

Original articles

A Prospective Study on the Incidence of Missed Injuries in Trauma Patients

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Abstract

Introduction. Missed injuries in trauma patients are injuries not identified during a primary and secondary trauma survey (Advanced Trauma Life Support, ATLS). These injuries are important because of the delay in correct treatment. There is a particularly important subgroup consisting of clinically significant missed injuries, which may cause serious complications in the patient or even death.

Material and method. A prospective study on missed injuries and clinically significant missed injuries. The study includes all trauma patients older than 16 years admitted to the resuscitation area or who had died during the first 24 hours. We collected injuries, time of their diagnosis and their treatment for each patient. For injuries detected later than 24 hours (ie missed injuries) we specified whether it was a clinically significant missed injury and its possible cause.

Results. From March of 2006 to January of 2007, 122 trauma patients were recorded with a mean Injury Severity Score of 20 (15.8). Of those, 40.3% had some missed injury, fractures being the most frequent miss (42.7%), followed by chest and abdominal injuries. A clinically significant injury (38.7% of all missed injuries) were found in 17% of trauma patients, the most frequent being spine, abdominal and chest injuries. There is a statistically significant relationship between the presence of missed injuries, high ISS and intubation before or after admission to hospital.

Conclusions. The rate of missed injuries and clinically significant missed injuries is high. Severe trauma patients and intubated patients have higher rates of missed injuries.

Key words: Trauma. Missed injuries. Clinically significant missed injury. Tertiary survey.

ESTUDIO PROSPECTIVO DE LA INCIDENCIA DE LAS LESIONES INADVERTIDAS EN EL PACIENTE POLITRAUMATIZADO

Introducción. Las lesiones inadvertidas en el paciente politraumatizado son aquellas no identificadas durante la revisión primaria y la secundaria (Advanced Trauma Life Support, ATLS). La importancia de estas lesiones radica en el retraso del inicio del tratamiento adecuado. Hay un subgrupo especialmente importante constituido por las lesiones inadvertidas clínicamente relevantes, que comportan complicaciones graves o incluso la muerte del paciente.

Material y método. Estudio prospectivo de las lesiones inadvertidas y de las clínicamente relevantes, que incluye a todos los politraumatizados mayores de 16 años ingresados en el área de críticos o aquellos que han fallecido durante las primeras 24 h. Para cada enfermo se recogen sus lesiones, el momento del diagnóstico y su tratamiento. En las lesiones detectadas después de las primeras 24 h, lesiones inadvertidas, se especifica si la lesión es clínicamente relevante y su posible causa.

Resultados. De marzo de 2006 a enero de 2007 se han recogido 122 politraumatizados con una media \pm desviación estándar del índice de severidad (ISS) de $20 \pm 15,8$. El 40,3% de los pacientes presentaba alguna lesión inadvertida, con más frecuencia las fracturas (42,7%), seguidas por las lesiones torácicas y abdominales. El 17% de los pacientes presentaba alguna lesión inadvertida clínicamente relevante (el 38,7% de todas las lesiones inadvertidas), entre ellas, las más frecuentes son las lesiones de columna, las abdominales y las torácicas. Hay una relación estadísticamente significativa entre la aparición de lesiones inadvertidas, ISS elevados y pacientes intubados antes o tras el ingreso.

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Conclusiones. La incidencia de lesiones inadvertidas y lesiones inadvertidas clínicamente relevantes es elevada. Los politraumatizados más graves y los intubados presentan una mayor incidencia de lesiones inadvertidas.

Palabras clave: Politraumatizado. Lesiones inadvertidas. Clínicamente relevante. Revisión terciaria.

Introduction

Advanced Trauma Life Support (ATLS) from the American College of Surgeons defines 2 stages in the initial management of the polytraumatized patient: the primary survey, with the objective of identifying and treating injuries that put the life of the patient in danger, and the secondary survey, which tries to detect all of the patients' injuries and initiate definitive treatment.¹⁻⁹ Even carrying out such detailed and standardized treatment, there are several missed injuries that occur. These are defined as injuries that are not identified during the primary and secondary surveys.¹⁻¹²

The importance of missed injuries results in a delay in initiating adequate treatment. There is an especially important sub-group of missed injuries which are known as clinically relevant missed injuries. These are injuries that can result in serious complications including patient death.¹⁻¹²

The incidence of missed injuries varies between 0.6% and 65%, and less missed injuries have been found in retrospective studies. Prospective studies find different incidences due to the methodology used and differences in the definition of missed injury.¹⁻¹²

Clinically important missed injuries comprise between 10% and 20% of all missed injuries, and some studies have found up to 40%.^{1-4,6-8,13}

A relationship has been found between the appearance of missed injuries and high injury severity score (ISS), low level of consciousness (Glasgow <8), positive toxicology screen, hemodynamically unstable intubated patients, or those who are seen in centers with little experience in the management of this type of patient.^{1-8,10,12-16}

Objective of the Study

To determine the number of missed injuries that occur in polytraumatized patients treated in our center.

Material and Method

This is a prospective study that includes all polytraumatized patients admitted to the critical area (ICU or semi-critical) or those that have died within the first 24 hours of admission; excluded were minors under 16 years of age.

The following data were recorded: age, gender, Charlson index,¹⁷ body mass index (BMI), history of coagulopathy, mechanism of injury, ISS,¹⁸

length of admission to the critical area and of hospitalization. Prior to hospital admission: vital signs, Glasgow coma scale, temperature, oxygen saturation, RTS (Revised Trauma Score),¹⁹ and medical-surgical treatment rendered. Upon admission: the same parameters plus complementary studies, blood tests (blood alcohol and urine toxicology screen), the need for transfusion, injuries produced, and complications/mortality. The time of prehospital and hospital treatment were recorded in all cases.

The diagnostic method, treatment, and time of diagnosis were noted for each specific injury. Missed injuries are those that are diagnosed clinically, radiologically or surgically after the primary and secondary survey and after 24 hours following the traumatic event. For each, clinical relevance has been evaluated, with a clinically relevant missed injury being defined as one which has led or may lead to serious complications including patient death.

Additionally, causes leading to a delay in diagnosis have been studied; these include 4 types: clinical error (missed injury during physical examination), radiological error (injury missed on a diagnostic test and detected upon review of the same test at a different time), communication error between the radiologist and clinician, and surgical error (injury missed during the surgical survey). A resident and an attending radiologist are permanently in the hospital to interpret the images.

Statistical Analysis

The descriptive analysis of the data has been performed using percentages and averages according to quantitative and qualitative variables. Where an inferential study has been performed, an alpha error of .05 is assumed.

We have tried to obtain a predictive model that allows for predicting which patients have a higher probability of missed injuries. For this purpose, logistical regression has been used.

In order to choose the maximum model from which to work, the maximum and minimum values for each variable were found during the preliminary phase in order to detect possible errors in the data matrix that may have past the above filters, as well as to detect the presence or absence of exceptional values.

Modeling was performed using the procedure described by Domenech. Hierarchical rules were followed at all times. From the maximum model, several more elegant models were obtained using sequential inclusion, sequential exclusion, and step by step regression. In a second stage, the variables that the above analyses indicated to be the most important were fixed into the model, and the remaining variables were progressively added in a controlled manner with the objective of improving the adjustment.

Once the final definitive model was obtained, the conditions for applying the model, especially the assumption of linearity, were analyzed. In practice, the residuals are analyzed according to the methodology described by Domenech.

During construction of the model, the likelihood-ratio test was always used instead of the Wald test.

Results

Between March 2006 and January 2007, 122 polytraumatized patients who were admitted to the critical area or who had died within the first 24 hours were recorded; 93 patients were males and 29 were females. The average age of polytraumatized patients was 44 (range, 16-99) years. The average ISS (standard deviation) is 20 (15.8), though it increases up to 24.5 (16.3) if you exclude patients that have been admitted to the semi-critical area for pain control. The primary mechanism of injury is closed trauma (93.4%) (Table 1). Mortality was 13% (16 patients), 5 of which had missed injuries, all of which were clinically relevant.

The 40.3% of patients had some type of missed injury. The most frequent missed injuries were fractures (facial, costal, in extremities, clavicular, cranial, and scapular), which make up 42.7% of all missed injuries (Table 2).

TABLE 1. Mechanism of Injury

| | |
|-------------------------------------|-------------|
| Closed Trauma (93.4%; 114 patients) | |
| Motorcycle accident | 25 patients |
| Car accident | 22 patients |
| Fall | 20 patients |
| Being run over | 19 patients |
| Slip and fall | 17 patients |
| Bicycle accident | 4 patients |
| Attack | 4 patients |
| Crush injury | 3 patients |
| Open trauma (6.6%; 8 patients) | |
| Bladed weapon | 6 patients |
| Amputation | 2 patients |

The 17% of patients had some type of clinically relevant missed injury. Of all missed injuries, 38.7% were clinically relevant missed injuries; the most frequent of which were spinal, abdominal, and thoracic injuries (Table 3).

The 32% of the clinically relevant missed injuries have required some form of additional therapeutic action or have caused patient death (Table 4).

As shown in Figure 1, the main error found for the incidence of missed injuries was the radiological one (65% of all missed injuries), followed by the clinical error (39%). Errors due to lack of communication and surgical errors are exceptional (Figure 1). Analyzing the errors associated exclusively with clinically relevant missed injuries, radiological errors continue to be the most frequent, followed by clinical ones (Figure 2).

A statistically significant relationship exists between missed injuries, the ISS, and orotracheal intubation (Tables 5 and 6).

No statistically significant relationship has been found between the other parameters studied (Table 5).

TABLE 2. Missed Injuries

| | |
|--|------------|
| Fractures (42.7%; 32 injuries) | |
| Facial | 9 injuries |
| Costal | 7 injuries |
| Extremities | 6 injuries |
| Clavicular | 3 injuries |
| Craneal | 3 injuries |
| Spinal column | 3 injuries |
| Scapular | 1 injury |
| Thoracic injuries (13.3%; 10 injuries) | |
| Hemothorax | 4 injuries |
| Pneumothorax | 2 injuries |
| Pneumomediastinum | 2 injuries |
| Hemomediastinum | 1 injury |
| Cardiac injury | 1 injury |
| Abdominal injuries (10.7%; 8 injuries) | |
| Liver injuries | 3 injuries |
| Intestinal injuries | 1 injury |
| Renal injuries | 1 injury |
| Suprarenal injuries | 1 injury |
| Urethral injuries | 1 injury |
| Splenic injuries | 1 injury |
| Spinal column injuries (9.3%; 7 injuries) | |
| Dislocations | 3 injuries |
| Spinal cord injuries | 3 injuries |
| Contusions | 1 injury |
| Superficial injuries (9.3%; 7 injuries) | |
| Erosions, contusions, hematomas, bruises, etc | 7 injuries |
| Sinus hemorrhage (5.3%; 4 injuries) | |
| Sinus hemorrhage | 4 injuries |
| Injuries to the extremities (5.3%; 4 injuries) | |
| Sprain, etc | 4 injuries |
| Cranial injuries (4.1%; 3 injuries) | |
| Contusion, ventricular hemorrhage, etc | 3 injuries |

TABLE 3. Clinically Relevant Missed Injuries

| | |
|--|------------|
| Spinal column injuries (31%; 9 injuries) | |
| Dislocation | 3 injuries |
| Fracture | 3 injuries |
| Spinal cord injuries | 3 injuries |
| Abdominal injuries (27.6%; 8 injuries) | |
| Liver injuries | 3 injuries |
| Intestinal injuries | 1 injury |
| Renal injuries | 1 injury |
| Suprarenal injuries | 1 injury |
| Urethral injuries | 1 injury |
| Splenic injuries | 1 injury |
| Thoracic injuries (24.2%; 7 injuries) | |
| Hemothorax | 3 injuries |
| Fracture of the first rib | 2 injuries |
| Scapular fracture | 1 injury |
| Cardiac injury | 1 injury |
| Cranial injuries (10.3%; 3 injuries) | |
| Cerebral contusion | 2 injuries |
| Ventricular hemorrhage | 1 injury |
| Injuries to the extremities (6.7%; 2 injuries) | |
| Compartmental syndrome | 2 injuries |

Discussion

The 40.3 % of polytraumatized patients that we have seen had missed injuries, an incidence higher than the data described up until now (0.6%-65%).¹⁻¹² This elevated incidence, compared to other studies (Enderson et al⁵ [2%], Buduhan et al² [8.1%], Brooks et al⁴ [22%]), can be explained by the prospective nature of this study, while those cited above are based on a retrospective database. This fact was proven by Enderson et al,^{5,20} who found a change in missed injuries from 2% to 9% according to whether based on a retrospective or prospective study. Of course, the best method for detecting missed injuries is autopsy, in addition to being an excellent method for evaluating quality of care in the polytraumatized patient.^{2,21-23} In our study, information from autopsy was not systematically collected; however, in 8 of the 16 deaths during this period, 100% had findings of missed injuries.

When compared to the prospective studies, our incidence was lower than some of the studies, such as that of Janjua et al,¹ who reported an incidence of 65%. One explanation for this is the loss of missed lesions that appear between finalizing the secondary survey and the first 24 hours, and those that appear following hospital discharge. We do not know if these losses would increase the incidence up to the maximum values found until now (65%).

TABLE 4. Clinically Relevant Missed Injuries That Require Additional Therapeutic Action or Are the Cause of Death

| Clinically Relevant Missed Injury | Additional Treatment/Death |
|---------------------------------------|--------------------------------|
| Urethral injury | Placement of double-J catheter |
| Hemothorax | Pleural drainage |
| Hemothorax | Pleural drainage |
| Hemothorax | Pleural drainage |
| Liver injury | Revision surgery |
| Spleen injury | Revision surgery |
| Compartmental syndrome in extremities | Surgical intervention |
| Cardiac injury | Cause of death |

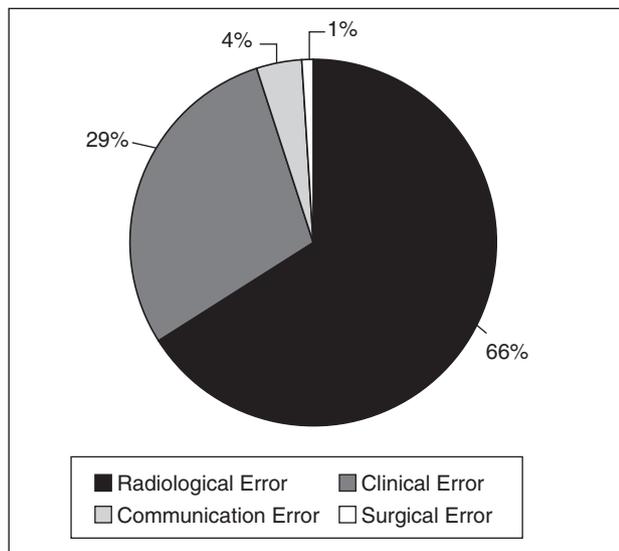


Figure 1. Errors associated with missed injuries.

Clinically relevant missed injuries appear in 17% of patients, and make up 38.7% of all missed injuries. The proportion of these injuries with respect to the total of missed injuries is high when compared with that found in the current literature (10%-35%).^{1-4,6-8,13} However, when our concept of a clinically relevant injury is applied, we find similar results to those published.³ Studies including in their definition only those injuries that require an additional therapeutic act or those that ended in a serious complication or death of the patient are those showing lower results.^{21,22} By applying this definition to our study, we find that clinically relevant missed injuries decline from 38.7% of the total to 10.7%, which is comparable to the above-mentioned results.

Previous studies have demonstrated an association between the appearance of missed injuries and an increased

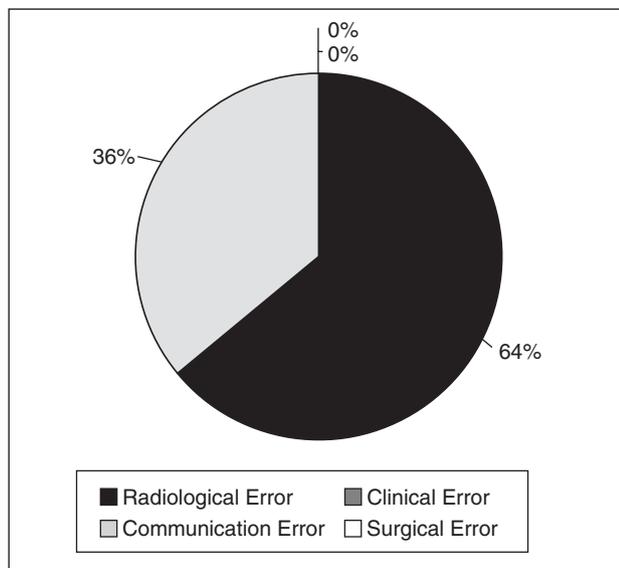


Figure 2. Errors associated with clinically relevant missed injuries.

TABLE 5. Relationship Between Missed Injuries and the Parameters Analyzed^a

| | No Missed Injuries | With Missed Injuries | P |
|--------------------------------------|--------------------|----------------------|------|
| ISS, mean (SD) | 18.3 (13.36) | 22.4 (16.08) | .01 |
| Pre-hospital intubation, patients, % | 15.8 | 36.4 | .024 |
| Hospital intubation, patients, % | 25 | 51.5 | .009 |
| Glasgow coma scale | 12.38 | 11.50 | .450 |
| Hospital SBP, mm Hg | 130 | 122 | .387 |
| Baseline lactate, mg/dL | 23.04 | 22.22 | .963 |
| Positive toxicology, ^b % | 85.7 | 71.4 | .186 |

^aSBP indicates systolic blood pressure; SD, standard deviation.

^bAnalyzed in 45% of patients.

ISS, a low level of consciousness (due to brain injury or positive blood toxicology screens), orotracheal intubation, hemodynamic instability, and closed trauma.^{1-8,10,12-16} Our study has observed a statistically significant relationship between missed injuries, increased ISS, and intubated patients, although wide standard deviation exists in the ISS that requires an increase in the number of patients in order to obtain the most clinically relevant results. No relationship has been found with the other parameters, given that the toxicology screens were not evaluable since they were only performed in 45.5% of patients and the mechanism of injury in 93.4% of patients was closed trauma.

Our incidence of missed injuries and, most importantly, clinically relevant missed injuries has made us think about mechanisms to reduce its prevalence. Evidently, the first and most important point is to be able to recognize them by analyzing our own results. It has also been shown that this incidence is also reduced with care of the polytraumatized patient by multidisciplinary teams who are sufficiently trained and using protocols such as ATLS.^{5,8,12,21,23} Given that these points are already being applied in our center, the main mechanism adopted is the application of the tertiary survey proposed by Enderson et al, which found a reduction of 35% in missed injuries by applying this protocol; by using this, early detection and treatment are achieved leading to an improvement in these patients' morbidity and mortality.^{1,3,4,7,8,10-12,23} The tertiary survey consists of a complete examination of the patient and the complementary studies performed during the primary and secondary surveys, and ordering new complementary studies if needed. This tertiary survey is performed once the primary and secondary surveys are completed, and prior to 24 hours following trauma. We must now evaluate if the application of the tertiary survey to our center leads to a reduction in

TABLE 6. Relationship Between Missed Injuries and Intubation

| | Patients With Missed Injuries, % | P |
|---------------------------------|----------------------------------|------|
| Pre-hospital intubation | 50 | .037 |
| Without pre-hospital intubation | 38.8 | .037 |
| Hospital intubation | 47.2 | .021 |
| Without hospital intubation | 25.9 | .021 |

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missed injuries, with the aim of improving care of our polytraumatized patients.

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