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ORIGINAL ARTICLE

High delayed and missed injury rate after inter-hospital transfer of severely injured trauma patients

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Abstract

Purpose Missed injuries are reported in 1.3–65% of all admitted trauma patients. The severely injured patient that needs a higher level of care which requires an inter-hospital transfer has an increased risk for missed injuries. The aim of this study was to establish the incidence and clinical relevance of missed injuries in severely injured patients who require inter-hospital transfer to a level 1 trauma center.

Methods All patients with an Injury Severity Score (ISS) ≥ 16 transferred to the University Medical Center Groningen (UMCG) between January 2010 and July 2015 were included. Data were obtained from a prospective trauma database and supplemented with information from the patient records. A delayed diagnosis was defined as any injury detected within the first 24 h after the initial trauma, with or without a tertiary survey. Missed diagnoses were defined as any injury diagnosed after 24 h following trauma.

Results Two hundred and fifty-one trauma patients were included. A total of 88 patients (35%) were found to have ≥ 1 new diagnoses with 65 (26%) patients that had 1 or more delayed diagnoses and 23 (9.2%) patients had 1 or more missed diagnoses (detected > 24 h after injury) after transfer to our hospital. For 47 of the 88 patients (53%), the new diagnoses required a change of management. The Glasgow Coma Scale (GCS) was the only statistically significant risk factor for a new diagnosis upon transfer.

Conclusions Inter-hospital transfer of severely injured patients increases the risk of a delayed detection of injuries. We found that 35% of all transferred patients with an ISS ≥ 16 have at least new diagnoses, with over half of these diagnoses requiring a change of management. Given these findings, clinicians should maintain a high index of suspicion when receiving a transferred severely injured trauma patient.

Keywords Trauma patient · Transfer · Delayed injuries · Missed injuries · Tertiary survey

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Background

To improve outcomes in trauma care for severely injured patients, an organized approach, such as the Advanced Trauma Life Support (ATLS®), is essential [1–3].

In severely injured patients, the initial focus lies on detecting immediate life-threatening injuries, the so called primary survey and timely making critical decisions. Due to patient related factors such as altered consciousness, distracting injuries, the need for immediate surgery or inter-hospital transfer to a higher level trauma center, the secondary survey may be curtailed or hindered. This can subsequently increase the chance of incomplete injury identification [4–9].

For this reason, a tertiary survey was introduced by Enderson et al., to be performed in the first 24 h after initial resuscitation [5]. The tertiary survey includes a top-to-toe physical re-examination and a thorough re-assessment of all additional investigations such as diagnostic imaging and laboratory results, within 24 h of admission [5, 6, 10–13].

Repeating the tertiary survey at a later moment is necessary when a patient is unconscious, non-cooperative or cannot yet be mobilized [5, 6, 10, 14–16]. For the population of severely injured patients who are referred to a higher level of care hospital, it is important to realize that the triad of primary, secondary and tertiary survey is often compromised. This carries the risk of losing vital information and missed injuries. The challenge for the trauma team at the receiving hospital is to detect those missed injuries as soon as possible, because any diagnostic delay may have clinical implications [6, 17, 18].

Aim of the study

The aim of this study was

1. To evaluate the incidence and nature of missed injuries in a retrospective cohort of severely injured patients who were transferred to a level 1 Trauma center.
2. To establish how often these new diagnosis required a change of clinical management.

Methods

Setting

The University Medical Center Groningen (UMCG) is a level I trauma center in the north of the Netherlands. It is a tertiary referral center with a catchment area of 25% of the Netherlands with 1.7 million inhabitants. The number of seriously injured patients (Injury Severity Score (ISS) ≥ 16) treated in the UMCG in 2014 was 267 which is 50% of all the seriously injured patients in the northern region of the Netherlands. The remaining patients were initially presented in local (level II or III) trauma centers [19].

According to our local protocol, all patients with an ISS ≥ 16 were subjected to a tertiary survey by a surgical resident within 24 h after admission. In case of an altered level of consciousness, a preliminary tertiary survey was undertaken and repeated regularly until the patient regained a sufficient level of consciousness to be reliably examined.

Study design

This is a cohort study utilizing the prospective UMCG Trauma Database which was complemented with retrospectively collected patient-specific information from the medical files of the included patients. The study was granted a waiver by the Medical Ethical Committee of the UMCG.

Inclusion criteria

All patients transferred to the UMCG from January 2010 to June 2015 with an ISS ≥ 16, independent of age and type of injury were eligible for inclusion.

Data collection

Data were collected through the UMCG Trauma Database and patient medical files.

The UMCG Trauma Database is prospectively managed by a dedicated and trained data manager as part of the Dutch National Trauma Registration [19] and includes all trauma patients admitted to the UMCG. For retrospectively complementing the Trauma Database, particular attention was given to transfer documentation including transfer papers, radiology reports from the referring hospital, admission documentation, final radiology reports after re-evaluation at the UMCG, surgery reports, discharge letters and outpatient medical correspondence.

Furthermore, demographic data, vital parameters, Glasgow Coma Score (GCS), diagnosis, time to diagnosis, treatment, and complications were recorded. The GCS from the initial resuscitation in the transferring hospital and from the time of arrival in the UMCG were both noted.

All new diagnoses were classified according to the Abbreviated Injury Scale (AIS, 2005 version) score and the diagnostic tool that was used to detect this new diagnosis (physical examination, additional investigations such as radiographic evaluation, blood results and other additional diagnostics) was recorded.

Finally, all new diagnoses and their treatments were evaluated for clinical relevance. As there is no accepted method in reporting this parameter [6, 20], we decided to evaluate

all new diagnoses and assess their clinical relevance by two experienced trauma surgeons (GAMG and MEM). We defined clinically relevant injuries as injuries that required a change of treatment, a cast, an operation, or resulted in increased morbidity and/or mortality.

Definitions

New diagnoses were defined as injuries that were detected after transfer of the patient from another hospital. These injuries were not recorded or described in the transfer notes by the referring trauma team at the time of transfer. New diagnoses were classified and divided in delayed and missed diagnosis using the classification described by Keijzers et al. and Vles et al. [12, 20]. Delayed diagnoses were defined as any injury detected within the first 24 h after the initial trauma, with or without a tertiary survey. Missed diagnoses were defined as any injury diagnosed after 24 h following trauma.

Due to the retrospective nature of this study, we assumed that any patient who was transferred after 24 h following injury underwent a tertiary survey at the referring trauma center. Therefore, we classified any injury found in our institution after this time as a missed diagnosis.

Data management

Statistical calculations were performed using Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, IL).

In our statistical analyses, we used an independent *T* test or Mann–Whitney *U* test to compare continuous variables among the group of patients. Results of normally distributed continuous variables are presented as mean and standard deviation (SD). Categorical variables were compared using the Fisher exact test and presented as frequencies and percentages. Logistic regression analysis was used to identify risk factors linked to a new diagnosis, either delayed or missed. A p value < 0.05 was considered statistically significant.

Results

During the study period, a total of 251 severely injured trauma patients (ISS ≥ 16) were transferred from another hospital to the UMCG of which 189 were transferred within 24 h after trauma. The patient characteristics are presented in Table 1. Patients were referred to our level 1 trauma center for various reasons (Table 2). Head injuries and vertebral fractures were the most common reasons for transfer.

Table 1 Characteristics of all included patients

Characteristics	$n = 251$
Age, year mean (SD)	39.3 (23.7)
Male, *n* (%)	174 (69.3)
ISS, mean (SD)	23.6 (8.6)
Number of already known diagnoses upon transfer	
One	62 (24.7)
Two	59 (23.5)
Three	59 (23.5)
Four	39 (15.5)
Five	21 (8.4)
Six	11 (4.4)
GCS at transferring hospital < 15 $n = 124$, *n* (%)	52 (41.9)
GCS after transfer < 15 $n = 224$, *n* (%)	88 (39.3)
Systolic blood pressure, mean (SD)	122.6 (21.6)
MAP, mean (SD)	95.4 (20.5)
Days to transfer, mean (SD)	1.4 (4.4)

Table 2 Reasons for transfer

Reason for transfer	
Head injury	88 (35.1)
Vertebral fractures	49 (19.5)
Pelvic fractures	18 (7.2)
Multi-trauma	36 (14.3)
Repatriation from abroad	6 (2.4)
Abdominal injury	42 (16.7)
Other injuries	12 (4.8)

Data presented as *n* (%)

Delayed injury rate

From the 251 included severely injured transferred trauma patients, 65 (26%) patients had 1 or more delayed diagnoses (detected < 24 h after injury) after transfer to our hospital and 23 (9.2%) patients had 1 or more missed diagnoses (detected > 24 h after injury) after transfer to our hospital. Seven patients (2.8%) had a combination of both 1 or more delayed and missed diagnosis.

One hundred and eighty-nine patients were transferred within the first 24 h after the trauma of which 67 patients (35.4%) had 1 or more new diagnosis with a total of 117 new diagnoses. Of these 117 new diagnoses, 99 (84.6%) were classified as delayed diagnosis and 18 (15.4%) as a missed diagnosis. Missed diagnosis had a mean time to diagnosis of 8.1 days (SD = 14.5 days). The other 62 patients were transferred after 24 h with a median of 6.5 days and a range of 1–40 days after the trauma. Of these 62 patients, 21 (33%) had 1 or more new diagnoses with a total of 33 new diagnoses, which were all classified as missed diagnosis. In total,

150 new injuries were detected which are presented in table according to the anatomical areas of the injuries (Table 3).

In this group, chest ($n=42$ [28%]) and upper extremity ($n=30$ [20%]) were the anatomical regions where injuries were most commonly not recognized. Rib fracture was the most common new diagnosis ($n=22$). The most severe new diagnosis was kidney laceration ($n=5$ [3.3%], grade I–IV), spleen-laceration ($n=1$ [0.7%], grade I) and 27 vertebral fractures, of which three required an operation.

Diagnostic method

Of the 150 new diagnoses, 39 injuries (26%) in 32 patients were detected by physical re-examination. The remaining 111 (74%) diagnoses, in 71 patients, were identified by the use of medical imaging. Of these additional 111 diagnoses, 79 (71%) diagnoses were identified by new additional medical imaging and 32 (29%) were diagnosed by re-evaluating the medical imaging done in the referring hospital. Clinical examples of missed injuries are presented in Figs. 1 and 2.

Clinical relevance of new diagnosis

Of the 88 patients with new diagnosis, a total of 47 (53%) patients had a change of treatment as a result to their new diagnosis. Fifteen patients had to be operated on due to an initially delayed or missed injury. The already initiated treatment of the remaining 41 (47%) patients was not affected by the new injury, and no additional morbidity was expected from the new injuries in this group.

One 75-year-old female patient died due to a new diagnosis. She was transferred 4 days after she fell out of her wheelchair and sustained a thoracic vertebral fracture. This fracture required operative stabilization for which she was transferred to our hospital. Initially, no head injury was suspected. During the initial 4 days of admission, at the referring hospital, she developed a delirium and deteriorating GCS but it was only after transfer to our hospital, that a CT-cerebrum was obtained. This revealed a traumatic subarachnoid bleeding (SAB). Unfortunately, the prognosis of this cerebral injury was poor and the patient died shortly after.

Risk factors

The Injury Severity Score (ISS-Score), hemodynamic factors and reason of transfer were not associated with the incidence of delayed and missed injuries. The Glasgow Coma Scale (GCS) was the only statistically significant risk factor for a new diagnosis upon transfer (See Table 4). Patients with a GCS of 8–12 had a 49% smaller chance of having a missed injury as patients with a GCS < 8. Patients with a GCS > 12 had a 2.7 times bigger risk (EXP) of having a missed injury as patients with a GCS < 8 (Table 5). As this correlation was an unexpected outcome, all prognostic details were analyzed for further plausible cause but none could be identified.

Table 3 Number of new diagnosis, delayed and missed, according to AIS classification

Anatomic region of diagnosis	Total new diagnosis	Delayed diagnosis	Missed diagnosis
Head	9 (6)	7 (77.8)	2 (22.2)
Face	7 (4.7)	4 (57.1)	3 (42.9)
Neck	0 (0)	0 (0)	0 (0)
Thorax	42 (28)	25 (59.5)	17 (40.5)
Rib/sternum	24 (57.1)	13 (54.2)	11 (45.8)
Pulmonary	16 (38.1)	11 (68.8)	5 (31.3)
Other	2 (4.8)	1 (50)	1 (50)
Abdominal	15 (10)	9 (60)	6 (40)
Liver	3 (20)	2 (66.7)	1 (33.3)
Spleen	1 (6.7)	0 (0)	1 (100)
Renal	5 (33)	3 (60)	2 (40)
Bowel	1 (6.7)	1 (100)	0 (0)
Other	5 (33)	2 (40)	3 (60)
Pelvic injury	5 (3,3)	5 (100)	0 (0)
Spine	27 (18)	19 (70.4)	8 (29.6)
Upper extremity	30 (20)	21 (70)	9 (30)
Lower extremity	14 (9.3)	8 (57.1)	6 (42.9)
Other	1 (0.7)	1 (100)	0 (0)

Data presented as *n* (%)

Fig. 1 Patient A was transferred because of abdominal trauma after a scooter vs lamppost accident. The patient had a grade II liver rupture, an os ilium fracture on the right side, bilateral lung contusion and right sided humerus fracture. The CT-scan was re-evaluated and showed an additional grade III kidney laceration that was overseen (or not communicated) by the referring team. The patient was treated conservatively for all his injuries and fully recovered

Fig. 2 Patient B was transferred because of a acetabular and 3–5 thoracal vertebral fractures after a motorcycle versus car accident. The patient was diagnosed at the referral centre with fractures of the inferior pubic ramus, and a proximal fibula fracture with possible a Maisonneuve injury. The X-rays from the referral center confirmed the earlier mentioned injuries and no new diagnosis were found. Additional imaging (pelvic and vertebral CT-scan) confirmed the instable comminuted acetabular and pelvic fracture right. During the admission, the pelvic fractures were stabilized with various places. Due to various hematomas, the left heel and the right foot, additional X-ray images were made on the third day of admission. The images showed a comminuted calcaneus fracture on the left leg and multiple fractures of the right foot. Due to the acetabular and pelvic fractures, the patient was already immobile as he was prescribed non weightbearing mobilization, and as such without any dislocation of the fractures a conservative for these new fractures was chosen. Further recovery was uneventful

Discussion

We found that transferred severely injured patients are particularly prone to having delayed or missed injuries with a missed injury percentage of 35% ($n=88$) of which 53% ($n=47$) were clinically relevant. These results suggest a high incidence of missed injuries for trauma patients that are transferred.

We found that most missed injuries (74%) were primarily found by the use of medical imaging of which 29% were in

Table 4 Predicting factors for a delayed or missed injury

	Mean(SD)	*P* value
Reason of transfer	–	0.89
Days to transfer	1.4 (4.4)	0.64
Saturation at referral center	98.7 (2.2)	0.51
Heart rate at referral center	88.8 (18.2)	0.70
MAP at referral center	95.4 (20.5)	0.75
Glasgow Coma Scale at referral center	12.4 (4.1)	0.026
Number of diagnosis upon transfer	2.7 (1.4)	0.65
ISS upon transfer	23.6 (8.6)	0.14

Table 5 Logistic regression outcome

	B	S.E.	Wald	Df	Sig	Exp (*B*)	95% C.I. for EXP (B)	
							Lower	Upper
GCS 3–8			7.202	2	0.027			
GCS 9–12	− 0.663	0.904	0.539	1	0.463	0.515	0.088	3.027
GCS 13–15	0.996	0.521	3.661	1	0.056	2.707	0.976	7.51
Constant	− 1.041	0.475	4.81	1	0.028	0.353		

retrospect detectable on the imaging done at the referring hospital. These results are comparable with other studies. Vles et al. found 40.8% of delayed diagnoses by re-examination and 16.3% by misinterpretation of radiological imaging, whereas Houshian et al. found 34.9% [12, 21]. This result underlines the importance of a protocolized re-assessment of all previously done imaging for transferred trauma patients.

Injury severity and clinical relevance

In most reports, a change in management is used as a substitute for injury severity or clinical relevance. Even though these described interventions have some merit to the severity or relevance of an injury, they are dependent on local policies whether to operate an injury or not. Nonetheless, because of the lack of a good tool for measuring clinical relevance, we also used the change of management in combination with the evaluation of injury severity by two experienced trauma surgeons as a determination of clinical relevance.

There were 15 (10%) missed injuries requiring operative intervention, which is 17% of all patients with a missed diagnosis. These numbers are comparable to other studies regarding the importance of a tertiary survey. In these studies, Enderson et al. described that 19%, Vles et al. 25% and Aaland et al. 34% of all trauma patients with a missed diagnosis required additional surgical intervention [5, 12, 13]. The study of Aaland et al. most likely has a higher intervention rate as they included all trauma patients seen at the emergency room and as such included more patients with an ISS < 16 [13].

We found that in 53% ($n = 47$) of patients with a missed diagnosis, this diagnosis resulted in a change of management (thus 'clinically relevant'). Chen et al. described 8.0% of all missed injuries to be clinically relevant, Buduhan et al. 11.1% and Janjua et al. 15% as where Guly et al. described the need for treatment changes in 32% of patients with a missed diagnosis which is significantly lower [10, 22–24]. A reason for this difference could be that our study focused on severely injured transferred patients with a high likelihood of incomplete initial trauma screening or that there is no uniform definition of a clinical relevant diagnosis.

Risk factors for missing a diagnosis in transferred severely injured patients

Most missed injuries are because of a combination of an incomplete physical examination, missed observation, absence of a physical sign or the unconscious, uncooperative patient. As such a physical examination on it's own to identify injuries, is described in literature to have limited usability [5, 25]. A lowered Glasgow Coma Scale is one of the recurrent factors in the literature that is associated with delay of diagnosis [4, 5, 12, 21, 24, 26–32]. In our study, however, it was the subgroup of patients with a higher GCS (≥ 8) that was prone to have a missed injury. It could be that patients with multiple injuries did not undergo a complete trauma screening at the referring centre before transfer as they were maybe thought to have suffered from less severe trauma.

Unfortunately, in transferred trauma patients, poor communication both between the treating medical teams but also with the patient is a factor that might cause delayed diagnosis. We did not separately investigate this item as due to the retrospective nature of this study, we unfortunately could not retrieve all the required information.

How to prevent missed injuries in transferred severely injured patients

With our study, we confirmed that severely injured transferred patients are at high risk of missing injuries. We advise an ongoing tertiary survey, with particular awareness of the injury mechanism with emphasis on commonly missed injuries such as wrist, ankle and rib fractures [21].

Secondly, as 32 of 150 diagnoses (21%) were found by re-evaluation of earlier medical imaging, a structured review procedure of all earlier performed medical imaging and other diagnostics is advised to be an integral component of the transfer process. As some diagnoses are most critical within the first hours following trauma, a dedicated radiologist should be a member of the receiving trauma team and review and officially report on all external medical imaging during the first survey following transfer.

More precise identification of where in the care chain diagnoses are delayed and quantifying the actual effect on

long-term health outcomes of these injuries should be evaluated in future prospective trials.

Limitations of this study

This study was subject to several limitations due to its retrospective design. Therefore, the outcome might underestimate the true incidence of missed injuries as not all possible risk factors could be taken into account.

Conclusion

Thirty-five percent of severely injured trauma patients had 1 or more new diagnoses after transfer to a hospital with a higher level of care. Fifty-three percent of these delayed or missed injuries required a change in treatment strategy. With this study, we aim to achieve that all involved medical team members become more aware of this fact and focus more on the importance of an ongoing tertiary survey in this precarious patient population. This will hopefully result in optimization of hospital-to-hospital transfer protocols and improve the adherence to these protocols by all medical staff involved.

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Compliance with ethical standards

Conflict of interest All the authors declare that they have no conflict of interest to report.

Ethical approval A waiver was granted by the Medical Ethical Committee of the UMCG.

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