Predictors of abdominal injuries in blunt trauma

Fatores preditivos de lesões abdominais em vítimas de trauma fechado

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A B S T R A C T

Objective: To identify predictors of abdominal injuries in victims of blunt trauma. **Method:** retrospective analysis of trauma protocols (collected prospectively) of adult victims of blunt trauma in a period of 15 months. Variables were compared between patients with abdominal injuries detected by computed tomography or/and laparotomy (Abbreviated Injury Scale abdome>0 - group I) and others (Abbreviated Injury Scale abdome= 0, group II). **Results:** A total of 3783 cases were included, with a mean age of 39.1 ± 17.7 years (14-99), 76.1% being male. Abdominal injuries were detected in 130 patients (3.4%). Patients sustaining abdominal injuries had significantly lower mean age (35.4 + 15.4 vs. 39.2 + 17.7), lower mean systolic blood pressure on admission (114.7 + 32.4 mmHg vs. 129.1 + 21.7 mmHg), lower mean Glasgow coma scale (12.9 + 3.9 vs. 14.3 + 2.0), as well as higher head AIS (0.95 + 1.5 vs. 0.67 + 1.1), higher thorax AIS (1.10 + 1.5 vs. 0.11 + 0.6) and higher extremities AIS (1.70 ± 1.8 vs. 1.03 ± 1.2). Patients sustaining abdominal injuries also presented higher frequency of severe injuries (AIS>3) in head (18.5% vs. 7.9%), thorax (29.2% vs. 2.4%) and extremities (40.0% vs. 13.7%). The highest odds ratios for the diagnosis of abdominal injuries were associated flail chest (21.8) and pelvic fractures (21.0). **Conclusion:** Abdominal injuries were more frequently observed in patients with hemodynamic instability, changes in Glasgow coma scale and severe lesions to the head, chest and extremities.

Key words: Patients. Diagnosis. Wounds and injuries. Blunt injuries. Abdominal injuries.

INTRODUCTION

In large cities, the most common mechanisms of blunt trauma include automobile accidents, pedestrian accidents and falls. The large energy dissipation may result in multiple injuries in different body segments and, among these, the abdomen presents some peculiarities. The liver and spleen are the organs most frequently injured. However, it is known that up to 40% of hemoperitoneums do not determine significant signs or symptoms at initial assessment. These false diagnoses result in deaths considered "preventable", as they would not occur if the lesions had been initially recognized [1].

There are several situations that complicate the diagnosis of abdominal injuries. Physical examination may be unreliable due to the presence of multiple trauma or change in the level of consciousness. The parameters of the clinical examination may be masked in patients with exogenous intoxication [2]. Thus, one turns to complementary tests, such as ultrasound and computed tomography.

The Focused Assessment Sonography for Trauma (FAST) is the ultrasound performed in the emergency room in order to detect free intraperitoneal fluid and pericardial effusion in trauma victims. This diagnostic method has limitations, mainly related to the volume of hemoperitoneum present at the examination, besides being dependent on the examiner [3]. Even a complete ultrasound exam, in which there is detailed evaluation of abdominal organs, can be false negative [4].

Computed tomography is currently the most accurate examination for this situation [5,6]. However, it also has its downsides. There is need for intravenous administration of iodinated contrast and radiation exposure. Depending on the protocol used, it may not be cost-effective compared to simpler tests. In addition, there are known limitations in the diagnosis of pancreatic and intestinal lesions [7].

We know that there are clinical variables that correlate with the presence of abdominal injuries in victims of blunt trauma, which can be called "predictors". This becomes important in light of the possibility of life-threatening intra-abdominal injuries not manifesting clinical signs at the time of initial abdominal examination. The identification of these predictors could guide the physician

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as to the seriousness of the case and suggest a more detailed and directed diagnostic investigation. Additionally, one can determine a closer monitoring and influence the time of discharge.

The aim of our study is to identify predictors of abdominal injuries in victims of blunt trauma.

METHODS

In the Emergency Department of the Brotherhood of the Holy Home of São Paulo, we conducted a prospective data collection of all trauma patients admitted to the emergency room between 2008 and 2009. We collected data on identification, mechanism of injury, vital signs at admission, trauma indices, complementary exams, associated diseases, injuries diagnosed and treatment.

The evaluation protocol for abdominal imaging that is routinely used in our department uses the FAST, complete ultrasound (U.S.) and, selectively, computed tomography (CT), depending on the assessment of the risk of abdominal injury by the attending physician. In addition to the imaging investigation, we perform laboratory tests, such as leukocyte count, serum amylase and blood gas analysis for evaluation of possible abdominal injuries. Leukocytosis, increased amylase and metabolic acidosis may suggest lesions not identified by imaging methods.

This study was approved by the Ethics Committee on Human Research of the Brotherhood of the Holy Home of São Paulo under number 064/11. We conducted a retrospective analysis of protocols collected in the period from October, 10th 2008 and September, 1st 2009. We included all blunt trauma victims older than 13 years. The stratification of gravity of the sample was carried through the rates of trauma: Glasgow Coma Scale (GCS) [8], Revised Trauma Score (RTS) [9], Abbreviated Injury Scale (AIS) [10], Injury Severity Score (ISS) [11] and Trauma Score - Injury Severity Score (TRISS) [12]. Variables were compared between patients with abdominal injuries (AIS abdomen> 0, group I) diagnosed by computed tomography and/or laparotomy and the individuals without abdominal lesions (abdominal AIS = 0, group II) to identify predictors of such injuries. Injuries with AIS> 3 were considered severe. Patients with free intraperitoneal fluid and retroperitoneal hematomas, but no specific lesions in the viscera, were not considered as having abdominal injury and were included in group II.

For analysis, we considered only those variables about which information was present in more than 95% of charts. We used the chi-square or Fisher tests to evaluate categorical variables. Numerical variables are presented as mean ± standard deviation. We used the Student t test to compare means. We considered $p < 0.05$ as statistically significant. We also calculated the odds ratio when appropriate.

RESULTS

We included 3783 blunt trauma victims, whose ages ranged between 14 and 99 years (mean 39.1 ± 17.7) and 2879 (76.1%) were male. The mean RTS, ISS and TRISS calculated for the sample were, respectively, 7.72 ± 0.6, 5.13 ± 8.3 and 0.97 ± 0.1. The mechanisms of trauma were accidents involving motorcyclists in 924 (24.4%), pedestrian accidents in 855 (22.6%), falls from own height in 644 (17.0%), falls from higher heights in 455 (12, 0%), assaults in 424 (11.2%), motor vehicle accidents in 337 (8.9%). The remaining 144 (3.9%) had associated trauma mechanisms, or did not fit the above groups.

The lesions found in the extremities were observed in 2233 (59.0%) patients, the cephalic segment in 1566 (41.4%), the thoracic in 216 (5.7%) and the abdominal segment in 130 (3.4%). In group I the most frequent abdominal injuries were of the liver, identified in 42 (32.3%) patients and the spleen, also in 42 (32.3%) (Table 1). The lesions of the stomach, small intestine and colon affected a total of 12 patients, corresponding to 0.3% of the total sample and 9.1% of group I. Severe abdominal injuries (AIS> 3) were identified in 84 patients, corresponding to 2.2% of the total sample and 64.6% of patients in group I.

We found that 3424 patients had normal abdominal examination at admission. Of these, 54 (1.6%) had some abdominal injury. From the 359 victims who had an altered abdominal examination, 76 (21.2%) had abdominal injury. When we analyzed only patients with abdominal injuries, we found that 54 (41.5%) had normal abdominal physical examination on admission. Only six patients had frank signs of peritonitis on physical examination and all these had abdominal injuries.

The comparison of numerical variables between the groups revealed that patients with abdominal injuries (group I) were characterized for having significantly ($p < 0.05$) lower mean age (35.4 years ± 15.4 vs. 39.2 ± 17.7), lower mean systolic blood pressure (SBP) on admission (114.7 mmHg ± 32.4 vs. 129.1 ± 21.7), higher mean heart rate on admission (91.6 ± 16.2 bpm vs. 82.6 ± 13.4 bpm), lower mean Glasgow Coma Scale on admission (12.9 ± 3.9 vs. 14.3 ± 2.0), higher mean AIS for segments head (0.95 ± 1.5 vs. 0.67 ± 1.1), thorax (1.10 ± 1.5 vs. 0.11 ± 0.6) and extremities (1.70 ± 1.8 vs. 1.03 ± 1.2) (Table 2). Patients in group I presented significantly ($p < 0.05$) lower mean RTS (7.37 ± 1.3 vs. 7.73 ± 0.5) and TRISS (0.86 ± 0.2 vs. 0.98 ± 0.1), as well as higher average ISS (22.6 ± 15.9 vs. 4.5 ± 7.1) when compared to group II.

We noted that there was a significant difference when comparing the frequency of trauma mechanisms between the groups ($p < 0.001$). The frequency of pedestrian accidents was higher (33.8% vs. 22.2%), and the falls from own height, lower (1.5% vs. 17.6%) in the group of patients with abdominal injuries.

In the comparison of nominal variables between groups, we observed that the group with abdominal injuries

Table 1 - Abdominal injuries identified by laparotomy and/or computerized tomography in victims of blunt trauma.

Injured organ	Number	Percentage of the patients with abdominal injury
Spleen	42	32.3%
Liver	42	32.3%
Kidney	18	13.8%
Small Intestine	8	6.1%
Mesentery	8	6.1%
Bladder/urethra	5	3.8%
Colon	3	2.3%
Pancreas	1	0.7%
Great vessels	3	2.3%
Stomach	1	0.7%
Ureter	1	0.7%
Diaphragm	2	1.5%

had a significantly higher frequency of abnormal abdominal examination (58.5% vs. 7.7%), GCS <8 at admission (14.6% vs. 6.4%), SBP <100 mmHg at admission (16.9% vs. 1.8%), chest drainage on admission (13.8% vs. 1.3%), severe injury to the cephalic segment (AIS > 3) (18.5% vs. 7.9%), spinal cord injury (6.2% vs. 1.0%), hemothorax (17.7% vs. 1.1%), pneumothorax (13.8 % vs. 1.4%), rib fractures (26.9% vs. 2.6%), flail chest (13.1% vs. 0.7%), pulmonary contusion (18.5% vs. 1 2%), subcutaneous emphysema (4.6% vs. 0.5%), severe injury to the thoracic segment (29.2% vs. 2.4%), fractures of the upper limbs (16.9% vs. 4.8%), fractures of the lower limbs (14.6% vs. 5.5%), open fractures of the upper limbs (4.6% vs. 1.0%), open fractures of the lower limbs (7.7 % vs. 3.0%), pelvic fractures (37.7% vs. 2.8%) and serious injuries (AIS> 3) in the extremities (40.0% vs. 13.7%) (Table 3). The highest odds ratios for diagnosis of abdominal injuries were the presence of flail chest (21.8) and pelvic fracture (21.0) (Table 3).

In group I, 39 laparotomies were performed, with 29 treatments. Sixty patients had nonoperative treatment of lesions in the liver, spleen and/or kidneys, ten arteriographies with embolization having been required in this group. Mortality was significantly higher in group I (12.3% vs. 1.9%, p <0.001). No complications were identified by the delayed diagnosis of abdominal injuries.

DISCUSSION

VNo one knows for sure the percentage of patients with abdominal injuries secondary to blunt trauma. In studies with larger samples, such as the one from Mackersie *et al.* [13], about 3% of victims of blunt trauma had some abdominal injury. In multiple trauma victims admitted with mild traumatic brain injury, their frequency increases to 10% [14]. Studying only patients sustaining "high energy" trauma, Deunk *et al.* [7] found approximately 30% of abdominal injuries. In cases of trauma victims with fractures of the pelvis, the incidence of associated abdominal injuries can achieve 40% [15].

The sample of this study has values of RTS, ISS and TRISS suggesting low-energy trauma. The frequency

Table 2 - Characteristics of the numerical variables between groups I e II. Data presented as average + standard deviation.

	Group I N=130	Group II N=3653	p
Age (years)	35.4 + 15.4	39.2 + 17.7	0.018
SBP on admission (mmHg)	114.7 + 32.4	129.1 + 21.7	<0.001
Heart rate (bpm)	91.6 + 16.2	82.6 + 13.4	<0.001
Glasgow Coma Scale	12.9 + 3.9	14.3 + 2.0	<0.001
AIS head	0.95 + 1.5	0.67 + 1.1	0.041
AIS thorax	1.10 + 1.5	0.11 + 0.6	<0.001
AIS extremities	1.70 ± 1.8	1.03 ± 1.2	<0.001
ISS	22.6 + 15.9	4.5 + 7.1	<0.001
RTS	7.37 + 1.3	7.73 + 0.5	0.003
TRISS	0.86 + 0.2	0.98 + 0.1	0.001

SBP: Systolic Blood Pressure; mmHg: millimeters of mercury. Bpm: beatings per minute. AIS: Abbreviated Injury Scale. RTS: Revised trauma score. ISS: Injury Severity Score. *TRISS: calculation of the survival probability.*

Table 3 - Distribution of the nominal variables between groups I e II according to gender. exams' results and type of injury.

	Group I N=130 (%)	Group II N=3653 (%)	*Odds ratio*	*P*
Male gender	78.5	76.2	-	0.560
Abnormal abdominal physical examination	58.5	7.7	16.7	<0.001
GCS < 8 on admission	14.6	3.4	4.9	<0.001
SBP < 100 mmHg on admission	16.9	1.8	11.3	<0.001
Orotraqueal Intubation on admission	18.5	3.0	7.4	<0.001
Chest tube on admission	13.8	1.3	12.6	<0.001
Severe injury cefaic segment (AIS > 3)	18.5	7.9	2.7	<0.001
Spinal cord injury	6.2	1.0	6.2	<0.001
Hemothorax	17.7	1.1	19.4	<0.001
Pneumothorax	13.8	1.4	11.6	<0.001
Rib fracture	26.9	2.6	13.6	<0.001
Flail chest	13.1	0.7	21.8	<0.001
Pulmonary contusion	18.5	1.2	19.0	<0.001
Subcutaneous Emphysema	4.6	0.5	10.3	<0.001
Fracture to upper limb	16.9	4.8	4.0	<0.001
Fracture to lower limb	14.6	5.5	2.9	<0.001
Open fracture to upper limb	4.6	1.0	4.8	<0.001
Open fracture to lower limb	7.7	3.0	2.6	0.003
Pelvis fracture	37.7	2.8	21.0	<0.001
AIS > 3 in extremities	40.0	13.7	4.2	<0.001

SBP: systolic blood pressure. mmHg: millimeters of mercury. GCS: Glasgow Coma Scale. AIS: Abbreviated Injury Scale. RTS: Revised trauma score. ISS: Injury Severity Score. *TRISS: calculation of the survival probability.*

of abdominal injuries was 3.4%. Severe lesions were present in 2.2% and bowel injuries in 0.3%. We believe that this low incidence renders the diagnosis of abdominal injuries even more difficult.

It is also known that a normal physical examination does not rule out the possibility of abdominal injury. Both clinical history and physical examination and laboratory tests may show false negative results. In 2010, Michetti *et al.* [2] found that 10% of victims of blunt trauma with normal physical examination on admission had abdominal injuries confirmed by imaging (computed tomography). In our study, we observed that from patients with normal abdominal examination, only 1.6% had abdominal injuries, but 41.5% of patients with some abdominal injury had no change in abdominal examination. Therefore, additional tests should be employed to identify these potential injuries.

The FAST and full abdominal ultrasound, methods routinely used for the evaluation of blunt abdominal trauma victims, have the problem false negativity [3,16-24]. Although there are groups that indicate the routine performance of computed tomography in blunt trauma victims, we know that there are limitations of its use. It requires the administration of intravenous and oral contrast material, resulting in anaphylactic reactions at a ratio of 1:1000. There is exposure to a dose of radiation, which can be associated with the onset of long-term neoplasia [25]. The risk of transfer should be considered. Depending on the distance between the emergency room and the CT scanner, the patient must be hemodynamically normal for its performance. Another limitation is the availability of this test, which is not regular. Tomography of the abdomen may also show false negative results, especially in lesions of the pancreas, retroperitoneal duodenum and jejunum/ ileum [26,27]. It is also known that the trauma care consumes an important part of the health system's budget [28]. This should also be considered in the systematic indication of computerized tomography in a sample of patients with low-energy trauma, in which the positivity of the test could hardly be more than 5%.

There is need to select patients at higher risk of injury to be submitted to computed tomography. It is with this objective that the idea to study variables that may be significantly associated with presence of abdominal injuries arises. These predictive factors can alert to a higher risk, allowing prioritization and targeting of diagnostic investigation.

In 1989, Mackersie *et al.* [13] studied the "indirect" signs related to the presence of abdominal injuries in patients who suffered blunt trauma. These authors noted that the presence of base excess lower than -5mEq/L of arterial blood gases, arterial hypotension on admission or at the trauma scene, injuries to the chest and pelvic fractures were significantly associated with the presence of abdominal injuries.

In 2010, Deunk *et al.* [7] proposed a selective indication for CT based on clinical, radiological, laboratory and ultrasound findings. In a study involving 1,040 victims of high-energy trauma, they identified nine independent factors significantly associated with the presence of abdominal injuries: changes in plain chest, spine or pelvis radiography, positive FAST, positive abdominal examination, changes in the physical examination of the spine, base excess less than -3mEq/L in arterial blood gas, systolic blood pressure less than 90mmHg and the presence of fractures in long bones. Based on these data, CT is indicated in hemodynamically stable patients who concurrently presented: signs of neurological impairment (Glasgow Coma Scale less than 8, anisocoria, skull fracture), abnormal abdominal physical examination, pelvic, lumbar spine or extremities fractures, base excess less than -3mEq/L on arterial blood gases, abnormalities on chest, pelvis or spine radiography, or positive FAST [7].

There is particular concern with the traumatized group with decreased level of consciousness, especially those with severe traumatic brain injury. Since there is no appropriate neurological level, the abdominal physical examination becomes impaired and serious injuries may go unnoticed, even in computerized tomography. The lesions most feared are those that occur in hollow viscera, because late diagnosis can have serious consequences [29]. Precisely in this group, the diagnosis by computed tomography is more difficult, which is a very dangerous combination.

Other studies have evaluated the presence of predictors of abdominal injuries in victims of blunt trauma. In 2004, Beck *et al.* [30] found a significant relationship between abdominal injuries and abnormal radiographs of the pelvis and the need for endotracheal intubation. The data found in our sample clearly show the association of abdominal lesions with a few variables: hemodynamic instability on admission, decreased level of consciousness on admission, increased severity of lesions in segments head, chest and extremities, as well as fractures of the pelvis and of long bones (Table 3). Many of these data are consistent with the studies cited above [7,13,30]. Interestingly, the presence of pelvic fracture is the single factor that appears most often as a predictor of abdominal injuries. In the study of Deunk *et al.*[7,] in 2010, the odds ratio for the presence of abdominal injury in patients with pelvic fractures was 46.8. In our study, the chance of a trauma patient with a fractured pelvis present an abdominal injury is 21 times higher when compared with patients without this type of fracture.

The association between chest and abdominal injuries is also already known [13]. In our sample, the highest odds ratio for the presence of abdominal lesions was observed in association with flail chest (OR = 21.8), a marker of severe chest trauma. Our data also confirmed the increased chance of injury in abdominal trauma with fractures of long bones and spine. However, we consider important to note that in our study the incidence of abdominal injuries was also higher in the presence of severe lesions of the cephalic segment and in patients with a decrease Glasgow Coma Scale. Clearly, for a proper diagnosis, patient should be viewed as a whole, as the signals from abdominal lesions can also be found in other body parts. Data from this study show a higher frequency of abdominal injuries in victims of pedestrian accidents, whereas for victims of falls from own height the incidence was lower.

Finally, we would draw attention to the sum of factors that complicate the diagnosis in clinical practice: abdominal injuries are more common precisely in situations of higher risk of going unnoticed, such as when there is lower level of consciousness, severe head trauma, need for intubation, need for analgesics (flail chest) or even in the operative treatment of fractures of the extremities, when an anesthetic is necessary.

The purpose of our study was precisely to widely assess which variables could be associated with abdominal injuries. Certainly, the use of these data can provide useful information to identify lesions that initially could go unnoticed, contributing to decreased morbidity and mortality associated with late diagnosis of abdominal injuries in victims of blunt trauma.

Data from this study allow us to conclude that the predictors of abdominal injuries in victims of blunt trauma are: mechanism of injury, hemodynamic instability, altered level of consciousness and presence of severe lesions in the skull, chest or extremities, especially flail chest and pelvic fractures.

R E S U M O

Objetivo: *Identificar fatores preditivos de lesões abdominais em vítimas de trauma fechado.* ***Métodos:*** *Análise retrospectiva dos dados das vítimas de trauma fechado com idade superior a 13 anos, em um período de 15 meses. Comparamos as variáveis entre os doentes com lesões abdominais diagnosticadas por tomografia computadorizada e/ou laparotomia – grupo I (*Abbreviated Injury Scale *abdome>0, grupo I) e os demais – grupo II (*Abbreviated Injury Scale *abdome=0,).* ***Resultados:*** *Foram incluídos 3783 casos, com média etária de 39,1 +17,7 anos (14 a 99 anos), sendo 76,1% do sexo masculino. Foram identificadas lesões abdominais em 130 doentes (3,4%). Os traumatizados com lesões abdominais apresentaram, significativamente, menor média etária (35,4 + 15,4 anos vs. 39,2 + 17,7 anos), menor média da pressão arterial sistólica à admissão (114,7 + 32,4mmHg vs. 129,1 + 21,7mmHg), menor média na escala de coma de Glasgow à admissão (12,9 + 3,9 vs. 14,3 + 2,0), maior média de AIS em segmento cefálico (0,95 + 1,5 vs. 0,67 + 1,1), maior média de AIS em segmento torácico (1,10 + 1,5 vs. 0,11 + 0,6) e maior média de AIS em extremidades (1,70 ± 1,8 vs. 1,03 ± 1,2). Os maiores* Odds ratio *foram presença de tórax flácido (21,8) e fraturas de pelve (21,0).* ***Conclusão:*** *As lesões abdominais foram mais frequentemente observadas nos doentes com instabilidade hemodinâmica, alteração na escala de coma de Glasgow, lesões graves em crânio, tórax ou extremidades.*

Descritores: *Pacientes. Diagnóstico. Ferimentos e lesões. Ferimentos não penetrantes. Traumatismos abdominais.*

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