

Predictors of missed injuries in hospitalized trauma patients in the emergency department

M. Emet · A. Saritas · H. Acemoglu ·
S. Aslan · Z. Cakir

Received: 21 October 2009 / Accepted: 16 December 2009 / Published online: 14 April 2010
© Urban & Vogel 2010

Abstract

Aim To determine the extent of missed injuries in patients hospitalized with major trauma in a Turkish Level 1 emergency department. We also tried to identify the primary factors contributing to each missed injury and to determine their subsequent adverse short-term clinical outcomes.

Methods This is a retrospective analysis of prospectively collected data on a cohort of trauma patients. Trauma patients were divided into two groups: patients with missed injury and others. Logistic regression was used to define factors affecting “missed injury”.

Results A total of 670 hospitalized trauma patients were included. The incidence of missed injuries in the patients and the rate of missed injury per patient were 13.3% (95% CI 6–20) and 1.64, respectively. The most frequently missed diagnosis was injuries of the musculoskeletal system (38%; 95% CI 30–46). It was “clavicle fracture and/or dislocation” (35%; 95% CI 16–53) when the rate of missed diagnosis according to the frequency of the specific injury was calculated. A multiple logistic regression analysis showed that the predictors of missed injuries were patient’s age (OR 0.74, 95% CI 0.63–0.87), total number of injuries (OR 1.74, 95% CI 1.38–2.20), and ISS (OR 1.10, 95% CI 1.03–1.18). Radiological errors were prominent in almost

90% (95% CI 85–95). Missed injury caused additional hospital stay (30%; 95% CI 21–40) and additional surgery was required (15%; 95% CI 8–23).

Conclusion The study highlights the need for a trauma team approach and the need for support of radiological report in the ED.

Keywords Missed injury · Trauma · Diagnosis · New injury severity score · Secondary survey

Introduction

Trauma care in busy emergency departments (ED) brings about medical errors as a result of unstable patients, incomplete histories, time-critical decisions, synchronous tasks, involvement of many disciplines, and inexperienced personnel working after-hours [1]. About 65% of the average ED patient load consists of major and minor trauma, which may explain why most medico-legal cases are related to trauma [2]. Unfortunately, 34% (20% primary examination, 14% secondary examination) of missed injuries during trauma treatment occur in the ED [1].

Misdiagnoses not only adversely affect patient outcome but also attenuate the reliability of the clinician and the institution [3]. A missed injury may attract attention as the most memorable event in a patient’s clinical course, clouding the brave efforts of the trauma team [4]. To reduce errors, hospitals need effective means of identifying errors and error-associated deaths, which have been found to be 2.7–6.5% [1, 5]. It is true that there is a general disinclination of physicians to admit and account for their errors. And the main issue with the literature is the quality of the papers because of the difficulties in researching this area.

M. Emet (✉) · A. Saritas · S. Aslan · Z. Cakir
Department of Emergency Medicine, Faculty of Medicine,
Ataturk University, 25090 Erzurum, Turkey
e-mail: mucahitemet@gmail.com

H. Acemoglu
Department of Medical Education, Faculty of Medicine,
Ataturk University, Erzurum, Turkey

The objective of this prospective study was to determine the extent of missed injuries of patients hospitalized with major trauma within a Turkish Level 1 ED. We also tried to identify the primary contributing factors leading to each missed injury and to determine their subsequent adverse short-term clinical outcomes.

Methods

Characteristics of the hospital

Erzurum is the largest city in the eastern part of Turkey. Ataturk University Training and Research Hospital is a unique trauma referral center in the eastern region with 1,150 beds. It provides healthcare services for the metropolitan Erzurum area and nine neighboring cities, giving it a population coverage of over three million. This institution meets the criteria of the American College of Surgeons for level one trauma centers. The number of trauma and major trauma (ISS > 16) cases per year is approximately 10,000 and 250, respectively. Neurosurgery and heart surgery is available for 24/7 h. An operating theater for trauma is available on request. Portable ultrasonography, echocardiography, and roentgenogram, and spiral computerized tomography are available 24/7 h in the ED. We also have facilities for performing laboratory analyses, and consultations from any department are possible.

General overview of trauma management in our hospital and in Turkey

In Turkey, trauma care in EDs is generally provided by general practitioners in state hospitals and emergency physicians in university hospitals. There are no trauma teams in any ED, nor is there any officially approved trauma surgery fellowship program in Turkey [6]. All trauma patients are initially examined (primary survey) by an “emergency medicine resident (EMR)” in our hospital. Following physical examination, imaging, and hematological tests, the EMR decides who to call to form the trauma team for the patient.

Study design and setting

This is a retrospective analysis of prospectively collected data on a cohort of trauma patients presenting to a level I trauma center in Turkey. The stated objectives of our study were to describe the rate of missed injuries in the ED, to identify risk factors for missed injuries, and to describe the adverse outcomes arising from the missed injuries.

For this study, the trauma team consisted of at least two physicians: an EMR and the physician who decided to

hospitalize the patient in his/her clinic. The consulted physicians came to the ED, evaluated the patients in the ED, and completed consultation forms. Thus, the primary and secondary physical examinations of trauma patients were performed by the EMR and the physician of the related clinic(s) (range = 1–7). The limits and durations of these examinations were not distinct. Following the decision for hospitalization, based on the physical and laboratory examinations, the EMR completed the standardized data-collection form modified from the document prepared by Soundappan et al. [3], before onward transfer from the ED. The EMR also used information from the consultation forms while filling in the collection form. This secondary form was not completed at any consistent point in time or after review of imaging studies, because obtaining the review of imaging studies could lengthen filling in the form by up to one week. Thus, the EMR and consultant(s) had to interpret all the imaging studies of the trauma patients they evaluated. The Glasgow coma scale (GCS) and the updated abbreviated injury scale (AIS) [7] was used to calculate the trauma scores of the patients and both injury severity score (ISS) and new injury severity score (NISS) were defined for each patient. Patients who were considered for hospitalization were only enrolled, and the mentioned forms completed, after consideration for hospitalization. The completed form was submitted to two physicians (ME and AS) who did not know (blinded) the primary physicians of the patients. They compared the ED secondary survey results with ward documents, where the tertiary examination was performed, recorded the day of hospitalization, whether an operation was needed or not. Specific injuries for each AIS region and consultations were recorded for each patient. For patients with missed injuries, the reasons for each missed injury and total number of missed injuries were identified. The adverse short-term clinical consequences (secondary outcomes) of missed injuries were determined by carefully examining the patients’ records. For patients for whom the writers (ME and AS) were sure that the missed injury was the cause of the pain, additional surgery, longer hospital stay and death; these were recorded on the forms.

Definitions

A missed injury was defined as a clinically significant injury that was not discovered or suspected on admission to the ED, that was not documented in emergency records, admission notes, or consultation notes, but was identified after onward transfer from the ED and before the patient was discharged. Any injury that was not mentioned in the chart was considered a “missed injury”. Posttraumatic complications or late developed findings of trauma were not classified as a “missed injury”.

Trauma patients with GCS 3–8 were accepted as comatose patients [8]. Delay in radiological reporting was described as the delay in the radiological report until the patient left the ED.

Inclusion and exclusion criteria

All hospitalized trauma patients assessed in our hospital's ED from 24th of April 2008 to 25th of January 2009 (9 months) were included. There was no age limitation. Both penetrating and blunt trauma, and referred patients and initial presentations were included. Patients excluded from the study were those who died in the ED, were transferred to another hospital from the ED, were discharged home from the ED, and those who were still hospitalized (Fig. 1). Still hospitalized patients were

excluded because length of stay was also discussed between two groups and, as these patients were still being evaluated, a later identified missed injury might affect the findings. Operated trauma victims who were later transferred from another hospital to our ED for intensive care facilities or available service beds were excluded. Injuries that were missed at the time of hospital discharge and were evident only during longer follow up of patients with multiple traumas (for example, bile leak from bile duct injury, pseudoaneurysm formation evolving with a vascular injury) were excluded.

Ethics and statistics

Institutional review board approval was obtained for the study. Variables were expressed as numbers, percentages, median, and minimum and maximum values. Percentages were given with 95% confidence intervals (95% CI). The variables were analyzed by use of the software Statistical Package for Social Sciences (SPSS 11.5; SPSS, Chicago, IL, USA). Departure from normality was tested by use of the Kolmogorov–Smirnov test of goodness-of-fit. Statistical analysis of univariate data was performed by using the chi-squared test and the Mann–Whitney U test. Logistic regression was used to define factors affecting “missed injury”. Both demographic and clinical variables were entered into an automated binary logistic regression enter model from which odds ratio (OR) and 95% CI for variables with a p value <0.2 were obtained. The goodness-of-fit of the model was evaluated by calculation of the R^2 statistic, for which adjusted $R^2 = 0.301$ and the associated p value = 0.127. This suggests that the logistic model fitted the data very well. A p value of <0.05 was considered statistically significant.

Results

A total of 670 hospitalized trauma patients were included in the study (Fig. 1). The mechanisms of injuries were as follows: motor vehicle accident (MVA) (38%; 95% CI 34–42%), falls from heights (19%; 95% CI 16–22%), falls (15%; 95% CI 12–18%), firearm injuries (8%; 95% CI 6–10%), edged weapon injuries (6%; 95% CI 4–8%), battering injuries (3%; 95% CI 2–4%), and others (10%; 95% CI 8–12%). The ISS and NISS scores were higher for those experiencing MVA than for patients injured by other mechanisms ($p < 0.0001$). Comparison of the characteristics of patients with and without missed injuries is shown in Table 1. Results from multiple logistic regression analysis showing the predictors of missed injuries is presented in Table 2.

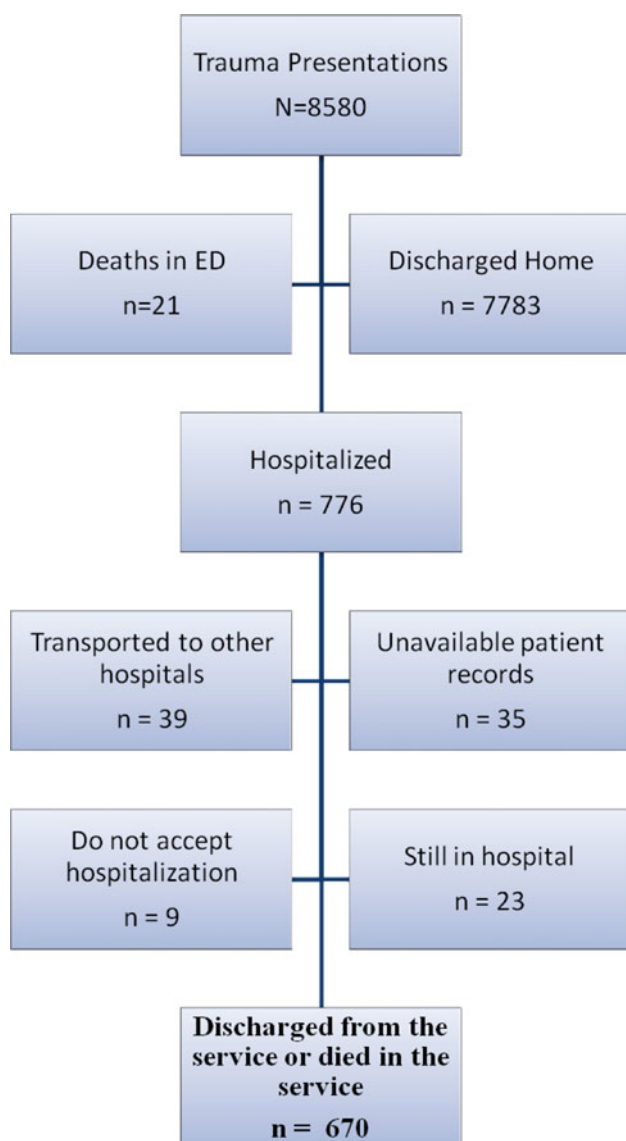


Fig. 1 Overview of study inclusion

Table 1 Patients' characteristics in the two groups

Characteristic	MI (<i>n</i> = 89)	No MI (<i>n</i> = 581)	<i>p</i> value
Median age (years)	36 (3–93)	28 (0.2–93)	0.0009
Male (%)	73.0 (63.8–82.3)	76.9 (73.6–80.4)	NS
MVA (%)	50.6 (50.5–70.8)	36.5 (32.6–40.4)	0.011
Fall from height (%)	15.7 (8.2–23.4)	19.4 (16.2–22.7)	NS
Median injuries per patient	3 (1–9)	1 (1–9)	<0.0001
GCS median	15 (3–15)	15 (3–15)	NS
Comatose patient (%) ^a	7.9 (2.3–13.5)	7.6 (5.5–9.8)	NS
ISS median	17 (4–61)	10 (2–43)	<0.0001
NISS median	17 (4–75)	11 (2–61)	<0.0001
Median seniority of ED physician (years)	3 (1–6)	5 (1–6)	<0.0001
Median number of consultant	3 (1–7)	2 (1–7)	<0.0001
Night shift (%)	55.1 (44.7–65.3)	53.4 (49.3–57.4)	NS
Median length of stay in ED (minutes)	160 (8–435)	100 (2–660)	<0.0001
Median hospitalization day	8 (1–36)	7 (1–121)	NS
Operation (%)	50.6 (40.2–61.0)	46.1 (42.0–50.0)	NS
Mortality (%)	13.5 (6.4–20.6)	6.5 (4.5–8.5)	0.020

Values in parenthesis are minimum and maximum values for median numbers and 95% CI values for proportions

MI, missed injuries; MVA, motor vehicle accident; GCS, Glasgow coma scale; ISS, injury severity score; NISS, new injury severity score; ED, emergency department; NS, not significant

^a Comatose patients are those with a GCS score of 3–8

Table 2 Multivariate logistic regression: predictors of missed injuries in hospitalized trauma patients

Characteristic	B	Adjusted OR	95% CI	<i>p</i>
Age	0.014	1.01	1.00–1.03	0.024
MVA	−0.053	0.95	0.56–1.62	0.846
Length of stay in ED	0.005	1.01	1.00–1.01	<0.0001
Seniority of ED physician	−0.301	0.74	0.63–0.87	<0.0001
Number of consultant	−0.183	0.83	0.64–1.08	0.172
Total number of injuries	0.556	1.74	1.38–2.20	<0.0001
ISS	0.094	1.10	1.03–1.18	0.008
NISS	−0.041	0.96	0.91–1.01	0.139
Death	−0.487	0.61	0.25–1.53	0.296

Variables entered: age, MVA, length of stay in ED, seniority of ED physician, number of consultant, total injury, ISS, NISS, and death

MVA, motor vehicle accident; ISS, injury severity score; NISS, new injury severity score; ED, emergency department; OR, odds ratio; CI, confidence interval

The most frequently consulted disciplines were orthopedics (51%; 95% CI 47–55%), neurosurgery (43%; 95% CI 40–47%), general surgery (25%; 95% CI 22–29%), and thoracic surgery (25%; 95% CI 22–28%). Of the patients, 46% (*n* = 308, 95% CI 42–50%) underwent a single consultation, 27% (*n* = 180, 95% CI 24–30%) underwent two, 16% (*n* = 110, 95% CI 14–19%) underwent three, 7%

(*n* = 48, 95% CI 5–9%) underwent four, 3% (*n* = 19, 95% CI 2–4%) underwent five, and 1% (*n* = 5, 95% CI 0.1–1.4%) underwent six or more consultations. Of patients with a missed diagnosis (*n* = 27, 95% CI 21–40%), 30% had not undergone a consultation at the relevant clinic of the missed diagnosis.

We found at least one missed diagnosis in 89 patients (incidence: 13.3%; 95% CI 6–20%). The number of missed injuries per patient was 1.64. The rate of missed diagnoses in all the injuries was 11% (146/1,290, 95% CI 10–13%) (Table 3). The anatomical location, specific types, and percentages of missed injuries are presented in Table 3. The most frequently missed diagnoses were injuries of the musculoskeletal system (38%; 95% CI 30–46%), followed by thoracic (24%; 95% CI 17–31%) and abdominal injuries (19%; 95% CI 13–25%). In 60% (95% CI 50–70%) of patients with missed diagnoses, the missed diagnosis was in the same anatomical localization as the trauma. The most frequently missed diagnoses were “lumbar fracture and/or dislocation” (*n* = 15), “maxillofacial fracture” (*n* = 14), and “hemothorax and/or pneumothorax” (*n* = 14). These became “clavicle fracture and/or dislocation” (35%; 95% CI 16–53%), “diaphragmatic laceration” (33%; 95% CI 20–87%), and “lumbar fracture and/or dislocation” (29%; 95% CI 17–41%) when the number of missed diagnoses according to the frequency of the specific injury was calculated (Table 3).

Table 3 Missed injury distribution and type

Injury	MI % (n/N)	Anatomic location MI % (n/N)
Skull fracture	5 (6/119)	Head and neck 4 (11/287)
Brain contusion	1 (1/80)	
ICH (subarachnoid, subdural, epidural)	4 (3/67)	
Cervical fracture and/or dislocation	5 (1/21)	Face 18 (16/91)
Maxillofacial fracture	21 (14/67)	
Eye injury	8 (2/24)	
Rib fracture	17 (13/75)	Thorax 15 (35/236)
Hemothorax and/or pneumothorax	20 (14/70)	
Pulmonary contusion	8 (4/51)	
Cardiac contusion and/or laceration	22 (2/9)	Abdomen/pelvic contents 15 (28/190)
Diaphragm laceration	33 (1/3)	
Thoracic fracture and/or dislocation	4 (1/28)	
Gastric and/or pancreatic contusion and/or laceration	0 (0/7)	Extremities/pelvic girdle 12 (56/486)
Splenic contusion and/or laceration	7 (2/28)	
Bowel perforation and/or laceration	13 (3/23)	
Liver contusion and/or laceration	5 (2/41)	
Kidney contusion and/or laceration	7 (1/14)	
Retroperitoneal hematoma	20 (5/25)	
Lumbar fracture and/or dislocation	29 (15/52)	
Humerus fracture and/or dislocation	2 (1/54)	
Radius and/or ulna fracture and/or dislocation	17 (8/46)	
Scapula fracture	26 (5/19)	
Clavicle fracture and/or dislocation	35 (9/26)	
Sternum fracture	0 (0/3)	
Pelvic fracture and/or dislocation	18 (14/79)	
Phalangeal and/or tarsal fracture-dislocation	13 (4/31)	
Tibia and/or fibula fracture and/or dislocation	8 (5/63)	
Femur fracture and/or dislocation	3 (3/97)	
Vascular injury	3 (1/29)	
Peripheral nerve injury	15(6/39)	
Total injury (n)	11 (146/1,290)	11 (146/1,290)

ICH, intracranial hemorrhage

The reasons for delayed diagnoses of injuries were multifactorial (Table 4). Radiological errors were prominent in almost 90% (95% CI 85–95%) of missed injuries. Delay in reporting and misinterpretations by clinicians (EMR and/or consultants) were common mistakes. Head injury or unconsciousness was the most common patient-related factor. In 82% (95% CI 74–90%) of patients with missed diagnoses, the diagnosis was made in the inpatient clinic using imaging tests such as X-ray and computerized tomography (CT), which were also available at the ED. Pain requiring analgesics was the most common condition caused by the missed diagnosis in these patients (49%; 95% CI 39–60%) (Table 4).

When patients with missed injuries were analyzed in detail, it was seen that missed injury caused additional hospital stay (30%; 95% CI 21–40%), additional surgery

was required (15%; 95% CI 8–23%), and missed injury caused death in two patients (2%; 95% CI –0.8–5.2%).

Discussion

All emergencies resemble each other at first sight, but each emergency has its own reasons for a missed diagnosis. The primary and secondary surveys outlined by the advanced trauma life support (ATLS) course [9] and the tertiary survey, first introduced by Enderson et al. [10], have helped to minimize the incidence of missed injuries. However, many injuries can still entirely escape detection at the hospital [11]. This prospectively collected data, that avoided using a subgroup but rather included all hospitalized trauma patients presenting to the ED, has provided us with

Table 4 Contributing factors to diagnosing tool and outcome of the missed injuries

Patient related (%)	Nil	60.3
	Head injury or unconsciousness	28.2
	Intubation	10.7
	Language	0.8
Radiological error (%)	Nil	11.5
	Inadequate view	4.6
	Failure to X-ray	19.1
	Misinterpretation by clinician ^a	29.8
	Delay in reporting	35.1
How was missed injury realized? (%)	X-ray	43.5
	CT	38.9
	USG	0.8
	Laparotomy	4.6
	MRI	5.3
	Other	6.9
Outcome of injury (%)	Nil	6.1
	Pain	48.9
	Restricted range of motion in extremity	8.4
	Complication	6.1
	Prolongation of hospitalization	30.5
	Death	2.2

CT, computerized tomography; USG, ultrasonography; MRI, magnetic resonance imaging

^a Misinterpretations by ED physician and consultant physician(s)

a more correct opinion for the extent and importance of the problem, compared with retrospective studies [4, 8, 11, 12]. The objective of this study was to explore a problem that has not been studied previously in a civil hospital in Turkey. Our rate of missed diagnosis (13.3%) was acceptable compared with rates reported in other studies (4.8–22%) performed in various countries [4, 8, 11, 13]. Notwithstanding, it is clearly evident that we have a very high rate of missed injury in this population.

We found that patients with missed injuries had significantly higher median age, more MVA accidents, more median injuries per patient, higher medians of ISS and NISS scores, longer lengths of stay in the ED, higher number of consultants, higher mortality, and a lower number of examinations by experienced senior ED physicians (Table 1). It has also been suggested in previous studies that missed diagnoses were higher in patients with higher ISS scores and longer lengths of stay in the ED [11, 13–15]. The reason for the longer length of stay in the ED for patients with missed diagnoses may be explained by the higher trauma scores, the larger number of injuries per

patient, and the larger number of consultations for these patients (Table 1). It has also been reported in previous studies that more trauma diagnoses were missed in patients with MVA as the trauma mechanism [3, 8, 14]. One reason for this may be that trauma scores are higher in those experiencing MVA than in patients injured by other mechanisms. Another reason may be that MVA crushes are specific blunt traumas which may cause harm to any body region especially if seat belts are not used. On the other hand, other blunt traumas, for example “fall from height”, have known trauma mechanisms and regions, for example calcaneus, femur, and lumbar fracture. In studies investigating the characteristics of patients with missed diagnosis, in addition to the reasons mentioned above, several other features included communication problems (foreigner, infant) [3], the patient being in the intensive care unit [16], the patient being directly dispatched to the operation room from the ED [16], ED admissions during the night time [17], misleading medical history [18], unconsciousness [18], intoxication [18], hemodynamic instability [18], and multiple injuries in the same extremity [18].

As a result of multivariate logistic regression analysis in our study, major predictors of missed injuries in hospitalized trauma patients were seniority of ED physician (OR 0.74, 95% CI 0.63–0.87), total number of injuries (OR 1.74, 95% CI 1.38–2.20), and ISS (OR 1.10, 95% CI 1.03–1.18) (Table 2). As the ED experience of physicians decreases, the probability of missed diagnosis increases, probably because of lack of knowledge and confidence of the physician in patient evaluation. In addition, difficult working conditions, more night duties, and seeing more patients during the first years may be other causes. Irrespective of the region of the trauma, total number of injuries was the major clinical predictor of missing injury. In the emergency setting for multiply injured patients, a fracture indicative of hospitalization may put a hold on further evaluation. This increases the likelihood that concurrent injuries will be overlooked even they exist in the same extremity [18, 19]. For that reason for the multiply injured, re-examining is the key to discovering missed injuries [13]. Another statement supported by the logistic regression analysis is that ISS seems to be a better predictor than NISS for missed injuries in trauma patients.

In 30% of patients with a missed diagnosis in this study, the patients had not undergone a consultation at the clinic relevant to the missed diagnosis. This may show that a trauma team approach which should include a previously determined number of specific physicians (as in developed countries) may reduce the number of missed injuries. On the other hand, even more alarming is the fact that the remaining 70% of patients with missed injuries obviously have been seen by the respective specialist. One possible reason was that the seniority of the consultants was low and

they were inexperienced. Another reason might be that they did not take possession of the trauma victim; they even sometimes think the EMR consulted them unnecessarily, and their prejudice is reflected in their notes.

Previous studies have shown that most missed diagnoses were located in the extremities and were musculoskeletal injuries [4, 8, 11, 13]. Missed diagnoses relating to the extremities and the musculoskeletal system were also significantly higher in number in our study (Table 3). However, when the ratio of missed injuries to the number of injuries in that region is considered, the percentage of missed injuries of the face, the thorax, and the abdomen was higher (Table 3). As the percentage of missed diagnoses according to anatomic regions was not calculated in previous studies, the authors suggest that the reason for the number of missed diagnosis being higher in the extremities was that the physician's focus being was primarily on visceral organs and neglected extremity traumas in trauma patients [11]. However, the reason may be because of the large number of traumas in the extremities and the musculoskeletal system, as it was in our study.

It is a known fact that for many missed injuries, it is impossible to discover which determinant was the main cause of delay in detection of the injury, and that multiple contributing factors can be ascribed to a single missed injury [11, 20]. In our study, radiological errors had a role in approximately 90% of patients with missed diagnosis. The most common radiological errors were "delay in reporting", "misinterpretation by the clinician", and "failure to X-ray". Many relevant studies have reported that "misinterpretation by the clinician or the radiologist" was the dominant radiological error [4, 11, 21, 22]. Incomplete imaging or low-quality imaging also had a considerable role in missed diagnoses [18]. Although analysis of the trauma X-rays by a consultant radiologist or reporting before the patient leaves the ED is ideal, neither of these currently occurs in our hospital, because of the increased workload of the radiologist. The period between admission and the formal radiology report may extend up to several weeks after admission in our hospital. In studies with a very low contribution of radiological error in missed diagnosis, difficult radiographs were reviewed by a consultant radiologist by means of telemedicine [3]. Thus, the formal reports of imaging investigations of patients should be prepared on time, preferably before the patient leaves the ED [4, 11].

The main limitation of this study is that, because of lack of available data about patients discharged from the ED, only admitted patients are evaluated. Those that were treated and released are excluded. Thus, this study only presents part of the picture. There was no follow-up of patients after discharge to determine whether they returned with a missed injury. The reliability of the determination

that the missed injury was identifiable in the ED and appropriate for evaluation in the ED was not taken into account, especially if the patient was unstable.

Conclusion

This study reveals the characteristics of missed injuries in our hospital and in our country. We found that major predictors of missed injuries in hospitalized trauma patients were seniority of ED physician, total number of injuries, and ISS. Because of radiological insufficiency and a missing trauma team, missed injuries entail longer hospitalization, additional surgery, and even death. Thus, our results highlight the need for a trauma team approach and the need for support of the radiological report in the ED. The main educational message is to stratify the diagnostic pathway in terms of multidisciplinary and online reporting of data/findings.

Conflict of interest statement None.

References

1. Gruen RL, Jurkovich GJ, McIntyre LK, Foy HM, Maier RV. Patterns of errors contributing to trauma mortality. Lessons learned from 2594 deaths. *Ann Surg.* 2006;244:371–80.
2. Evans R. Trauma misdiagnosis in the emergency unit. *Clin Risk.* 2003;9:175–8.
3. Soundappan SV, Holland AJ, Cass DT. Role of extended tertiary survey in detecting missed injuries in children. *J Trauma.* 2004;57:114–8.
4. Kalemoglu M, Demirbas S, Akin ML, Yildirim I, Kurt Y, Uluutku H, et al. Missed injuries in military patients with major trauma: original study. *Mil Med.* 2006;171:598–602.
5. Gedeberg R, Thiblin I, Byberg L, Wernroth L, Michaëlsson K. The impact of clinically undiagnosed injuries on survival estimates. *Crit Care Med.* 2009;37:449–55.
6. Taviloglu K, Ozdogan M. Current trends in trauma education and thoughts about emergency surgery in Turkey. *Isr J Emerg Med.* 2008;8:15–9.
7. Committee on injury scaling. Abbreviated injury scale (AIS) 2005—update 2008 manuals. Des Plaines: Association for the advancement of automotive medicine; 2008.
8. Houshian S, Larsen MS, Holm C. Missed injuries in a level 1 trauma center. *J Trauma.* 2002;52:715–9.
9. American College of Surgeons Committee on Trauma. Initial assessment and management. In: Advanced trauma life support reference manual. Chicago: American College of Surgeons; 1994. p. 17–37.
10. Enderson BL, Reath DB, Meadors J, Dallas W, DeBoo JM, Maull KI. The tertiary trauma survey: a prospective study of missed injury. *J Trauma.* 1990;30:666–70.
11. Buduhan G, McRitchie DI. Missed injuries in patients with multiple trauma. *J Trauma.* 2000;49:600–5.
12. Thomson CB, Greaves I. Missed injury and the tertiary trauma survey. *Injury.* 2008;39:107–14.
13. Brooks A, Holroyd B, Riley B. Missed injury in major trauma patients. *Injury.* 2004;35:407–10.

14. Janjua KJ, Sugrue M, Deane SA. Prospective evaluation of early missed injuries and the role of tertiary trauma survey. *J Trauma*. 1998;44:1000–7.
15. Rizoli SB, Boulanger BR, McLellan BA, Sharkey PW. Injuries missed during initial assessment of blunt trauma patients. *Accid Anal Prev*. 1994;26:681–6.
16. Biffl WL, Harrington DT, Cioffi WG. Implementation of a tertiary trauma survey decreases missed injuries. *J Trauma*. 2003;54:38–44.
17. Okello CR, Ezati IA, Gakwaya AM. Missed injuries: a Ugandan experience. *Injury*. 2007;38:112–7.
18. Stanescu L, Talner LB, Mann FA. Diagnostic errors in poly-trauma: a structured review of the recent literature. *Emerg Radiol*. 2006;12:119–23.
19. Ward WG, Nunley JA. Occult orthopaedic trauma in the multiply injured patient. *J Orthop Trauma*. 1991;5:308–12.
20. Furnival RA, Woodward GA, Schunk JE. Delayed diagnosis in pediatric trauma. *Pediatrics*. 1996;98:56–62.
21. Kremli MK. Missed musculoskeletal injuries in a university hospital in Riyadh: types of missed injuries and responsible factors. *Injury*. 1996;27:503–6.
22. Clarke DL, Gouveia J, Thomson SR, Muckart DJ. Applying modern error theory to the problem of missed injuries in trauma. *World J Surg*. 2008;32:1176–82.