A criteria-directed protocol for in-hospital triage of trauma patients

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Objective **To better match hospital resources to patients' needs of trauma care, a protocol for facilitating in-hospital triage decisions was implemented at a Swedish level I trauma centre. In the protocol, physiological parameters, anatomical injuries and mechanism of injury were documented, and used to activate full or limited trauma team response. The aim of this study was to evaluate the efficacy of the criteria-directed protocol to determine in-hospital trauma triage in an emergency department.**

Methods **Level of triage and triage rates were compared before and after implementation of the protocol. Overtriage and undertriage were assessed with injury severity score higher than 15 as the cutoff for defining major trauma. Medical records for undertriaged patients were retrospectively reviewed.**

Results **In 2011, 78% of 1408 trauma team activations required full trauma response, with an overtriage rate of 74% and an undertriage rate of 7%. In 2013, after protocol implementation, 58% of 1466 trauma team activations required full trauma response. Overtriage was reduced to 52% and undertriage was increased to 10%. However, there were no preventable deaths in the undertriaged patients.**

Conclusion **A criteria-directed protocol for use in the emergency department was efficient in reducing overtriage rates without risking undertriaged patients' safety.** ***European Journal of Emergency Medicine*** **25:25–31**

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Keywords: emergency care, injury, overtriage, trauma team activation, undertriage

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Introduction

Trauma is the most common cause of death in young adults in Sweden, as in most of the developed countries in the world [1,2]. Patient outcome is highly dependent on the level of care provided after the injury [3,4]. To reduce the risk of death or disability after trauma, correct triage is essential [5]. Triage is the prioritization of patients' care, on the basis of the severity, type and nature of the injury together with available resources, to identify patients in need of immediate assessment and intervention. Criteria for trauma triage are based on physiological parameters, specific anatomical injuries and the underlying mechanism of injury (MOI). Triage is used in prehospital and in-hospital settings. In-hospital triage of trauma victims is used for directing patients to an adequate level of care in the hospital. The alarm-activating process of the local trauma team is pivotal for subsequent assessment and treatment of the patient [6,7].

Monitoring 'overtriage' and 'undertriage' can be used as an indication of trauma care quality. Overtriage occurs when minimally injured patients are triaged to a higher level of care and full trauma team treatment. Overtriage may lead to an overconsumption of human and financial resources [6]. A consequence of overtriage is that the full trauma team personnel are called from other urgent activities and therefore other critically ill nontrauma patients' care may be less prioritized [8]. Undertriage occurs when the severity of the injury is underestimated and seriously injured patients are triaged to a lower level of care. Undertriage is a medical problem and may increase the risk of disability or death. The effort to keep undertriage low often leads to a higher overtriage rate. According to the American College of Surgeons Committee of Trauma recommendations, an undertriage rate of no more than 5% and overtriage rates up to 25–35% can be acceptable [6].

To avoid high overtriage rates, most trauma centres use a two-tiered triage criteria system. This system aims to select trauma patients with affected physiology and specific anatomic injuries to full trauma team activation (TTA+) including assessment and treatment by a multi-professional team. Trauma patients presenting with MOI

criteria only will activate a limited trauma team (TTA−). MOI criteria alone have been shown to have a low predictive value for the detection of severe injuries [7,9–11]. Low rates of correct triage and high overtriage rates are a common problem in trauma centres in Scandinavia and interventions to improve correct triage have been warranted [12–17].

We hypothesized that a triage protocol for directing trauma patients to the correct level of care reduces overtriage, maintains low undertriage rates and improves correct triage. We investigated the efficiency of a triage protocol by comparing the number of patients assigned to overtriage and undertriage level before and after implementation of the protocol. We also investigated whether undertriaged patients were subjected to an increased risk of adverse clinical outcome because of protocol implementation.

Methods

Study design

A before and after design was applied to compare correct triage rates before (2011) and after (2013) implementation of a criteria-directed protocol. To control for the confounding effects of protocol development, revision and implementation, data from 2012 were omitted.

Setting

Karolinska University Hospital, Solna, in Sweden is the primary trauma centre in the region (level I) and serves about 2.5 million inhabitants. Annually, around 1500 patients are admitted to the hospital because of traumatic injuries. Approximately 300 of these patients are severely injured injury severity score (ISS) > 15. The hospital adapted a two-tiered triage criterion in 2006, with TTA+ or TTA−. TTA+ leads to immediate transfer to the trauma bay, where a full multiprofessional team, consisting of at least one trauma surgeon, an anaesthesiologist, an orthopaedic surgeon, a nurse anaesthetist, a theatre nurse, an emergency department (ED) nurse, a radiologist, a radiology nurse, a theatre nurse assistant and an ED nurse assistant, will assess and treat the patient. For TTA−, the patient is assessed and treated in the ED by a team consisting of ED physicians and ED nurses. This model is commonly used in Scandinavian countries [18,19]. The trauma bay and ED are located on different floors because vicinity to the operating theater and computed tomography scan is important for the severely injured trauma patient. The trauma bay is situated within the department of anaesthesia, surgical services and intensive care medicine, whereas the ED is part of the department of emergency medicine, with a different location and organization.

Before 2012, the prehospital unit reported preestablished criteria to the triage designated nurse in the ED. The triage responsible nurse decided what level of care to alert on the basis of prehospital information only. Criteria for trauma triage were at that time only present as guidelines in the local trauma manual, no formal support for triage decisions was at hand and there was no systematically recorded information on trauma patients.

In 2012, a protocol was developed and implemented in the ED. The protocol included criteria for trauma triage on the basis of physiological parameters, specific anatomical injuries and MOI. In the protocol, guidelines from the trauma manual were clarified and explicitly defined as follows: 'afflicted Glasgow Coma Scale (GCS)' was specified as GCS less than 14, 'instable blood pressure' was defined as 'systolic blood pressure less than 90 mmHg' and 'afflicted breathing' was defined as respiratory rate (RR) less than 10 or higher than 29. Each criterion was evaluated, formally documented in the protocol and rendered in a recommendation of TTA level, TTA+, or, TTA− (Fig. 1). Protocol criteria were divided into two sections: (a) criteria for physiological parameters and specific anatomic injuries (upper box) and (b) MOI criteria (lower box). If one or more criteria for physiological parameters and specific anatomical injuries were fulfilled, full trauma team was activated and the limited team was activated if only one or more of MOI criteria was fulfilled (Fig. 1).

In 2013, the protocol was used to determine whether full or limited team was to be activated. To ensure that triage was maintained at a safe level, peer review of undertriaged patients was performed by a group of clinicians including a trauma surgeon, an anaesthesiologist and two nurse anaesthetists with extensive experience of trauma triage and treatment of trauma patients.

Patients

All trauma patients at least 15 years old admitted to the hospital who were either (a) treated at the trauma unit, (b) arriving with ambulance or helicopter as priority one alert after trauma or (c) retrospectively found to have an ISS more than 9 were included in a trauma registry and included in the study. The local trauma registry is considered to be a complete registry with validated criteria [20].

Trauma patients admitted to the hospital from 1 January to 31 December 2011, when no protocol for trauma triage was used, were compared with trauma patients from 1 January to 31 December 2013, when the protocol had been implemented. Trauma patients transferred from other hospitals or patients admitted to neurosurgery or neurointensive care were excluded because they were not exposed to trauma triage and had a separate track to immediate care in the hospital facility (Fig. 2).

Outcome and triage definitions

Primary endpoints were overtriage and undertriage rates. We used ISS on the basis of the Abbreviated Injury Scale [21,22]. Overtriage was considered present when trauma patients with minor injuries (ISS < 15) were triaged to the

Fig. 1

Category	Exact criteria	Yes
Vital functions	1. Airway obstruction/intubated	☐
(activates full team)	2. Respiratory rate <10 or >29	☐
	3. Systolic blood pressure <90 or unstable	☐
	4. GCS < 14 or reduced consciousness	☐
Specific anatomic injuries	1. Penetrating violence towards head, neck, torso, proximal to elbow or knee	☐
(activates full team)	2. Two or more proximal long-bone fractures	☐
	3. Suspected pelvic fracture	☐
	4. Flail chest	☐
	5. Extremity paralysis caused by trauma	☐
	6. Amputation proximal to wrist or ankle	☐
	7. Combination of trauma and burns/drowning/hypothermia	☐
Mechanism of injury	1. Car-crash >70 km/h belted or air-bag	☐
(activates limited team)	2. Car-crash >50 km/h not belted or air-bag	☐
	3. Motor cycle-crash	☐
	4. Patient stuck in car, car turned over	☐
	5. Patient ejected, death in the same vehicle	☐
	6. Pedestrian or bicyclist run over by motor vehicle	☐
	7. Falls >3 m	☐
	8. Crushing over torso	☐
Selected trauma level:	Full team	Limited team

The criteria-directed protocol. If one or more of the criteria in the upper box was fulfilled, the full trauma team was activated. The limited trauma team was activated if one or several criteria in the lower box were present, but none in the upper box.

full trauma team treatment. Undertriage was defined as severely injured patients with ISS more than 15 triaged to a limited trauma team treatment. In this study, ISS greater than and less than 15 was used as a cut-off point to calculate overtriage and undertriage retrospectively [23].

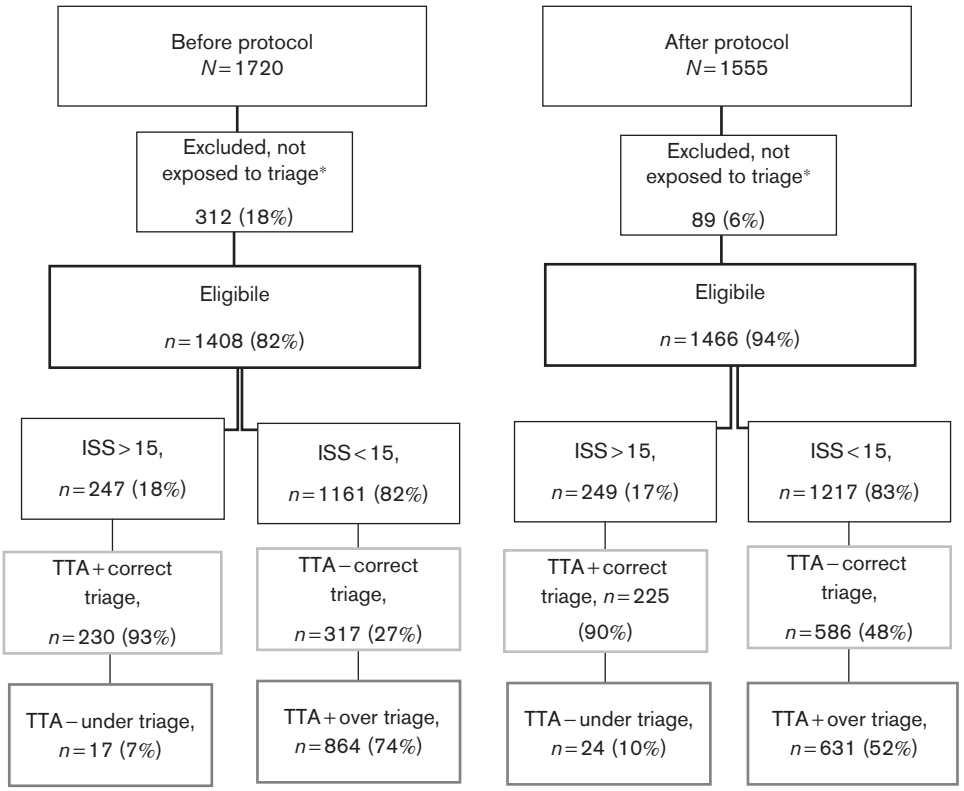
Data collection

Patient characteristics and trauma-related data such as systolic blood pressure, RR, GCS, type of injury (blunt or penetrating), TTA level, ISS and mortality at discharge from hospital were obtained from the local trauma registry. Comorbidity was assessed as American Society of Anaesthesiology-scale (1–6). In 2013, protocols were consecutively collected from the ED.

Statistics

Data were reported as median and interquartile range. Student's *t*-test, the Mann–Whitney *U*-test and Fischer's

Fig. 2



Flow chart of included patients. *Patients transferred from other hospitals or patients admitted to neurosurgery or neurointensive care not exposed to trauma triage having a separate track to immediate care in the hospital. ISS, injury severity score (1–75); TTA+, full trauma team activation; TTA−, limited trauma team activation.

exact test were used to compare continuous and categorical variables, where appropriate. According to injury severity and full or limited trauma team response, patients were categorized into correct triage, overtriage and undertriage. Triage rates were calculated and compared between groups using an intention-to-treat approach. Thus, all triaged patients, irrespective of the existing protocol, were included in the analysis. Undertriage was calculated as 1 − sensitivity, where sensitivity was the probability of assignment of a full team to the seriously injured patient (ISS > 15) and overtriage was 1 − specificity defined as the probability of a limited team to the less injured patient (ISS < 15). A *P*-value of less than 0.05 was considered statistically significant. Statistical analyses were carried out using Graph Pad Prism, version 5.03 (Graph Pad Software, La Jolla, California, USA) and IBM SPSS statistics V22 (IBM Corp., Armonk, New York, USA).

Ethics

The study was approved by the regional Ethical Review Board in Stockholm, Sweden. (Ethical approval Dnr: 2010/1065-31/1 and 2012/1965-32).

Results

The number of patients before and after the protocol was 1408 and 1466, respectively. Patient characteristics and trauma-related data were similar in the two groups, except for the fact that trauma patients before the protocol had significantly less comorbidity and lower GCS at hospital admission ($P < 0.05$). In both groups, the majority of patients were men (70 and 69%), with a median age of 39 and 40 years. Trauma was mostly blunt (91 and 90%) (Table 1).

Before the protocol, 78% ($n = 1094$) of patients were triaged to TTA+. The sensitivity for correct trauma triage in 2011 was 230/247 (93%) and the specificity was 297/1161 (26%) (Table 2). The overtriage rate for these patients was 74% and the undertriage rate was 7%.

In 2013, 84% ($n = 1231$) of the patients were triaged by protocol in the ED. In 72% ($n = 1056$) of the protocols, TTA+ or TTA− was documented and criteria were followed. Thus, documentation was incomplete in 28% ($n = 410$). In 2013, 58% ($n = 856$) were triaged to TTA+. The sensitivity for correct trauma triage was 225/249 (90%) and the specificity was 586/1217 (48%) (Table 2). The introduction of the criteria-directed protocol for

Table 1 Characteristics of the patients included

Category	Before protocol ($N=1408$)	After protocol ($N=1466$)	P-value
Men [*n* (%)]	981 (70)	1006 (69)	NS
Age (years) [median (IQR)]	39 (25–55)	40 (26–57)	NS
ASA 1–2 [*n* (%)]	1303 (93)	1296 (88)	<0.05
ISS [median (IQR)]	5 (1–12)	5 (1–10)	NS
SBP (mmHg) [median (IQR)]	140 (126–158)	140 (125–159)	NS
RR [median (IQR)]	18 (14–20)	17 (14–20)	NS
GCS [median (IQR)]	15 (14–15)	15 (15–15)	<0.05
Blunt trauma [*n* (%)]	1288 (91)	1324 (90)	NS
Mortality [*n* (%)]	72 (5)	54 (4)	NS

Mortality within 30 days after trauma.
ASA, American Society of Anaesthesiologist physiological status (1–6); GCS, Glasgow Coma Scale; IQR, interquartile range; ISS, injury severity score (1–75); NS not significant; RR, respiratory rate; SBP, systolic blood pressure.
$P<0.05$ is considered statistically significant.

Table 2 Comparison of injury severity with trauma team activation

	Before protocol (2011)			After protocol (2013)		
	ISS > 15	ISS < 15	Total	ISS > 15	ISS < 15	Total
TTA+	230 (*a*)	864 (*b*)	1094	225 (*a*)	631 (*b*)	856
TTA−	17 (*c*)	297 (*d*)	314	24 (*c*)	586 (*d*)	610
Total	247	1161	1408	249	1217	1466
Sensitivity (%)	93			90		
Specificity (%)	26			48		

Sensitivity, $a/(a+c)$, specificity, $d/(b+d)$.
ISS, injury severity score (1–75); TTA+, full trauma team activation; TTA−, limited trauma team activation.

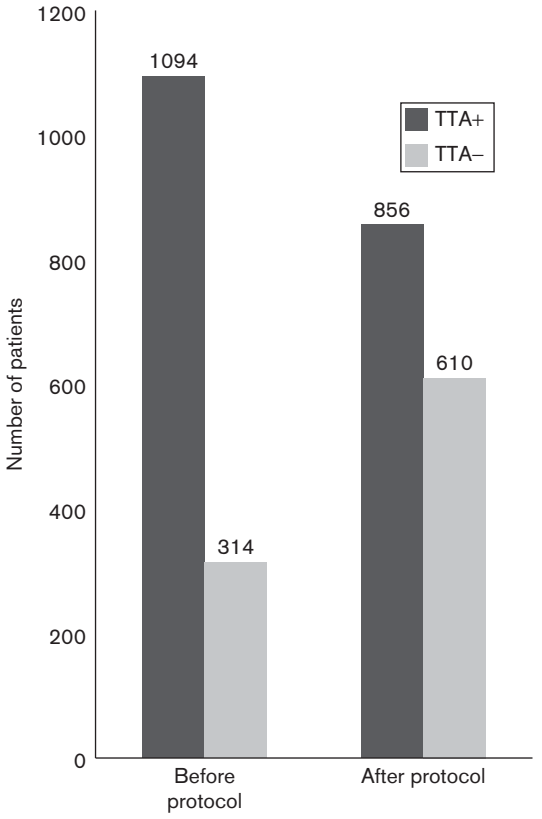
Table 3 Characteristics of undertriaged trauma patients

	Before protocol ($N=17$)	After protocol ($N=24$)	P-value
Men (*n*)	14	14	NS
Age (years)	70 (38–79)	60 (44–80)	NS
ASA 1–2 (*n*)	13	18	NS
ISS	19 (17–25)	17 (17–21)	NS
Blunt violence (*n*)	17	23	NS
Mortality (*n*)	1	2	NS

Data presented as median and interquartile range or numbers.
Mortality within 30 days after trauma.
ASA, American Society of Anaesthesiologist physiological status (1–6); ISS, injury severity score (1–75), NS, not significant.
$P<0.05$ is considered statistically significant.

in-hospital triage reduced the overtriage rate to 52%. However, undertriage rates increased to 10%. Of 24 undertriaged patients, three were retrospectively found to be misclassified cases: one patient with an unrecognized increase in RR to 40, one patient had penetrating head injury and one case was a failure to reveal a GCS of 13. These patients were misclassifications triaged to the limited trauma team. Detailed review of the misclassified patients and the 21 undertriaged patients' medical charts did not indicate any adverse outcome or preventable deaths. On comparing characteristics and trauma-related data for undertriaged patients before and after protocol implementation, no significant differences were found (Table 3). As a consequence of protocol implementation, the number of patients triaged to TTA+ was reduced from 78% ($n=1094$) to 58% ($n=856$). However, the number of patients treated at the ED increased from 314 (22%) to 610 (42%) ($P<0.05$) (Fig. 3).

Fig. 3



Trauma team activation. TTA+, full trauma team activation at the trauma bay; TTA−, limited trauma team activation in the emergency department.

Discussion

Implementation of a criteria-directed protocol as a tool for determining trauma alert level reduced overtriage by almost one-third and the undertriage rate increased from 7 to 10%.

Even though the criteria-directed protocol reduced the overtriage rates to 52%, it still exceeds the American College of Surgeons Committee of Trauma recommendation of 25–35% [6]. One explanation for the high overtriage rate may be that the cutoff level for overtriage and undertriage was based only on ISS. Physiological variables are highly important for TTA and triage, but were not taken into account in this study as it is not included in the ISS score [24]. ISS as a measure for overtriage and undertriage has been criticized as ISS more than 15 alone does not necessarily mean that patients are in need of full TTA. Still, patients with ISS less than 15 may be in immediate need of other urgent interventions such as surgery or radiographs. A discrepancy has been described between patients who actually need the highest level of care and those according to a retrospective calculation of ISS are expected to need the highest level of care [25,26]. It has also been suggested that a composite outcome of ISS together with urgent interventions, ICU-admission or emergent surgery would be a more accurate method for calculating overtriage and undertriage [17,27]. In this study, we chose ISS more than 15 as a cutoff to facilitate comparisons with results from previous studies in this field. However, another option could have been to use ISS more than 12 as a cutoff for major trauma definition according to the updated version of AIS version 2005 update 2008 [28]. The high overtriage rate may also be explained by the case mix of trauma patients at our hospital. In Sweden, drug abuse is an independent predictor for trauma [29]. An intoxicated or drug-influenced patient with GCS more than 14 leads, according to the protocol criteria, to full TTA, even though he or she only suffers from minor injuries,.

For an even better concordance between major trauma and care level and to further reduce overtriage rates, the criteria might need to be renewed. Another option to improve trauma triage would be to establish the use of a third group of criteria for those who may not necessarily need to be triaged to a full trauma team, but are in need of a fast-track treatment such as elderly patients, pregnant women or patients with major somatic comorbidities [30]. International trauma research presents different methods for calculating overtriage and undertriage rates. A uniform definition and terminology would facilitate national and international comparisons of trauma triage rates between centres [20,24,25,31,32].

Limitations

Triage is a difficult task requiring experienced staff and having the exact criteria at hand as a check list or protocol when activating the trauma team may facilitate triage decisions [33]. In this study, 74% of the protocols were completed, which indicates that further efforts to improve documentation in the ED are needed. Continuous training and feedback are valuable to improve adherence to protocol use [34]. To minimize the influence of missing protocols, we carried out the sensitivity and specificity analysis according to intention to treat. However, possible bias caused by missing protocols cannot be entirely removed. In this study, no psychometric validation of the protocol was made, but is suggested before wider use of the protocol.

Peer review may be considered a subjective measure, but the evaluation of undertriaged patients was performed by a multidisciplinary group, followed by a consensus discussion.

Having the trauma bay and ED on separate floors, with the organizational problems that it may entail, may also influence the result of the study. Finally, being a single-centre study with a certain case mix may limit the generalizability of the study.

Conclusion

A criteria-directed protocol for use in the ED was efficient in reducing overtriage rates without risking undertriaged patients' safety. The redistribution of patients being more correctly triaged provides us with a possibility to improve patient care and allocation of resources for a better match to patient needs.

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Conflicts of interest

There are no conflicts of interest.

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