Identifying severe abdominal injuries during the initial assessment in blunt trauma patients

Identificação de lesões abdominais graves na avaliação inicial das vítimas de trauma fechado

Samires Farrath[1]; José Gustavo Parreira,TCBC-SP[2]; Camilla Bilac Olliari[3]; Mateus Almeida Silva[3]; Jacqueline Arantes Giannini Perlingeiro,TCBC-SP[2]; Silvia Cristine Soldá,TCBC-SP[2]; José Cesar Assef,TCBC-SP[4]

A B S T R A C T

Objective: To evaluate the predictive factors of severe abdominal injuries (SAI) identified in the initial assessment of blunt trauma victims. **Methods**: A retrospective analysis of data from blunt trauma victims older than 13 years undergoing abdominal computed tomography and/or laparotomy was carried out. Serious injuries were considered with an Abbreviated Injury Scale (AIS) greater than or equal to three. Variables were compared between both A (SAI) and B (no SAI). We conducted an initial univariate statistical analysis to identify the variables associated with the presence of SAI. From these we selected those that had p <0.20 and could be evaluated on admission of the patient for multivariate analysis (logistic regression). **Results**: The sample consisted of 331 cases and 140 (42.3%) patients had abdominal injuries. Of these, 101 (30.5%) had abdominal injury with AIS e" 3 (Group A). In univariate analysis, conditions significantly associated with the SAI (p <0.05): systolic blood pressure (SBP) in the pre-hospital setting (p = 0.019), SBP at admission (p <0.001), heart rate at admission (p = 0.047), altered physical examination of the abdomen (p <0.001) and the presence of pelvic fractures (p = 0.006). The following variables were significantly and independently correlated with the presence of severe abdominal injuries: SBP at admission (p = 0.034), altered abdominal physical examination (p <0.001), lower limb fracture (p <0.044), motorcycle accident as mechanism of injury (p = 0.017) and positive FAST (p <0.001). **Conclusion**: the variables present at baseline were significantly associated with the presence of SAI: SBP, physical examination, altered abdominal examination, presence of open fractures of the lower limb, motorcycle accident and positive FAST.

Key words: Abdomen. Wounds and injuries. Abdominal injuries. Trauma severity indices. Diagnosis.

INTRODUCTION

The increasing development of technology and increasing social inequality predispose to a higher incidence of accidents and interpersonal violence, the care for victims of trauma in our hospitals being increasingly frequent [1]. In large centers, the mechanisms of blunt trauma are the most observed, involving traffic accidents, falls and assaults [2]. Many of these victims have involvement of multiple body regions, which can hamper the diagnosis of existing lesions.

Abdominal injuries have been reported as the leading cause of preventable deaths in trauma victims [3]. This occurs because they may go unnoticed at an early time. Complications and deaths arising from this misdiagnosis could ultimately be avoided if there were early diagnosis and treatment. There are several factors involved in the diagnosis of abdominal injuries, such as decreased level of consciousness, the association of other "distracting" injuries or even surgical treatment of concomitant injuries. Previous studies have shown that a large percentage of patients with abdominal injuries display normal physical examination on admission [4-6].

Thus, the objective evaluation of the abdomen by imaging methods becomes necessary in a large number of patients. The Focused Assessment Sonography for Trauma (FAST) or even a complete ultrasound examination of the abdomen may be used for this purpose [6,7]. However, their accuracy is between 60% and 80%, not enough to rule out the presence of abdominal injuries. Their results may be compromised by factors such as small volume of intracavitary liquid, retroperitoneal lesions, gas interposition, obesity and being operator-dependent [7]. The most accurate test for the detection of abdominal injuries is computed tomography [6,8,9]. Nonetheless, there are questions as to the possibility of adverse reactions to iodinated contrast, the cumulative radiation dose and cost of performing this exam

without any specific criteria [6,8,9]. Some authors propose alternative methods to computerized tomography (CT) to guide therapy, trying to better select their use [10].

Clinical variables associated with the presence of abdominal injuries in adult victims of blunt trauma have been previously studied [5,10-12]. The analysis of these factors can direct and guide diagnostic research and monitoring. However, we found no references that relate these variables to the presence of severe abdominal injuries.

The aim of our study was to identify predictors of severe abdominal injuries in victims of blunt trauma, using clinical variables available on admission of the patient.

METHODS

This was a retrospective analysis of medical records and the trauma charts, completed prospectively, for all blunt trauma victims over the age of 13 years, admitted to the emergency room of the Central Emergency of SCSP, between June 2008 and December 2009.

Our protocol for objective evaluation of the abdomen in blunt trauma victims employs initial physical examination, imaging and laboratory. Imaging tests are FAST, complete abdominal ultrasound (U.S.) and CT, the latter being selectively requested and dependent on the assessment of risk of abdominal injury by the attending physician. WBC, serum amylase and blood gas analysis are also requested. Leukocytosis, hyperamylasemia and metabolic acidosis (base deficit greater than 6 mEq/L) suggest injuries that may not have been identified by imaging.

Data collected on identification were: mechanism of injury, prehospital information, vital signs on admission, trauma indexes, exams, related diseases, injuries diagnosed and treatment. The severity stratification of the sample was carried through the trauma indexes: Glasgow Coma Scale (GCS) [13], Revised Trauma Score (RTS) [14], Abbreviated Injury Scale (AIS) [15], Injury Severity Score (ISS) [16] and TRISS [17]. We considered severe abdominal injuries (SAI) the ones with AIS > 3.

For the analysis of predictors of severe abdominal injuries, we included only patients who underwent CT of the abdomen and / or laparotomy. Variables were compared between the following two groups: A – patients with serious abdominal injuries (AIS abdomen > 3), and B – patients without severe abdominal injuries (AIS abdomen <3).

Statistical analysis was performed with the collaboration of the Division of Statistics of the Department of Social Medicine, Faculty of Medical Sciences of Santa Casa de São Paulo. We used the chi-square test or Fisher for the analysis of qualitative variables. Quantitative variables were evaluated using the nonparametric Mann-Whitney test. We performed a univariate analysis, initially comparing groups A and B. In a second step, we carried

out a multivariate analysis using a Stepwise Forward logistic regression model. We selected for the logistic regression variables with p <0.20 in the univariate analysis that could be identified on admission of the patient to the emergency room. We considered p <0.05 as significant.

This study was approved by the Ethics in Research Committee of the Brotherhood of Santa Casa de São Paulo (SCSP) under number 064/11.

RESULTS

During the study period, 4,532 victims of blunt trauma were admitted to the emergency room. Of these, 331 underwent abdominal CT and/or laparotomy, forming the study group. The average age of this sample was 36.4 ± 15.9 years, 265 being males (80.1%). The mean ISS was 19.9 ± 14.3. The most common mechanisms of injury were trampling in 108 cases (32.6%), motorcycle accidents in 71 (21.5%) and fall from height 63 (19.0%).

On admission, the mean ± standard deviation of systolic blood pressure (SBP), heart rate (HR), respiratory rate (RR) and Glasgow Coma Scale (GCS) were, respectively, 118.9 ± 34.7 mmHg, 92 3 ± 20.6 bpm, 17.2 ± 8.7 and 12.6 ± 4.1 ipm.

Lesions to the head were diagnosed in 147 (44.4%) patients, being classified as severe in 92 (27.8%). Thoracic lesions were observed in 105 patients (31.7%), considered severe in 86 (26.0%) patients. Lesions on extremities were identified in 185 (55.9%) cases, of which 136 (41.1%) were severe.

The abdominal injuries were diagnosed in 140 (42.3%) patients presenting AIS e" 3 in 101 cases (30.5%) (Group A). The most often injured organs were the spleen (56 patients, 41 AIS > 3), liver (53 patients, 33 AIS > 3), and kidneys (22 patients, 18 AIS > 3). Fifty-four patients (16.3%) had fractures of the pelvis (Table 2).

Upon univariate analysis of predictors of severe abdominal injury, we observed that the following quantitative variables were significantly associated with the SAI (p <0.05): prehospital SBP (p = 0.019), SBP at admission (p <0.001) and AIS of cephalic segment (p = 0.015). Age (p = 0.064) and HR at admission (p = 0.061) had similar values, but did not reach statistical significance (Table 3). Qualitative variables associated with the presence of SAI were: altered physical examination of the abdomen (p <0.001), serious injury in head segment (p = 0.038) and the presence of pelvic fractures (p = 0.006) (Table 4).

We selected the following variables for logistic regression analysis: age, SBP at admission, heart rate at admission, EKG, motorcycle accident as the mechanism of injury, physical assault as a mechanism of injury, gender, altered physical examination of the head, altered physical examination of the chest, altered physical examination of

Table 1 - Mechanisms of trauma in the 331 cases included in the study sample.

Mechanism of trauma	n	%
Pedestriam Trampling	108	32.6
Motorcycle accident	71	21.5
Fall from height	63	19.0
Automobile accident	41	12.4
Physical assault	36	10.9
Fall from the standing height	5	1.5
Other	7	2.1

Table 2 - Abdominal lesions identified in the 140 patients of the sample.

Organ injured	Number	Injuries with AIS > 3
Spleen	56	41
Liver	53	33
Kidney	22	18
Small bowel	11	8
Bladder	7	2
Colon	3	1
Pancreas	2	1
Stomach	1	1

the abdomen, altered physical examination of the pelvis, altered chest radiography, altered pelvis radiograph, positive FAST and presence of pelvic fracture. Of these, the following variables were significantly and independently correlated with the presence of severe abdominal injuries: SBP at admission (p = 0.034), altered physical examination of the abdomen (p <0.001), lower limb fracture (p = 0.044), motorcycle accident as the mechanism of injury (p = 0.017) and positive FAST (p <0.001).

DISCUSSION

Abdominal injuries are present in approximately 2% to 3% of blunt trauma victims [5,11]. However, this rate often increases as the sample is selected by gravity. In multiple trauma victims admitted with mild head trauma, this frequency increases to 10% [18]. Studying only patients with high-energy trauma mechanisms, Deunk et al. found approximately 30% of abdominal injuries [10]. In cases of trauma victims with fractures of the pelvis, the incidence of associated abdominal injuries can reach 40%[19]. In our sample, determined by the aforementioned inclusion criteria, abdominal injuries were found in 42.3%, and classified as severe in 30.5%. This demonstrates the severity of the patients studied, a fact demonstrated by the ISS of 19.9 ± 14.3.

In the blunt trauma victims, abdominal injuries may go unnoticed, this misdiagnosis being considered a cause of preventable deaths [3,20]. This is due to difficulties in obtaining a reliable physical examination when facing associated injuries in different body segments, especially those of Traumatic Brain Injuries (TBI) [4,18]. Moreover, victims of violence and accidents are often under the influence of illicit drugs or alcohol, which also reduces the reliability of physical examination abdominal [21].

The most accurate test for the diagnosis of abdominal lesions is the CT [6]. Nevertheless, the signs of lesions in hollow organs can be very subtle or absent, even for the best equipment [22]. There are also cases of injuries to hollow viscera without pneumoperitoneum or pneumoretroperitoneum [22]. This fact, coupled with difficulties in physical examination, make these lesions quite feared because of the serious consequences of late diagnosis [20,23,24]. The delay in the diagnosis of abdominal lesions may be associated with increased length of stay in intensive care and hospitalization, and increase morbidity and mortality [23].

Table 3 - Comparison of quantitative variables between groups A (severe abdominal injury, AIS e" 3) and B (abdomen AIS <3) – univariate analysis. Data presented as mean ± standard deviation.

	Group A N=101	Group B N=230	*p*
Age	34.0 ± 14.7 anos	37.5 ± 16.3anos	0.064
SBP at admission	107.8 ± 31.3mmHg	123.8 ± 35.0mmHg	<0.001
HR at admission	95.3 ± 17.9bpm	90.9 ± 21.7 bpm	0.061
Glasgow Coma Scale	12.6 ± 3.9	12.1 ± 4.2	0.273
Head AIS	1.0 ± 1.5	1.5 ± 1.8	0.015
Thorax AIS	1.1 ± 1.6	0.9 ± 1.5	0.284
Extremities AIS	1.7 ± 1.9	1.8 ± 1.8	0.689
ISS	28.0 ± 13.9	16.2 ± 12.9	<0.001

SBP: systolic blood pressure. mmHg: millimeters of mercury. HR: heart rate. Bpm: beats per minute. AIS: Abbreviated Injury Scale. ISS: Injury Severity Score.

Table 4 – Comparison of qualitative variables between groups A (severe abdominal injury AIS >= 3) and B (abdominal injury AIS <3): univariate analysis. Data presented as percentage related to the presence of the variable in a particular group.

	Group A N=101	Group B N=230	*p*
Male gender	77.2%	81.7%	0.216
Altered abdominal Physical examination	61.4%	28.7%	<0.001
Orotracheal intubation at admission	18.8%	26.5%	0.084
Chest drainage at admission	14.9%	11.7%	0.269
Severe head segment injury (AIS ± 3)	20.8%	30.9%	0.038
Severe thoracic injury (AIS ± 3)	30.7%	23.9%	0.124
Upper limb fracture	16.8%	15.2%	0.041
Lower limb fracture	16.8%	12.2%	0.167
Open upper limb fracture	5.9%	3.0%	0.172
Open lower limb fracture	5.0%	10.0%	0.092
Fracture of the pelvis	24.8%	12.6%	0.006
Severe extremities injury (AIS ± 3)	41.6%	40.9%	0.499

AIS: Abbreviated Injury Scale

It is evident that the evaluation in abdominal blunt trauma victims cannot be based only on a supplementary examination, but on the sum of several information derived from physical examination, mechanism of trauma, laboratory tests and imaging. In this context, it is important to evaluate the clinical variables that are significantly associated with the presence of abdominal lesions, also known as "indicators" [5,10,11,12,19].

In 1989, Mackersie *et al.* defined indicators of abdominal injury as: the value of Base Excess smaller than -5 mEq/L in arterial blood gases, hypotension at admission or at the accident site and the presence of chest injuries and/or fractures the pelvis [11]. In 2010, Deunk et al. carried out a study involving 1,040 victims of blunt trauma and identified the following independent factors significantly associated with the presence of abdominal injuries: alterations in chest, spine or pelvis radiographs, positive FAST, altered abdominal physical examination, altered Physical examination of the spine, base excess lower than -3 mEq/L in arterial blood gases, systolic blood pressure less than 90 mmHg and the presence of fractures in long bones [10]. In 2012, Farrath *et al.* defined, as injury indicators: the mechanism of trauma, hemodynamic instability, altered level of consciousness and the presence of severe lesions in skull, chest or extremities, especially flail chest and pelvic fractures [5].

In this study we aimed to evaluate, through a multivariate analysis, the variables associated with abdominal injuries with AIS e" 3, defined as "severe". Other studies have not found this feature. We selected only patients with CT and/or Exploratory Laparotomy, ie, diagnosis of injury or lack of it, objectively defined, in order to ensure the result "true" negative and "true" positive as reference. The purpose of the selection of lesions considered severe (AIS e" 3) as the group study was to identify patients

who would need specific treatment more often. Thus, the most important variables for the surgeon to use when making critical decisions could be better analyzed. Another important point was the attempt to select for the multivariate analysis only the variables that could be identified on admission of the patient in the emergency room, ie, those that would be available to the surgeon in a moment of decision.

The variables related to the presence of severe abdominal injury in the univariate analysis were prehospital SBP, SBP at admission, heart rate at admission, altered abdominal examination at admission, and fractures of the upper limbs or pelvis. These variables were also observed in previous studies, confirming their importance in the identification of traumatized more likely to have abdominal injuries [5]. However, not all of them were confirmed by multivariate analysis. After logistic regression, severe abdominal injuries were associated with: SBP at admission, positive FAST, altered abdominal physical examination, open fracture of the lower limb and motorcycle accident as the mechanism of trauma. Interestingly, neither serious injury to the chest nor pelvis fractures were significantly associated with the presence of severe abdominal injuries when logistic regression was applied.

The results of the multivariate analysis draw attention to a fact observed in clinical practice. When the results of the physical examination of the abdomen or imaging tests are positive, the possibility of serious injury is also greater. However, a negative test does not rule out injury. Even in group A, approximately 40% of patients had normal abdominal examination on admission. We tried to find a model for the "exclusion" of severe abdominal injuries, but this was not possible mathematically, which demonstrate the different forms of presentation of abdominal injuries in victims of blunt

trauma. This justifies the wide use of imaging methods for the objective evaluation of the abdomen. Nonetheless, the results of this approach need to be carefully evaluated.

There are several criticisms to FAST as an evaluation method in abdominal trauma. In 2004, Shuster et al. observed a sensitivity of 43%, not providing security for its use as a screening tool [25]. The best results were observed in patients with hemodynamic instability, when the presence of intra-abdominal free fluid in great volume safely identifies the presence of hemorrhage. In hemodynamically stable patients, the negative FAST does not exclude abdominal lesions [26,27]. In this study, we observed that the positive FAST related independently with the presence of SAI. This may be related to a higher volume of free fluid seen in SAI when compared to minor abdominal injuries, facilitating identification in FAST.

Another interesting point in the multivariate analysis was to confirm the greater chance of serious abdominal injuries in motorcycle accidents victims. This is an extremely serious problem in big cities. Previous studies have shown that fractures in the lower limbs are more frequent in injured motorcyclists when compared to other trauma mechanisms[28]. We also observed that the abdominal injuries are more common in blunt trauma victims with limb fractures, ie, there is a clear association between abdominal injuries and this mechanism of injury, especially when there are fractures in the extremities. This becomes even more important in practice, because these are precisely the patients with "distracting" injuries and in need of analgesics, hampering the abdominal examination. Moreover, patients with open fractures are generally candidates for surgical treatment, getting from the supervision of the general surgeon. With the results observed in this study, the objective investigation of the abdomen becomes mandatory in these patients, even with normal physical examination. In the cases with high chance of severe abdominal injuries, we believe that CT is the preferred method. However, there are several criticisms to the nonselective employment of this exam.

CT can carry some risk to the patient, for example, anaphylactic reactions due to administration of contrast, tumors from exposure to radiation and high costs. There are published data that point to a relationship between the prior CT and neoplasms. It is estimated that in the United States there were 16,406,921 CT exams performed in 2008. These tests would be related to 3,750 cancer cases, which resulted in 1,994 deaths [29].

It is also important to consider the cost that this diagnostic method generates for the health system. It is estimated that no more than 5% of the cases are positive for patients with low-energy trauma [6]. If we consider its nonselective use and we use the 2008 numbers, when 16,406,921 CT scans were performed in the U.S., we could estimate that 15,586,581 examinations would be negative. There is therefore great resource consumption with normal exams. Another problem generated by performance of normal exams would be erratic optimization of diagnostic resources in often overcrowded emergency rooms.

In 2010, Deunk *et al*. proposed a selective criterion for requesting computed tomography in victims of blunt trauma, based on clinical, radiological, laboratory and ultrasound exams[10]. CT was indicated in hemodynamically stable individuals who concomitantly present signs of neurological deterioration (Glasgow Coma Scale less than 8, pupillary abnormalities, skull open fracture), abnormal abdominal examination, fractures of the pelvis, lumbar spine or extremities, base excess lower than -3 mEq/L in arterial blood gas, abnormalities on chest, pelvis or spine radiographs, or positive FAST [4]. This study also suggested indicators of injury, but did not individualize serious injuries. As for fractures of the pelvis, we know that they can be associated with abdominal injuries by 40%, being a strong indicator of their presence [19].

On the other hand, Tillou *et al*. conducted a study In 2009 to support the use of routine full-body scan for victims of blunt trauma. In their sample, the criterion for selective application failed to identify lesions in 17% of cases [30].

Finally, it is worth mentioning that there is still no universal and optimal algorithm to be used in the investigation of abdominal injuries in blunt trauma victims. Probably, each institution must develop its protocol, based on the local situation in terms of severity of trauma and the availability of additional tests. However, it is extremely important that this assessment protocol is implemented and regularly evaluated in order to improve its performance. In this study the variables associated with serious abdominal injuries were identified by multivariate analysis and we believe that they should be considered in assessment protocols of victims of blunt trauma.

In conclusion, this study shows that the variables present in the initial assessment of trauma that were significantly associated with the presence of SAI were: SBP, altered abdominal physical examination, presence of open fractures of the lower limb, motorcycle accident as the mechanism of trauma and positive FAST.

R E S U M O

Objetivo: avaliar os fatores preditivos de lesões abdominais graves (LAG) identificáveis na avaliação inicial das vítimas de trauma fechado. *Métodos:* análise retrospectiva dos dados das vítimas de trauma fechado com idade superior a 13 anos submetidas à tomografia computadorizada do abdome e/ou laparotomia exploradora. Consideramos como graves as lesões com Abbreviated Injury Scale *(AIS)* maior ou igual a três. As variáveis foram comparadas entre os grupos A *(LAG)* e B *(Sem LAG)*. Realizou-se inicialmente uma análise estatística univariada para identificar as variáveis associadas à presença de LAG. Destas, foram selecionadas para a análise multivariada *(regressão logística)* as que tivessem p<0,20 e pudessem ser avaliadas na admissão do doente. *Resultados:* a amostra foi composta por 331 casos, sendo que 140 (42,3%) pacientes apresentaram lesões abdominais. Destes, 101 (30,5%) tinham lesão abdominais com AIS >= 3 (Grupo A). Na análise univariada, associaram-se significativamente às LAG (p<0,05): pressão arterial sistólica (PAS) no pré-hospitalar (p=0,019), PAS à admissão (p<0,001), frequência cardíaca à admissão (p=0,047), exame físico do abdome alterado (p<0,001) e presença de fraturas de pelve (p=0,006). As seguintes variáveis se relacionaram significativamente e independentemente com a presença de lesões abdominais graves: PAS à admissão (p=0,034), exame físico abdominal alterado (p<0,001), fratura exposta de membro inferior (p<0,044), "motociclista" como mecanismo de trauma (p=0,017) e FAST positivo (p<0,001). *Conclusão:* das variáveis presentes na avaliação inicial, se associaram significativamente com a presença de LAG: PAS, exame físico abdominal alterado, presença de fratura exposta de membro inferior, "motociclista" como mecanismo de trauma e FAST positivo.

Descritores: Abdome. Ferimentos e lesões. Traumatismos abdominais. Índice de gravidade do trauma. Diagnóstico.

REFERENCES

1. Reichenheim ME, de Souza ER, Moraes CL, de Mello Jorge MH, da Silva CM, de Souza Minayo MC. Violence and injuries in Brazil: the effect, progress made, and challenges ahead. Lancet. 2011;377(9781):1962-75.

2. Zan RP, Silveira L, Simões O. Emergências: quem nos procura? Uma visão do atendimento nas unidades de emergência do Hospital Central da Irmandade da Santa Casa de Misericórdia de São Paulo. Arq Med Hosp Fac Cienc Med Santa Casa São Paulo. 2007;52(3):81-6.

3. West JG, Trunkey DD, Lim RC. Systems of trauma care: a study of two counties. Arch Surg. 1979;114(4):455-60.

4. Michetti CP, Sakran JV, Grabowski JG, Thompson EV, Bennet K, Fakhri SM. Physical examination is a poor screening test for abdominal-pelvic injury in adult blunt trauma patients. J Surg Res. 2010;159(1):456-61.

5. Farrath S, Parreira JG, Perlingeiro JAG, Solda SC, Assef JC. Fatores preditivos de lesões abdominais em vítimas de trauma fechado. Rev Col Bras Cir. 2012;39(4):295-301.

6. Fabian TC, Croce MA. Abdominal trauma, including indications for celiotomy. In: Mattox KL, Feliciano DV, Moore EE, editors. Trauma. 4th ed. New York: McGraw-Hill; 2000. p. 1583-602.

7. Kornezos I, Chatziioannou A, Kokkonouzis I, Nebotakis P, Moschouris H, Yiarmenitis S, et al. Findings and limitations of focused ultrasound as a possible screening test in stable adult patients with blunt abdominal trauma: a Greek study. Eur Radiol. 2010;20(1):234-8.

8. Atri M, Hanson JM, Grinblat L, Brofman N, Chughtai T, Tomlinson G. Surgically important bowel and/or mesenteric injury in blunt trauma: accuracy of multidetector CT for evaluation. Radiology. 2008;249(2):524-33.

9. Mitsuhide K, Junichi S, Atsushi N, Masakazu D, Shinobu H, Tomohisa E, et al. Computed tomographic scanning and selective laparoscopy in the diagnosis of blunt bowel injury: a prospective study. J Trauma. 2005;58(4):696-701; discussion 701-3.

10. Deunk J, Brink M, Dekker HM, Kool DR, Blickman JG, van Vugt AB, et al. Predictors for the selection of patients for abdominal CT after blunt trauma: a proposal for a diagnostic algorithm. Ann Surg. 2010;251(3):512-20.

11. Mackersie RC, Tiwary AD, Shackford SR, Hoyt DB. Intra-abdominal injury following blunt trauma. Identifying the high-risk patient using objective risk factors. Arch Surg. 1989;124(7):809-13.

12. Erfantalab-Avini P, Hafezi-Nejad N, Chardoli M, Rahimi-Movaghar V. Evaluating clinical abdominal scoring system in predicting the necessity of laparotomy in blunt abdominal trauma. Chin J Traumatol. 2011;14(3):156-60.

13. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. Lancet.1974:2(7872):81-4.

14. Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the Trauma score. J Trauma.1989;29(5):623-9.

15. Association for Advancement of Automotive Medicine. The abbreviated injury scale. Des Plaines, IL: Association for Advancement of Automotive Medicine; 1990.

16. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma.1974;14(3):187-96.

17. Boyd CR, Tolson MA, Copes W. Evaluating trauma care: the TRISS method. Trauma Score and Injury Severity Score. J Trauma. 1987,27(4):370-8.

18. Wu SR, Shakibai S, McGahan JP, Richards JR. Combined head and abdominal computed tomography for blunt trauma: which patients with minor head trauma benefit most? Emerg Radiol. 2006;13(2):61-7.

19. Parreira JG, Haddad L, Rasslan S. Lesões abdominais nos traumatizados com fraturas de bacia. Rev Col Bras Cir. 2002;29(3):153-60.

20. Sung CK, Kim KH. Missed injuries in abdominal trauma. J Trauma. 1996;41(2):276-82.

21. Moore EE. Alcohol and trauma: the perfect storm. J Trauma. 2005;59(3 Suppl):S53-6; discussion S67-75.

22. Matsushima K, Mangel PS, Schaefer EW, Frankel HL. Blunt hollow viscus and mesenteric injury: still underrecognized. World J Surg. 2013;37(4):759-65.

23. Neal MD, Peitzman AB, Forsythe RM, Marshall GT, Rosengart MR, Alarcon LH, et al. Over reliance on computed tomography imaging in patients with severe abdominal injury: is the delay worth the risk? J Trauma. 2011;70(2):278-84.

24. Crookes BA, Shackford SR, Gratton J, Khaleel M, Ratliff J, Osler T. "Never be wrong": the morbidity of negative and delayed laparotomies after blunt trauma. J Trauma. 2010;69(6):1386-91; discussion 1391-2.

25. Shuster M, Abu-Laban RB, Boyd J, Gauthier C, Mergler S, Shepherd L, et al. Focused abdominal ultrasound for blunt trauma in an emergency department without advanced imaging or on-site surgical capability. CJEM. 2004;6(6):408-15.

26. Miller MT, Pasquale MD, Bromberg WJ, Wasser TE, Cox J. Not so FAST. J Trauma. 2003;54(1):52-9; discussion 59-60.

27. Ballard RB, Rozycki GS, Newman PG, Cubillos JE, Salomone JP, Ingram WL, et al. An algorithm to reduce the incidence of false-negative FAST examinations in patients at high risk for occult injury. Focused Assessment for the Sonographic Examination of the Trauma patient. J Am Coll Surg. 1999;189(2):145-50; discussion 150-1.

28. Parreira JG, Gregorut F, Perlingeiro JAG, Solda SC, Assef JC. Análise comparativa entre as lesões encontradas em motociclistas envolvidos em acidentes de trânsito e vítimas de outros mecanismos de trauma fechado. Rev Assoc Med Bras. 2012;58(1):76-81.

29. Zallman L, Woolhandler S, Himmelstein D, Bor DH, McCormick D. Computed tomography associated cancers and cancer deaths following visits to U.S. emergency departments. Int J Health Serv. 2012;42(4):591-605.

30. Tillou A, Gupta M, Baraff LJ, Schriger DL, Hoffman JR, Hiatt JR, et al. Is the use of pan-computed tomography for blunt trauma justified? A prospective evaluation. J Trauma. 2009;67(4):779-87.

Address correspondence to:
José Gustavo Parreira
E-mail: jgparreira@uol.com.br