

Extremity Fractures as the Most Common Missed Injuries: A Prospective Cohort in Intensive Care Unit Admitted Multiple Trauma Patients

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ABSTRACT

Background: Although an intensive care unit (ICU) admission is a risk factor for missed injury, there has been some disagreement on whether missed injuries in trauma ICU patients have a longer length of stay (LOS). With this in mind, these patients' frequency of missed injuries and related factors were investigated.

Materials and methods: This was a prospective cohort study on multiple trauma injury patients in a tertiary referral trauma center's trauma intensive care unit (TICU) from March 2020 to March 2021. A tertiary survey was conducted in the TICU by attending physicians to find the types I and II missed injuries (any injury discovered after primary and secondary surveys during the hospital stay). A logistic regression model was designed for predictors of missed injuries in ICU-admitted multiple trauma patients.

Results: Out of 290 study participants, 1,430 injuries were found, and of those injuries, 74 cases (25.5%) had missed injuries. In other words, there were 103 missed injuries, resulting in a missed injury detection rate of 7.2%. The most frequently missed injuries (43.4%) were concluded as extremities fractures. The regression model showed that the patients with missed injuries are prone to longer TICU LOS [odds ratio (OR) = 1.15; $p = 0.033$], and cases who underwent a computed tomography (CT) scan are less likely to have missed injuries (OR = 0.04; $p < 0.001$). The abbreviated injury scale (AIS) range was 1–3 in missed injuries.

Conclusion: Our research underlines the importance of finding missed injuries and the necessity of CT scan to decrease them. In teaching centers, life-threatening injuries decrease with increasing visits and examination times. Although these missed injuries do not increase mortality, they cause longer TICU LOS and costs.

Keywords: Abbreviated injury scale, Care unit, Extremity, Intensive, Missed injury, Trauma.

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HIGHLIGHTS

Do patients with missed injuries in the trauma ICU have a longer LOS? Our research underlined the importance of finding missed injuries and the necessity of CT scan to decrease them. Intensive care units consume nearly 22% of hospital resources, and a longer LOS can increase costs.

INTRODUCTION

Discovering all injuries in multiple trauma patients while considering the struggles with resuscitation and saving patients' lives is a major challenge. However, mortality followed by missed injury is pushed into the background, and long-term effects and quality of life are brought into focus.^{1,2} Missed injuries may exacerbate the severity of the patient's status or cause a significant increase in the hospital stay, ICU LOS, and overall patient care costs.^{3,4} ICUs only account for 10% of the hospital beds but consume nearly 22% of the hospital resources.⁵

With a range between 1% and 40%, the incidence of missed injuries has been reported variably.⁶ Recently, a tertiary trauma survey (TTS) has been suggested as one of the solutions to decrease missed injuries. After the primary and secondary surveys, an assessment should be performed, including a physical re-examination and reconsideration of all investigations within 24 hours of admission.⁷

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There are two types of missed injuries. The first type is defined as any injury record after the first 24 hours⁸ and is missed during the primary and secondary surveys but is found in the tertiary survey. The second type is picked up after the tertiary survey, either during the hospital stay or following discharge.⁷

Table 1: Characteristics of the patients with and without missed injury

Variables	All participants n = 290 (%)	Patients with missed injuries n = 74 (%)	Patients without missed injuries n = 216 (%)	p-value*
Mechanism of injury	PCA ¹	74 (25.5%)	27 (36.4%)	0.002
	FFH ²	65 (22.4%)	22 (29.7%)	
	MVA ³	96 (33.1%)	19 (25.6%)	
	Others	55 (19%)	6 (8.1%)	
TICU ⁴ LOS ⁵	7, IQR 4,10	7.5, IQR 4,13	7, IQR 4, 9.75	0.006
Hospital LOS	12, IQR 7,18	12, IQR 7.75,24	12, IQR 7,17	0.042
Intubation	116 (40%)	41 (55.4%)	75 (34.7%)	0.002
CT ⁶ scan	277 (95.5%)	67 (90.5%)	210 (97.2%)	0.024
Death during hospitalization	30 (10.3%)	10 (13.5%)	20 (9.2%)	0.300
GCS ⁷ < 13	125 (43.1%)	44 (59.4%)	81 (37.5%)	0.001

*The comparisons were made between the patients with missed injuries and those without. ¹Pedestrian car accident, ²Falling from a height, ³Motor vehicle accidents, ⁴Trauma intensive care unit, ⁵Length of stay, ⁶Computed tomography, ⁷Glasgow coma scale

Although extensive research has been carried out on missed injuries, little is known about missed injuries in ICU-admitted patients. However, staying in the ICU is one of the most increasing hospital cost factors and is known as one of the risk factors for missed injury.⁹ This prospective cohort study aimed to describe the frequency of missed injuries in a single tertiary referral trauma center and its associated factors.

MATERIALS AND METHODS

This prospective cohort study was conducted on patients with multiple trauma injuries in the TICU of Shahid Madani Hospital, Alborz University of Medical Sciences, Karaj, Iran from March 2020 to March 2021. This tertiary teaching referral trauma center works with the Swiss cheese model in risk management. The patients were followed during their hospitalization period.

All multiple trauma adult patients (age over 18 years) were included. To be eligible to be included in the study, patients could be revised to be admitted to the TICU by an emergency medicine specialist after the primary and secondary trauma surveys in the emergency department and a tertiary survey in the ICU by an changes to the attending physician. A patient or a representative, or a surrogate should have been able to give informed consent. Refusing to take part at any point excluded them from the study. The patients who were deceased before the tertiary survey and those with isolated brain injuries were also excluded. All patients were examined by a team consisting of a radiologist, an orthopedist, and a general surgery specialist.

The primary outcome of this study was discovering types I or II missed injury. The type I missed injury was defined as an injury discovered in the first 24 hours after admission and missed during the first or second survey in the emergency department. The type II missed injury was defined as an injury discovered more than 24 hours after admission and during the hospital stay with the same criteria. The gathered data included the variables age, sex, mechanism of injury, TICU LOS, hospital LOS, CT scan, death during the hospital stay, intubation status on TICU admission, type of missed injuries based on anatomical place, and Glasgow coma scale (GCS). In addition, AIS was used to evaluate the severity of injuries. This scale classifies injuries based on their anatomical site

on a six-point scale. These scales include minor, moderate, serious, severe, critical, and maximal from AIS 1 through 6.¹⁰

The sampling method of this study was convenience.

Statistical Analysis

Categorical variables were described as frequencies, and continuous variables were described using mean and standard deviation (SD), or median and interquartile range (IQR). Proportions for categorical variables were compared using the Chi-square test or Fisher's exact test. An independent samples t-test or a Mann-Whitney U test was used to compare the numerical variable. A logistic regression model was designed to calculate the adjusted OR with the variables with *p*-value less than 0.2 as independent variables and missed injury as the dependent variable. The statistical package for the social sciences (SPSS) application (version 16) for Windows (SPSS®, Inc., Chicago, Illinois, USA) was used to analyze the data; *p* < 0.05 was considered statistically significant.

Ethical Considerations

All patients were identified by a random computer-generated unique code, and no personal data was revealed to any party during data extraction or analysis. This study was approved by the medical ethics committee of Alborz University of Medical Sciences (ABZUMS), Karaj, Iran under the code of IR.ABZUMS.REC.1400.166.

RESULTS

Among the 290 patients admitted to the TICU, a total number of years 1,430 injuries were diagnosed. The mean age was 31.2 ± 11.34 , and 73.8% (*n* = 214) of the participants were male. Of all cases, 216 patients (74.5%) did not have any additional injury, but 74 cases (25.5%) were detected with 103 types I and II missed injuries (7.2% of all identified injuries).

Of 74 patients with missed injuries, 36.4% had a pedestrian car accident (PCA) mechanisms of injury, and among patients, without missed injuries, motor vehicle accident (MVA) covers the most common mechanism (35.6%) (Table 1).

The average TICU LOS and hospital LOS were higher in cases with missed injuries than in patients without missed injuries (median = 7.5, IQR 4,13 vs median = 7, IQR 4,9.75; *p* = 0.006) (Table 1).

Table 2: Frequency of different anatomical places of injury in patients with missed injury

Anatomic place of injury	Number of patients with missed injury (number of injuries)
Head and neck*	14 (18)
Thorax**	5 (8)
Abdomen	8 (12)
Pelvic	3 (3)
Extremities and axis Fx	33 (45)
External***	13 (17)

*Vitreous detachment, perforated eardrum, and lacerations, **Contusion, pneumothorax, flail chest, and rib fractures (Fx), ***Tendon injury and nerve injury (although the number of patients with missed injury is 74, a total of 2 patients had more than 1 anatomic place of injury)

Table 3: Results of logistic regression model analysis: predictors of missed injuries in ICU admitted multiple trauma patients

Variables	p-value	Adjusted OR	95% CI	
			Lower	Higher
TICU ¹ LOS ²	0.033	1.151	1.012	1.309
LOS	0.896	1.005	0.927	1.090
Intubation	0.233	2.948	0.500	17.394
Sex (male)	0.926	1.040	0.450	2.404
GCS ³ > 13	0.582	1.629	0.286	9.270
PCA ⁴	0.005	Reference	-	-
FFH ⁵	0.382	0.707	0.325	1.537
MVA ⁶	0.017	0.393	0.182	0.847
Other mechanisms	0.001	0.167	0.056	0.496
Age	0.881	0.998	0.967	1.029
CT ⁷ scan	0.000	0.049	0.012	0.196

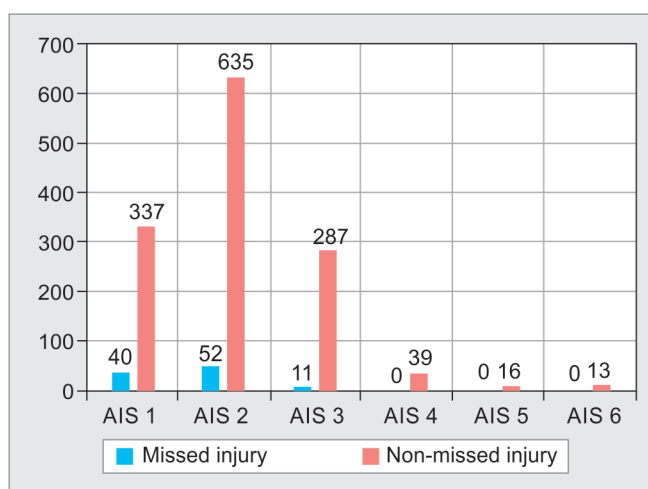
¹Trauma intensive care unit, ²Length of stay, ³Glasgow coma scale, ⁴Pedestrian car accidents, ⁵Falling from a height, ⁶Motor vehicle accidents, ⁷Computed tomography

Forty-one patients (55.4%) with missed injuries were intubated; this proportion among the non-missed injured patients was 36% (77 cases) ($p = 0.002$).

Death during hospitalization in patients with and without missed injuries was 9 (12%) and 18 (8%), respectively ($p = 0.300$). A CT scan was conducted in 67 (91%) of the missed injury and 210 (97%) non-missed injury patients ($p = 0.024$). There was no statistical significance between the ages of the patients who were diagnosed with a missed injury and those who were not (30.38 ± 8.84 vs 31.51 ± 12.08 ; $p = 0.390$). The proportion of male patients was the same in both groups (77.02% vs 72.68%; $p = 0.464$).

Extremity fractures were the most anatomical place of missed injuries (43.4%), followed by head and neck, external, and abdominal injuries (18.4%, 17.1%) and 10.5%, respectively (Table 2).

The variables, mechanism of injury, TICU LOS, hospital LOS, intubation, CT scan, and GCS, were entered in the regression model as the independent variables, and the missed injury was entered as the dependent variable (Table 3). The regression model showed that the patients with missed injuries tend to have longer TICU LOS (OR = 1.15; $p = 0.033$), and the patients who underwent a CT scan are less likely to be diagnosed with a missed injury (OR = 0.04; $p < 0.001$). In addition, patients with MVA and other trauma

**Fig. 1:** Abbreviated injury scale in patients with and without missed injuries based on a 6-point scale

mechanisms have lower odds of being diagnosed with a missed injury compared to those with PCA (OR = 0.393, $p = 0.017$; OR = 0.167; $p = 0.001$, respectively). However, the odds of having a missed injury do not differ between those who have fallen from a height (OR = 0.70; $p = 0.382$) as their main mechanism of injury and those with PCA.

The AIS distribution in patients with types I and II missed injuries and without missed injuries based on a 6-point scale is shown in Figure 1.

DISCUSSION

Although our results show a higher rate of missed injuries than previous ICU admitted works,^{11,12} they are consistent with those discussed in the study of Tammelin et al.¹³ The possible explanation for this might be that, in contrast with previous works, we are both prospective with more CT scans.

However, the findings of Biff et al.¹⁴ and Emet et al.¹⁵ show the association of age in patients with missed injury; our study, similar to that of Tammelin et al.,¹³ did not find a significant relationship between age and missed injury.

The findings in the most common mechanisms of injury support another study¹⁶ about developing countries. The most common mechanisms of injury was road accidents, and the second one was falling from a height, which is also the second most common etiology of injury-associated mortality in India.¹⁶

Most of the missed injuries conclude with extremity fractures, which is in line with all previous studies.^{4,13,14} It is, therefore, likely that in the emergency department, most of the concentration is on the body's midline because of the more life-threatening organs located there.

The distribution of AIS shows that there are no missed injuries in AIS 4–6. This may mean tertiary survey is more efficient on minor injuries, similar to previous studies.¹³ There was no significant difference in death during the hospitalization between the patients with and without missed injuries; our finding supports the previous meta-analysis that has reported no significant difference between patients with tertiary survey and without.² It may be due to our hospital being a tertiary teaching center with interns and residents, which means that an informal tertiary survey is in processing always, and life-threatening trauma is not being missed.

There was a significant difference in the TICU LOS and LOS average of missed injury patients and non-missed injury ones, which confirms previous findings in^{4,15,17} that it may increase hospital, insurance, and patient care costs.

Despite the fact that the study by Tammelin et al.¹³ found no extended LOS between the two groups. That may be because of the lower study population number.

Our results in patients who underwent CT scans differ from the previous study, which was reported approximately the same in both groups¹³ and had significantly different. Furthermore, our model shows that patients who underwent the CT scan are less likely to have missed injuries in the future. As mentioned in the literature review, a pan scan detects significant organ injury.¹⁸

Prior studies have noted the importance of GCS for injuries to be missed,¹⁹ and this study confirms a significant difference between patients with and without missed injuries. These may explain the correlation between consciousness and giving history or mentioning the pain by the patient.

The current study does not support the previous research about the proportion of intubation between the patients with and without missed injuries.¹³ We have found significant differences, which may need more future work with controls.

The strength of our study is the study population in contrast with the previous studies and its prospective method.

One of our limitations was the absence of follow-up after discharge and the lack of emergency surgery data, which is mentioned as a missed injuries risk factor.⁹

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