, primarily due to traffic accidents and interpersonal violence. Some studies have noted the importance of falls as a mechanism of trauma, both due to its frequency and its severity<sup>2,3</sup>. Among its most important prognostic factors, there is the height of the fall<sup>2-4</sup>, the larger it is, the more frequent and severe are the injuries found. It is therefore valid to differentiate between two main groups of victims of falls: the ones falling from the same level and the ones falling from higher. There are

many studies on victims of falling from the standing height, mainly because it is the most common mechanism of injury in the elderly<sup>3</sup>. In these cases, the lesions on the extremities are the most frequently observed, but there is a considerable percentage of severe injuries to the cephalic segment.

The fall from height is a mechanism that can cause a wide variety of lesions, associated both with the direct impact on the surface and with the deceleration<sup>4,5</sup>. They are more common in young men, keeping close relationship with suicide attempts<sup>6-8</sup>. In such cases, falls from greater heights and higher rates of mortality are usually involved<sup>9</sup>. Other factors related to high mortality rates are height and the landing site, besides the combination of cephalic, thoracic and/or abdominal lesions<sup>10</sup>. It is believed that the height over which the lesions become significantly more severe is at least five stores, or 16 meters<sup>11</sup>. However, severe injuries are also found in falls from shorter heights. In suicide attempts, there are more frequently found fractures of the lumbar spine, pelvis and lower limbs. Accidental falls, on their turn, display a higher number of liver lacerations and multiple organ failure<sup>12</sup>.

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We did not find a study comparing the severity of the lesions found among victims of fall from height and other mechanisms of blunt trauma in the literature. The aim of this study was to analyze the lesions diagnosed in victims of falls, as well as its severity, comparing them with the ones diagnosed in victims of other mechanisms of trauma.

## METHODS

This study was approved by the Ethics in Research Committee of the Brotherhood of the São Paulo Holy Home (number 550,427 of 02/26/2014).

At the Emergency Department Irmandade da Santa Casa de Misericórdia de São Paulo. (ISCMSP), we prospectively collected data of all admitted trauma patients from 2008 to 2010 in order to form a trauma registry for quality control service. The data were initially collected by Surgery residents at admission of the patient and, subsequently, by the service assisting physicians during hospital stay until discharge.

We conducted a retrospective analysis of the information contained in this record of trauma, including data from blunt trauma victims over the age of 13 years. We excluded records in which the trauma mechanism was not described and in which the information was not accurate.

We collected information about the mechanism of injury, vital signs at admission, complementary exams, lesions diagnosed as well as their severity, and treatment. We considered for analysis all variables recorded in over 90% of the charts. The stratification of lesions' severity was performed by the trauma indices Abbreviated Injury Scale (AIS), published by the Association for the Advancement of Automotive Medicine 13, and Injury Severity Score (ISS). To each organ correspond lesions grouped in increasing severity, ranging from 1 to 6. AIS = 1 injuries are defined as "minor"; AIS = 2, as "moderate"; AIS = 3 "severe"; AIS = 4, as "very severe"; AIS = 5, as "critical"; and AIS = 6 are lethal. The ISS is an anatomical index based on the AIS organic lesions scale 14. Lesions are grouped into six segments: head and neck; face; chest; abdomen; extremities and bony pelvis; and external. The most severe injury of the three most severely affected segments is selected, the sum of their squares being the ISS score.

In this study, we considered "severe" injuries the ones with AIS  $\geq$  3 in the different body segments. We used the classification of Key and Conwell modified by Kane (KCK) 15 to stratify the severity of pelvis fractures. In this classification, type I fractures are those that do not compromise the pelvic ring, the type II compromise the pelvic ring at one point, and the type III, in more than one point. We consider complex the type III pelvic fractures.

Victims of blunt trauma were separated into two groups: Group 1 - victims of falls, and Group 2 - victims of other mechanisms of blunt trauma, including: motor vehicle-pedestrian collisions, motorcyclists, falls from standing height, occupants of four-wheeled vehicles, assaults and other unclassified blunt trauma mechanisms.

Variables were compared between the two groups, identifying the specific characteristics of victims of falls from height. We used the chi-square tests for evaluation of qualitative variables. For the analysis of numerical variables, we used Student's t test and, when necessary, the Fisher's exact test. We considered  $p < 0.05$  as significant.

## RESULTS

We included 4,532 victims of blunt trauma, of which 76.2% were male, aged 14-99 years (mean  $39.2 \pm 17.6$ ). For this sample, the mean systolic blood pressure, Glasgow Coma Scale, and ISS assessed at admission were, respectively,  $128.4 \pm 22.6$  mmHg,  $14.2 \pm 2.1$  and  $5.0 \pm 8.1$ . The most common mechanisms of injury were accidents involving motorcyclists (24.1%), followed by motor vehicle-pedestrian collisions (22.2%), falls from the standing height (17.5%), falls from height (12.2%), assaults (11.2%), accidents involving occupants of four-wheel vehicles (9.2%) and other mechanisms of blunt trauma (3.7%).

There were 555 (12.2%) victims of falls from height, which formed the Group 1. The most frequently injured segments were extremities / pelvic bone, followed by injuries to the head, thorax and abdomen (Table 1). Severe injuries had the same distribution, being present in the extremities / pelvic bone in 17.5% of cases, in the head in 8.4%, 5.5% in the thorax and 2.9% in the abdomen.

In the comparison of quantitative variables between the groups, there was no significant difference between the mean vital signs (systolic blood pressure, heart rate, respiratory rate) and Glasgow Coma Scale measured at admission. The group of victims of falls had mean age significantly higher. Regarding the severity of injury, the AIS of head and abdominal segments were similar between the two groups. The mean chest AIS, AIS of the extremities / pelvis and ISS were higher in victims of falls ( $p < 0.05$ ) (Table 2).

Compared with group 2, victims of falls had a significantly ( $p < 0.05$ ) higher frequency of intubation and drainage of the chest on admission, chest drainage during hospital stay, higher incidence of spinal cord trauma, pneumothorax, hemothorax, rib fractures, pelvic fractures, upper limbs closed fractures and upper limb open fractures. The frequency of KCK type-III fractures of the pelvis was significantly higher in victims of falls (1.6% vs. 0.3%). Also statistically significant, victims of falls from height showed a lower frequency of open fractures of the lower limbs (Table 3).

**Table 1 -** Frequency of lesions diagnosed in victims of falls from height, divided according to the severity and body segment (AIS).

AIS Segment	1	2	3	4	5	Total
Head	25.4%	3.2%	3.2%	2.5%	2.7%	37.1%
Thorax	1.1%	2.3%	3.8%	1.3%	0.4%	8.8%
Abdomen	0.9%	0.9%	1.3%	0.9%	0.7%	4.7%
Extremities/pelvic bone	31.0%	11.2%	9.7%	4.7%	3.1%	59.6%

There was no significant difference between groups regarding the frequency of extradural hematoma, subdural hematoma, subarachnoid hemorrhage, brain contusion, facial fractures, flail chest, pulmonary contusion, diaphragmatic, liver, spleen, kidney and bladder injuries, and closed lower limb fractures. Victims of falls had a significantly higher frequency of severe injuries (AIS e" 3) in the chest and extremities. Severe injuries to the head and abdominal segments were also more frequent in the group of falls from height, though without statistical significance (Table 3).

## DISCUSSION

In victims of falls from height, the exchange of energy between the body and the soil determines injuries in variable frequency and severity. There are several factors involved, such as the height of the fall and the way the body hits the ground, the characteristics of impact and velocity of falling<sup>16,17</sup>. The use of alcohol or psychoactive substances, although increasing the risk of falls, does not usually correspond to injury severity<sup>18,19</sup>. In our study, we

observed that fall was the mechanism of injury in 12.2% of trauma victims. Mild injuries in extremities and head segments were the most frequently observed, but it is emphasized that severe injuries were diagnostic in a significant number of cases. In 2012 Gulati et al.<sup>20</sup> observed a high incidence of orthopedic injuries related to this trauma mechanism, mainly to limbs.

In our series, several lesions were significantly more frequent in victims of falls from height, among them the spinal trauma and fractures of the pelvis. There was also a higher frequency of upper limb fractures, pneumothorax, hemothorax and rib fractures. We observed that the incidence of traumatic brain injury (TBI) was comparable to that observed in other trauma mechanisms. The incidence of TBI in victims of falls from height is variable and considered high in some studies and low in others<sup>21-23</sup>. Nevertheless, it is believed that TBI is the most frequent cause of death in victims of falls from heights, especially above three meters, in association with severe chest injuries<sup>24,25</sup>.

Some differences among victims of fall from height and other trauma mechanisms were sharp. The comparison of average rates of trauma among groups

**Table 2 -** Comparison of mean  $\pm$  standard deviation of quantitative variables between groups. (Group 1: victims of falls from height; Group 2: victims of other mechanisms of blunt trauma).

	Group 1 N=555	Group 2 N=3977	p
Age	41.25 $\pm$ 17.54 anos	38.90 $\pm$ 17.64 anos	0.007
SBP at admission	129.28 $\pm$ 26.12 mmHg	128.29 $\pm$ 22.09 mmHg	0.342
HR at admission	83.47 $\pm$ 14.64 bpm	82.93 $\pm$ 13.77 bpm	0.405
RR at admission	17.40 $\pm$ 4.74 ipm	17.43 $\pm$ 4.17 ipm	0.882
GCS at admission	14.13 $\pm$ 2.40	14.28 $\pm$ 2.06	0.112
Sat Hb at admission	96.14 $\pm$ 3.71	96.02 $\pm$ 3.77	0.638
AIS head	0.65 $\pm$ 1.15	0.66 $\pm$ 1.07	0.761
AIS neck	0.01 $\pm$ 0.17	0.009 $\pm$ 0.1	0.904
AIS thorax	0.23 $\pm$ 0.82	0.13 $\pm$ 0.63	0.001
AIS abdomen	0.13 $\pm$ 0.68	0.10 $\pm$ 0.60	0.292
AIS extremities	1.16 $\pm$ 1.33	0.99 $\pm$ 1.17	0.002
ISS	6.18 $\pm$ 9.61	4.80 $\pm$ 7.9	<0.001

SBP: systolic blood pressure, mmHg: millimeters of mercury, HR: heart rate, bpm: beats per minute, RR: respiratory rate, ipm: respiratory incursions per minute, Sat Hb: hemoglobin saturation (by pulse oximetry), AIS: Abbreviated Injury Scale, ISS: Injury Severity Score.

**Table 3** - Comparison of the frequencies of qualitative variables between groups. (Group 1: victims of falls from height; Group 2: victims of other mechanisms of blunt trauma).

	Group 1 N=555	Group 2 N=3977	p
Male gender	77.6%	76.0%	0.411
Alcohol breath at admission	8.1%	9.0%	0.500
OTI* at admission	5.0%	3.1%	0.018
Chest Drainage at admission	2.7%	1.5%	0.039
Epidural Hematoma	2.5%	1.5%	0.069
Subdural Hematoma	2.3%	1.6%	0.193
Cerebral Contusion	4.1%	2.7%	0.060
Face Fracture	3.2%	4.7%	0.127
Spinal Trauma	4.1%	0.8%	< 0.001
Hemothorax	3.1%	1.6%	0.011
Pneumothorax	3.6%	1.5%	0.001
Rib Fractures	5.2%	3.0%	0.006
Pulmonary Contusion	2.7%	1.7%	0.082
Chest Drainage	3.6%	2.1%	0.028
Fracture of Pelvis	4.1%	1.4%	<0.001
Upper Limb Fracture	6.8%	4.9%	0.049
Lower Limb Fracture	5.9%	5.4%	0.619
Open Upper Limb Fracture	2.3%	0.9%	0.001
Open Lower Limb Fracture	1.4%	3.3%	0.019
Death	2.7%	2.0%	0.289
ALS+ cephalic > 3	8.4%	7.7%	0.761
ALS+ thorax > 3	5.5%	3%	0.001
ALS+ abdomen > 3	2.9%	2.3%	0.292
ALS+ extremities > 3	17.5%	13.3%	0.002

OTI: orotracheal intubation. ALS: Abbreviated Injury Scale.

showed greater severity in the extremities and chest injuries in victims of falls from height. Another important point is the observation that the ISS was significantly higher in victims of falls from height when compared to other mechanisms of trauma. This means that, taking into account all body segments, falls from height represent a mechanism of injury with greater anatomical damage.

The severity of the victims of falls from height can also be inferred by the higher frequency of spinal cord injuries, complex fractures of the pelvis and long bones. Fractures of the pelvis are considered markers of severe trauma and large energy dissipation<sup>26,27</sup>. When present, about 90% have associated injuries and mortality is significantly higher<sup>26</sup>. This should draw the attention of the emergency doctor in the first contact with the patient, so that the measures for the rapid diagnosis and prompt treatment are taken. Another factor associated with severity in these individuals was the highest frequency of tracheal intubation on admission when compared with other mechanisms of blunt trauma.

The results from this study are important for the physician responsible for the initial treatment of these cases, both at the scene and in the hospital. The recognition of specific features in victims of falls from height can assist

in screening these patients, as well as in transfer, indication of diagnostic tests and monitoring. It is important to understand that trauma victims with life-threatening injuries often have no major clinical signs and may go unnoticed at an initial examination. We must always consider the "dynamic" feature in the evolution of traumatic injuries as well as their multiplicity and association. Initially stable patients and considered "low risk" can evolve in a short time to the imminent risk of death. The time lost in this "delayed diagnosis" has a significant impact on prognosis and may be responsible for severe complications and even death of the patient. Thus, methods for rapid and effective recognition of trauma victims with potentially severe injuries, even before the first clinical manifestations, become of utmost importance.

Understanding the severity of the trauma mechanism involved in falls from height is extremely important. There is real potential for severe and lethal lesions, as demonstrated in this study. Even in patients with few symptoms, this mechanism of trauma draws attention to the need for rapid clinical evaluation and prompt performance of diagnostic tests. This would certainly reduce the time to diagnosis and treatment, providing the best results and prognosis.

In conclusion, victims of fall from height have greater anatomic injury severity, greater frequency and severity of lesions in the thoracic segment and extremities /

pelvic bone, and greater frequency of spinal cord trauma when compared with victims of other mechanisms of trauma.

## R E S U M O

**Objetivo:** analisar as lesões diagnosticadas nas vítimas de queda de altura, comparando-as com as diagnosticadas em outros mecanismos de trauma fechado. **Métodos:** estudo retrospectivo dos protocolos de trauma (coletados prospectivamente) de 2008 a 2010, incluindo as vítimas de trauma fechado com idade superior a 13 anos, admitidas na sala de emergência. A gravidade das lesões foi estratificada pelo Abbreviated Injury Scale (AIS) e Injury Severity Score (ISS). As variáveis foram comparadas entre o grupo de vítimas de quedas de altura (Grupo 1) e as demais vítimas de trauma fechado (Grupo 2). Empregamos os testes t de Student, qui-quadrado e Fisher para a comparação entre os grupos, considerando o valor de  $p < 0,05$  como significativo. **Resultados:** foram analisados 4532 casos de trauma fechado, sendo que 555 (12,2%) foram vítimas de quedas de altura. As lesões graves (AIS<sup>3</sup>) foram observadas em extremidades (17,5%), em segmento cefálico (8,4%), torácico (5,5%) e em abdome (2,9%). As vítimas do grupo 1 apresentaram, significativamente ( $p < 0,05$ ), maior média etária, de AIS em extremidades/pelve, de AIS em segmento torácico e de ISS. O grupo 1 também apresentou, significativamente ( $p < 0,05$ ), maior frequência de intubação orotraqueal na admissão, pneumotórax, hemotórax, fraturas de costelas, drenagem de tórax, trauma raquimedular, fraturas de pelve, fraturas complexas de pelve e de fraturas em membros superiores. **Conclusão:** As vítimas de queda de altura apresentaram maior gravidade anatômica do trauma, maior frequência e gravidade de lesões em segmento torácico e em extremidades.

**Descritores:** Acidentes. Causas Externas. Ferimentos e Lesões. Fraturas Ósseas. Traumatismo Múltiplo.

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