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ORIGINAL ARTICLE

The yield of tertiary survey in patients admitted for observation after trauma

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Abstract

Purpose Existing literature on trauma tertiary survey (TTS) focusses on multitrauma patients. This study examines the yield of the TTS in trauma patients with minor (AIS 1) or moderate (AIS 2) injury for which immediate hospitalization is not strictly indicated.

Method A single center retrospective cohort study was performed in a level II trauma center. All hospitalized trauma patients with an abbreviate injury score (AIS) of one or two at the primary and secondary survey were included. The primary outcome was defined as any missed injury found during TTS (Type 1). Secondary outcomes were defined as any missed injury found after TTS but during admission (Type 2); overall missed injury rate; mortality and hospital length of stay.

Results Out of 388 included patients, 12 patients (3.1%) had a type 1 missed injury. ISS and alcohol consumption were associated with an increased risk for type 1 missed injuries (resp. OR = 1.4, OR = 5.49). A type 2 missed injury was only found in one patient. This concerned the only case of trauma related mortality. Approximately one out of five patients were admitted for more than 2 days. These patients were significantly older (66 vs. 41 years, $p < 0.001$), had a higher ISS (4 vs. 3, $p = 0.007$) and ASA score, 3–4 vs. 1–2 (42.5% vs. 12.6%, $p < 0.001$).

Conclusion TTS showed a low rate of missed injuries in trauma patients with minor or moderate injury. TTS helped to prevent serious damage in two out of 388 patients (0.5%). ISS and alcohol consumption were associated with finding missed injury during TTS.

Keywords Trauma · Missed injury · Tertiary survey · Patient safety · Quality of care

Introduction

The Advanced Trauma Life Support (ATLS), as developed by the American College of Surgeons, is a worldwide method for the first treatment of trauma patients. At first, the ATLS approach included two systematic surveys for early diagnosis of both life-threatening and non-life-threatening injuries. During the primary survey, life-threatening conditions are identified and treated in a prioritized sequence (ABCDE). The secondary survey is a more thorough head-to-toe examination with the initiation of definitive care [1]. However, in some trauma patients, these two surveys sometimes fail to identify all sustained injuries. Missed injuries are seen in 1–9% trauma patients after the primary and secondary survey [2, 3]. Possible explanations for missing injury at the primary and secondary survey could be the stressfull environment at the emergency department, the complexity of some of the injuries or an altered level of the patients' consciousness.

An additional Trauma Tertiary Survey (TTS), which comprises an in-hospital general physical re-examination and a review of all diagnostic investigations within 24 h, proofed to be successful in reducing the number of missed injuries in multitrauma patients: patients with an Injury Severity Score (ISS) higher than 16 [4–10].

Studies describing the TTS mainly focus on multitrauma patients (ISS ≥ 16). However, trauma patients with an ISS

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scores < 16 are frequently admitted to the hospital for the treatment of minor injury, social reasons or just for observation after a high energy trauma. Since the tertiary survey is also performed in these cases, even when no injury is found during the primary and secondary survey. The aim of this study was to investigate the outcome of the TTS in this group. Hospitalization raises healthcare costs, the chance of hospital-acquired infections, delirium and other complications [11–13].

We hypothesized that the performance of a TTS in this group might not be beneficial.

Methods

Study design

We performed a single center retrospective cohort study at a level 2 trauma center in the Netherlands. The study was approved by the hospital's ethical committee (N2020-0310).

Patients

All trauma patients, admitted to our hospital between 2015 and 2018, were included when only minor or moderate injury was found during primary and secondary survey. Injury was classified according to the Abbreviated Injury Scale (AIS) Table 1 [14]. Minor injury (AIS = 1) was defined as injury for which no operative treatment is needed (e.g., superficial laceration, fracture of the nose, rib contusion). Moderate injury (AIS = 2) was defined as injury for which no immediate treatment was required (e.g., olecranon fracture, patella fracture, distal radius fracture). Reasons for admission could be: no severe injuries found at the primary or secondary survey, but admission just for observation after a high energy trauma; minor injury without requiring immediate in-hospital treatment, but no sufficiënt home care.

Trauma care was provided following ATLS guidelines. All patients were first received at the emergency department's trauma bay, here the primary survey were performed as soon as the patient arrived; a prioritized structured way to identify and treat life-threatening injuries directly (ABCDE). If a patient was stable and the necessary adjuncts had been performed (e.g., X-chest, X-pelvis), the patient was moved to a regular emergency room, where a secondary survey took place (within 1 h after admission): a thorough head-to-toe examination to identify all injuries. The tertiary survey was performed within 24 h after admission on the hospital ward. It comprises a general fysical re-examination and review of al investigations, including blood results and imaging, [1].

Data collection

Demographics collected were: age, gender, BMI, Injury Severity Score (ISS) [15], America Society of Anesthesiologists (ASA)-score [16], mechanism of injury, alcohol consumption (defined as a promillage of ≥ 0.5 at time of admission at the ER), days of admission, missed injuries and trauma related mortality. All patient data was anonymized to guarantee patient privacy. We dichotomized hospital length of stay with a cut-off point at 2 days to investigate which factors contribute to an unexpected prolonged admission. Although the TTS was performed within 24 h, the cut-off point was set at 48 h for a more reliable distinction between long hospitalized patients and patients who just exceeded the 24-h window due to—for example—transport problems or post-discharge placement issues.

Outcome measures

The primary outcome measure in this group was defined as the yield of the tertiary survey, meaning the total number and type of missed injuries found during TTS within 24 h after admission (Type 1 missed injury [2]). All injuries found after primary and secondary survey and within 24 h after admission were defined as type 1 missed injury. Secondary outcome measures were defined as missed injuries found after TTS but during the hospital admission (Type 2 missed injury [2]); overall missed injury rate (Type 1 and 2 combined); hospital length of stay; and trauma related mortality. Missed injuries were also classified according to the Abbreviated Injury Scale (AIS) Table 1.

Table 1 Abbreviated injury scale (AIS)

1. Minor	Injury for which no treatment is needed (e.g., superficial laceration, fracture of the nose, rib contusion)
2. Moderate	Injury for which only outpatient treatment was required (e.g., olecranon fracture, distal radius fracture, 1–3 costal fractures without pneumothorax or hematothorax)
3. Serious	Injury which requires in-hospital Non-ICU treatment. (e.g., open fracture of the humerus, > 3 rib fractures without flail chest, abdominal organ contusion)
4. Severe	Injury which requires ICU observation and/or basic treatment. (e.g., perforated trachea, ruptured spleen, chest-wall perforation)
5. Critical	Injury which requires intubation, mechanical ventilation or vasopressors for blood pressure support. (spinal cord transection, deep laceration of kidney of liver)
6. Maximal	Not survivable. (e.g., decapitation, torso transection)

Patients who underwent surgery during the same admission for any AIS one or two trauma related injury, were excluded for the hospital length of stay analysis, because of the assumption that this direct operative care could result in a longer hospital length of stay. Surgery in this group was defined as surgery performed for injury with an AIS of one or two; meaning that the injury did not require immediate surgery and cosurgery and could have been performed in an elective setting.

Data analysis

Statistical analysis was performed with SPSS version 25 (IBM Corp., Armonk, NY) for Mac. Non-parametric data was reported as medians noted with interquartile range. Differences between the study groups were tested for statistical significance. Fisher's exact tests were used for categorical data and Mann–Whitney-*U* tests for continuous variables, as all variables were non-normally distributed. Univariable logistic regression analysis was used to identify possible predictors for a positive TTS.

Results

Between 2015 and 2018, a total of 4968 trauma patients were admitted to our hospital, 388 patients were included in this study (Fig. 1). Median age was 44 years [IQR 24.00, 64.0] and 136 patients (38.3%) were female. The median BMI was 25.00 [IQR 22.00, 28.00], 252 patients (64.9%) had an AIS of 1 and the median ISS was 2.00 [IQR 1.00, 4.00]. Sixty-five patients (18.3%) had an ASA 3 or 4 score and 25 (7.0%) had consumed alcohol (promillage ≥ 0.5) at the time of admission at the ER. The most frequent mechanism of injury was a high-speed motor vehicle accident, this occurred in 159 (32.8%) patients (Table 2).

Type 1 missed injury

Twelve patients (3.1%) had a type 1 missed injury. Ten injuries were classified as moderate injury (AIS: two) for which conservative treatment was initiated as shown in Table 3. Two of these injuries were classified as severe (AIS: four) and had to be treated operatively. Both of these two patients had an AIS of 2 in two body regions (ISS of eight) at arrival and were admitted for observation because of rib-fractures. One patient showed a decrease of hemoglobin at the TTS, based on a leaking arteria mesenterica. The bleeding was coiled by the intervention radiologist, but a laparotomy was needed to clear the intraperitoneal hematoma. In the other patient, free air was seen during the reassessment of the CT-scan. Laparotomy showed a colon perforation for which a resection was performed with a primary anastomosis.

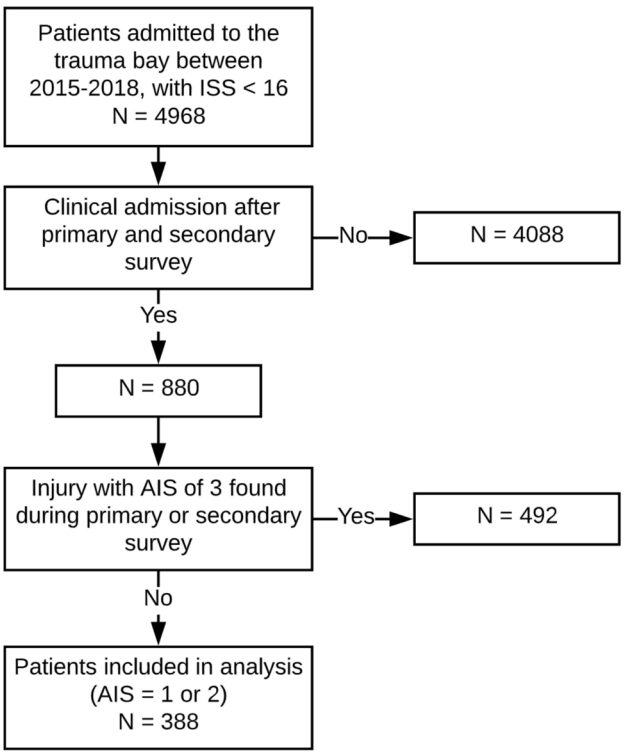

Fig. 1 Inclusion

Table 2 Mechanism of injury (%)

MVA high speed	159 (32.8%)
MVA moderate speed	4 (0.8%)
MBA	21 (4.3%)
Fall from height (> 1.5 m)	39 (8.0%)
Fall from standing height	37 (7.6%)
Pedestrian vs. car	8 (1.6%)
Cyclist vs. car	23 (4.7%)
Bike accident	28 (5.8%)
Fall from stairs	40 (8.2%)
Other	29 (6.0%)

MVA motor vehicle accident, High speed: > 30 km/h, Moderate speed: < 30 km/h

MBA motor bike accident

Compared to patients without type 1 missed injury, there was no significant difference in gender, BMI, AIS or hospital length of stay. The ISS and the use of alcohol were associated with higher rates of type 1 missed injuries (Table 4).

Type 2 missed injury, overall missed injury rate and mortality

There was only one case (0.3%) of a type 2 missed injury; a 65-year-old male after a high-speed motor vehicle accident

Table 3 Specifics of type 1 missed injuries found in this study

Patient	Mechanism	ISS on arrival	Missed Injury	Management	AIS
Male 72 years	Fall from height	8	Leakage of mesenteric artery	Operative	Severe (4)
Female 63 years	MVA high speed	8	Perforated colon	Operative	Severe (4)
Female 35 years	MVA high speed	2	Costal fractures (1–3)	Analgesia	Moderate (2)
Female 49 years	MVA high speed	9	Costal fractures (1–3)	Analgesia	Moderate (2)
Male 69 yeas	MVA high speed	1	Impressionfracture L2	Analgesia, fysiotherapy	Moderate (2)
Male 73 years	Fall from standing height	1	Costal fractures	Analgesia	Moderate (2)
Male 4 years	Pedestrian vs. car	1	Clavicula fracture	Immobilization (sling)	Moderate (2)
Male 18 years	Bike accident	5	Scaphoïd fracture	Immobilization (plaster)	Moderate (2)
Male 27 years	Fall from stairs	5	Patella fracture	Immobilization (lohmed)	Moderate (2)
Female 82 years	Fall from stairs	1	Metacarpal fractures	Immobilization (buddy-tape)	Moderate (2)
Male 51 years	Other	6	Femurfracture (lateral epicondyle)	Immobilisation (plaster)	Moderate (2)

MVA Motor vehicle accident, High speed: > 30 km/h

Table 4 Characteristics of type 1 missed injuries

	Negative TTS $N=376$	Positive TTS $N=12$	p	Odds ratio [CI]
Age mean (range)	47.00 [26.00, 63.00]	50 [21.75, 71.25]	0.883*	1.001 [0.977–1.026]
Gender = female (%)	147 (39.1%)	4 (30.8%)	0.772**	0.779 [0.230–2.633]
BMI [median (IQR)]	25.00 [22.00, 28.00]	24.00 [21.00, 27.00]	0.383*	0.924 [0.805–1.061]
AIS 2 (%)	130 (34.6%)	6 (50.0%)	0.357**	1.892 [0.598–5.984]
ISS [median (IQR)]	3.00 [1.00, 4.00]	5.00 [1.25, 7.50]	0.038*	1.389 [1.079–1.788]
Mortality	0	0		
ASA 3 and 4	66 (17.6%)	3 (23.1%)	0.454**	1.566 [0.413–5.940]
Alcohol = yes (%)	23 (6.1%)	3 (23.1%)	0.039**	5.116 [1.296–20.194]
Hospital length of stay*** [median (IQR)]	1.00 [1.00, 2.00]	1.50 [1.00, 6.75]	0.370*	1.153 [1.054–1.262]

TTS trauma tertiary survey, *MVA* motor vehicle accident, High speed: > 30 km/h, moderate speed: < 30 km/h

*Mann–Whitney-*U*-test

**Fisher's exact

(MVA). During the primary and secondary survey only a minor back injury was found (AIS of one). Tertiary survey showed no missed injury. The patient remained hospitalized because of general weakness without evidence of neurological or surgical pathology. Three days after admission he developed neurological symptoms (ataxia of the upper limbs en sensory loss of the lower limbs) and an MRI of the spine was made. It showed myelumcompression caused by anteroposition of cervical vertebrae six on seven (not detectable at the CT-scan performed at the ER). The patient was immediately transferred to a level 1 neurosurgical specialized hospital, were decompressive surgery of the cervical cord was performed in combination with a spondylodesis of cervical vertebrae 6 and 7. Despite this operative management the patient developed a tetraplegia and became dependant on mechanical ventilation. One month later the treatment was stopped because of the patient's wishes. This was the only case of trauma related mortality in this study. The overall missed injury rate in this study, type 1 and 2 combined, was 3.4%.

Hospital length of stay (≤ 2 days vs. > 2 days)

Out of the 388 patients, 20 underwent surgery (Table 5) during the primary admission and were therefore excluded for the hospital length of stay analysis. Of the remaining 366 patients, 73 patients (19.9%) were hospitalized for more than 2 days (Table 6). These patients were significantly older compared to patients who were admitted for 1 or 2 days (66 vs. 41 years old, $p > 0.001$), had a higher AIS (AIS = 2: 49.3% vs. 29.4%, $p = 0.002$) and ISS (4.00 vs. 3.00, $p = 0.007$) and also the ASA-score was significantly higher (ASA 3 and 4: 42.5% vs. 12.6%, $p > 0.001$). All other variables did not differ significantly.

Table 5 Surgery in included patients

Wound care/debridement	7
Fixation of radial fracture	4
Fixation of humeral fracture	2
Fixation of tibial fracture	2
Fixation of patella fracture	1
Fixation of clavicle fracture	1
Fixation of mandibular	1
K-wire fixation of metacarpal five fracture	2
Laparotomy	2
Total	22

Discussion

Tertiary Trauma Survey proofed to be succesfull in multitrauma patients, but less is known of its effectiveness in patients with minor trauma. The question arises whether the tertiary survey is usefull in this group and which factors contribute to the chance for missed injury. To our knowledge this is the first study reporting on the outcome of the tertiary survey in a trauma population without severe injury (AIS of ≥ 3) at the primary and secondary ATLS survey.

We observed 3.1% type 1 missed injury, this can be considered as low. In a systematic review conducted by Keijzer et al. [2] 4.3% type 1 missed injuries were found. However, they note that there was great heterogenity between the studies included in their review. Type 1 missed injury rates, varied from 1.5% to 19.3% (with an outlier of even 65%). Moreover, the two largest studies in this review [18, 19] (who included more than 9000 subjects, reporting a missed inury rate of approximately 1.5%), only recorded missed injury when this resulted in a change of treatment or required intervention. This leads to an underestimation of the type 1 missed injury rates.

In the findings of our study there appears to be an association between type 1 missed injury and the ISS score. Previous studies [2, 17, 20–22] have shown an association in patients with an ISS ≥ 16 (polytrauma). But now, even in patients with an ISS < 16, the higher the score, the higher the chance of a missed injury. We expect this to be due to a more trustworthy physical examination when there is less distracting injury.

Alcohol consumption was also associated with higher chances of finding missed injuries at the tertiary survey. Aaland and Smith [23] have noted this link before. In their study 39% out of 56 trauma patients with missed injury were intoxicated (0.63 positive predictive index). Alcohol consumption leads to an altered reaction during physical examination. Therefore injuries can be missed more easily.

Two out of twelve type 1 missed injuries (17%) were finally classified as severe (AIS 4) and even needed operative intervention. This is comparible to previous research of Giannakopoulos et al. [24] and Vles et al. [17] in which operative management was required in respectively 20% and 25% of the patients with missed injuries. Concerning the severity of the injuries found, conducting the TTS helped to prevent more serious damage in these two patients.

Type 2 missed injury was found only in one patient (0.3%). Though the injury was severe, it appeared that it was not detectable on routine imaging and could not have been detected earlier by tertiary survey due to a late onset of symptoms. Only one study, Biffl et al. [25], reported on type 2 missed injury in particular, they found a 1.5% type 2 missed injury rate. However, this rate was found in

Table 6 Characteristics of hospital length of stay (1 or 2 days vs. more than 2 days)

	Hospital stay < 2 days N = 293	Hospital stay > 2 days N = 73	*P*	Odds ratio [CI]
Age [median (IQR)]	41.00 [24.00, 58.00]	66.00 [52.50, 80.00]	> 0.001*	1.052 [1.037–1.067]
Gender = female (%)	104 (35.5%)	36 (49.3%)	0.032**	1.768 [1.054–2.967]
BMI (median [IQR])	25.00 [22.00, 28.00]	26.00 [22.00, 29.00]	0.472*	1.018 [0.959–1.082]
AIS 2 (%)	86 (29.4%)	36 (49.3%)	0.002*	2.342 [1.388–3.952]
ISS [median (IQR)]	3.00 [1.00, 4.00]	4.00 [2.00, 5.00]	0.007*	1.207 [1.066–1.366]
Mortality	0	0		
ASA 3 and 4	37 (12.6%)	31 (42.5%)	> 0.001**	5.107 [2.865–9.104]
Alcohol = yes (%)	24 (8.2%)	2 (2.7%)	0.129**	0.316 [0.073–1.368]
Clinical significant injury found during TTS (%)	7 (2.4%)	3 (4.1%)	0.424**	1.751 [0.442–6.943]

TTS trauma tertiary survey, *MVA* motor vehicle accident, High speed: > 30 km/h, Moderate speed: < 30 km/h

*Mann–Whitney-*U*-test

**Fisher's exact

trauma patients with ISS scores higher than 16, who were admitted to the intensive care unit (ICU). The explanation for this very low percentage type 2 missed injury is the accurately performed primary, secondary ánd tertiary survey, who together detecte most missed injuries.

The overall missed injury rate (type 1 and 2 combined) in this study was 3.4%. This seems to be low compared to existing literature. A review conducted by Pfeifer et al. [19] showed missed injury rates varying from 1.3% to 39%, Keijzer et al. [2] found an overall missed injury rate of 5.8% and Giannakopoulos et al. [24] reported 8.2%. Importantly, these studies investigated all trauma patients including polytrauma patients (ISS > 16).

Twenty-one percent of our patients were admitted for more than 2 days. These patients were on average older and had a higher ISS and ASA-score. This is in line with the study conducted by Kashkooe et al. [26], a cross-sectional study with a population of approximately 14,000 patients. They indicated that patients of higher age were more susceptible to have a longer hospital length of stay. Ramarkably, one out of five patients is admitted to the hospital for more than 2 days, while there is no serious injury at admission and few missed injuries are found during TTS. An explanation for this might be that pre-existant comorbidities and higher chances of in-hospital complications such as pneumonia, result in a longer hospital stay. In addition, we expect that the absence of adequate home care in older patients is an important factor. Improving home care in frail elderly could result in earlier discharge and might prevent in-hospital complications.

Although the percentage of severe injury found at the TTS is low [2 out of 388 patients (0.5%)], it can be concluded that performing a TTS in this study's population still is usefull in some cases. But considering the overall findings of this study, we recommend to maintain a high threshold in the admission of trauma patients for TTS when the following criteria are met: Patients without AIS of 3 or more found at primary or secondary survey, ISS lower than eight, ASA 1 or 2, no alcohol intoxication, the patient has the wish to go home and adequate social support can be provided. Discharging a patient instead of hospitalisation can contribute to the well-being of the patient and to the saving of medical expenses.

The results of this study should be interpreted within the context of the study design; a retrospective single-center cohort study. However, this study is conducted in a large level 2 trauma center were patients with all different socio-economic and ethnic backgrounds are seen. This makes our study population representative to other countries. Future research should focus on predicting variables of a positive tertiary survey in these trauma patients and a standardized guideline should be developed to supports physicians in deciding whether to admit a patient or sending them home safely.

Conclusion

Trauma tertiary survey showed low percentages of missed injury (3.1%) in trauma patients without serious injury (AIS of 3 or higher) upon admission. Tertiary trauma survey revealed severe missed injuries in 2 cases (0.5%). ISS and alcohol consumption were associated with higher chances of finding missed injuries during tertiary survey and a higher age and a ASA-score (3 or 4) often results in an unexpected longer admission. The use of the tertiary survey in trauma patients with an ASA score of 1 or 2, a low ISS upon arrival, without an alcohol intoxication and with adequate home care can be discussed.

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Data availability Yes.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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