

Original Article

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Time from injury to arrival at the trauma centre in patients undergoing interhospital transfer

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ABSTRACT**INTRODUCTION:**

Trauma patients may require interhospital transfer to definitive care following initial assessment at a primary facility. A prolonged time to transfer may be associated with a poor outcome. The aim of this study was to determine the time from injury to arrival in patients undergoing interhospital transfer to the Trauma Centre at Rigshospitalet, University of Copenhagen, Copenhagen, Denmark.

METHODS:

Data were obtained from our local trauma registry for the period from 1 November 2016 to 31 October 2019. We included patients who underwent interhospital transfer to our trauma centre. Patients were compared according to a 360-minute time interval between injury and arrival.

RESULTS:

In the study period, 250 patients underwent interhospital transfer to our trauma centre. The median age was 47 years (interquartile range (IQR) 26-65), the majority were male (68.4%) and a total of 113 patients (46.9%) had an Injury Severity Score (ISS) > 15. The 30-day mortality was 6% (95% confidence interval (CI) 3.6-9.7). The median time from injury to arrival at our trauma centre was 255 minutes (IQR 192-371). We found that 67 patients (27%; 95% CI 21.7-32.6) arrived at our trauma centre more than 360 minutes after time of injury. The patients arriving later than 360 minutes were significantly older ($p = 0.004$) than the remaining patients. There was no significant difference in the unadjusted 30-day mortality (odds ratio (OR) 1.01, 95% CI 0.3-3.3).

CONCLUSIONS:

Time from injury to arrival at our trauma centre exceeded 360 minutes for 67 patients (27%) who were significantly older than the remaining patients transferred.

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TRIAL REGISTRATION: not relevant.

Trauma is the leading cause of death in younger people up to 49 years of age, causing as many as 5 million deaths worldwide annually [1]. In well-organised trauma systems, the most severely injured patients should be brought directly to a major trauma centre because treatment at major trauma centres seems to be associated with a much lower mortality after trauma than treatment at less specialised institutions [2].

However, severely injured patients may also be brought to a hospital with fewer resources and transfer to a major trauma centre may be needed after initial assessment and stabilisation [3-5].

According to the Advanced Trauma Life Support (ATLS) guidelines, time from injury to highly specialised care is essential in trauma patients [6]. A decrease in time from injury to definitive care for severely injured patients following the implementation of a physician-staffed helicopter decreased 30-day mortality [7]. The aim of this quality assurance study was to investigate time from injury to arrival at our trauma centre. Based on previous studies by Prabhakaran et al. [8] and Meisler et al. [9], we decided to consider a maximum of 10% of the patients arriving later than 360 minutes after the time of injury as an adequate level of quality.

METHODS

Study design and setting

This is a single-centre, retrospective study based on data from patients recorded in the local trauma registry at the Level 1 Trauma Centre of Rigshospitalet, University of Copenhagen in The Capital Region of Denmark. The database contains data from patient charts registered using a unique civil registration number per patient assigned to all persons, including foreign nationals, who take up residence in Denmark (CPR number). The study was approved as a quality assurance study by the hospital management of Rigshospitalet. For quality assurance, registration in a trial database is not required in Denmark. Furthermore, under Danish law it is not needed to obtain informed consent from patients or to achieve approval by the Research Ethics Committee and The Danish Patient Safety Authority.

The Level 1 Trauma Centre at Rigshospitalet in the Capital Region, Copenhagen, is the only highly specialised trauma centre in the eastern part of Denmark. The centre covers a total population of approximately 2.6 million citizens. The pre-hospital emergency medical service consists of ambulances staffed by paramedics and physician-staffed mobile units (MECU) and helicopters (HEMS) both staffed by anaesthesiologists. Referral of severely injured patients follows local protocols ensuring that the most severely injured patients are brought directly to the major trauma centre.

Participant selection

We included patients transferred from other hospitals to the trauma centre at Rigshospitalet, Denmark, between 1 November 2016 and 31 October 2019 within 24 hours from the time of injury. We only included patients who had been assessed at the primary hospital with subsequent transfer to our facility for further assessment and treatment with a full trauma team activation after arrival. We excluded patients without a valid CPR number and patients in whom the time interval between the injury and arrival at the trauma centre of Rigshospitalet exceeded 24 hours. We also excluded patients transferred from Greenland and the Faroe Islands.

Data collection

Data were extracted from our local trauma registry at the Level 1 Trauma Centre at Rigshospitalet, Copenhagen, Denmark. Data are stored in a legal and secure research data web application. The data extracted included age, sex, Injury Severity Score (ISS), trauma mechanism (blunt, penetrating, burn, mixed), injury mechanism (traffic, fall, etc.) and injured body regions. Data on the primary admission facility included transportation method to primary admission, time spent at the emergency department, if a trauma team was activated, and if computed tomography (CT), pleural drainage, or surgery was performed. Data on the admission to our trauma centre included where the patient was transferred from, the interhospital transfer time, if a CT was performed in the trauma centre, if surgery was performed, time to start of surgery after arrival at the trauma centre, Intensive Care Unit (ICU) length of stay (LOS),

hospital LOS and 30-day mortality. Time of injury was obtained either from the pre-hospital record or the medical record; if it was unattainable, time of injury was defined as five minutes before creation of the pre-hospital record. Time from injury and the time of arrival at our trauma centre were used to calculate a total time in minutes from injury to arrival at our trauma centre.

Outcome measures

The primary outcome was the proportion of patients with a time interval exceeding 360 minutes from time of injury to arrival at our trauma centre. The secondary outcomes were time from injury to arrival at our trauma centre and 30-day survival. Effect modifiers were age, sex and Injury Severity Score.

Statistical analyses

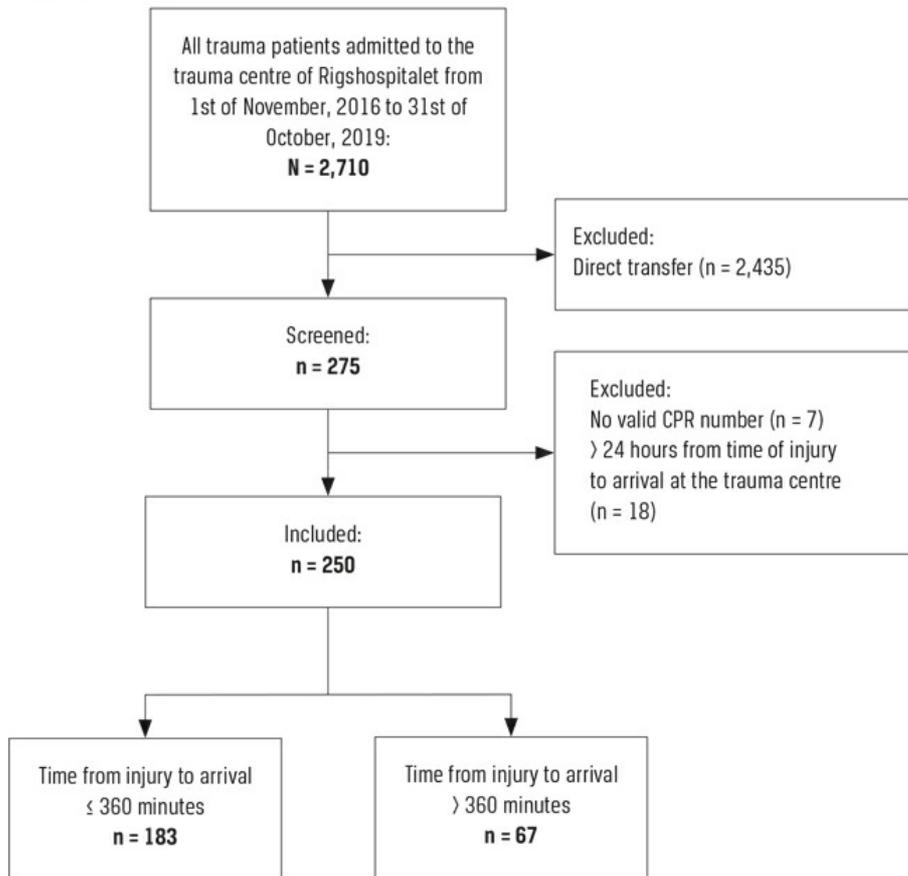
Continuous variables are reported as medians with interquartile range (IQR) and compared using the Mann-Whitney U test. Categorical data are reported as numbers (%) with a 95% confidence interval (CI) and compared by the Chi-squared test. The 30-day mortality difference is reported as an odds ratio with 95% confidence intervals. We compared patients according to a 360-min interval between injury and arrival at our trauma centre. All statistical analyses were performed using RStudio (version 3.5.2., Boston, Massachusetts, USA). A p value below 0.05 was considered statistically significant.

Trial registration: not relevant

RESULTS

A total of 2,710 patients were admitted to the Trauma Centre at Rigshospitalet during the period from 1 November 2016 to 31 October 2019. Interhospital transfer occurred for 275 patients (10.1%). We excluded 25 patients, leaving a cohort of 250 patients (**Figure 1**). The median age was 47 years (IQR 26-65), most were male (68.4%) and 113 patients (46.9%) had an ISS > 15 (**Table 1**). At the primary facility, a full trauma team was activated in 66.4% of the admitted patients and the median time spent from arrival to departure from the primary facility was 157 minutes (IQR 115-222) (**Table 2**). The median time from injury to arrival at our trauma centre was 255 minutes (IQR 192-371), including a median interhospital transfer time of 32 minutes (IQR 18-47). The 30-day mortality was 6% (95% CI 3.6-9.7). In 183 patients, the time from injury to arrival at our trauma centre was lower than 360 minutes, whereas 67 patients arrived more than 360 minutes (27%; 95% CI 21.7-32.6) (**Table 2**) after sustaining their injury. Arrival according to a 240 minute-interval and a graphical representation are shown in supplementary files (**Table 4, Figure 2**, https://ugeskriftet.dk/files/a03200138_-_supplementary.pdf).

FIGURE 1 / Flow chart of patients admitted to our trauma centre.



CPR number = unique civil registration number.

TABLE 1 / Characteristics of trauma patients undergoing interhospital transfer to our trauma centre (N = 250).

Age, median (interquartile range), yrs	47 (26-65)
Sex, male, n (%)	171 (68.4)
<i>Injury Severity Score, n (%)^a</i>	
≤ 15	128 (53.1)
> 15	113 (46.9)
<i>Trauma mechanism, n (%)</i>	
Blunt	230 (92)
Penetrating	14 (5.6)
Mixed: blunt/penetrating	3 (1.2)
Mixed: blunt/penetrating incl. burn injury	3 (1.2)
<i>Injury mechanism, n (%)</i>	
Traffic accident	101 (40.4)
Fall	87 (34.8)
Assault	16 (6.4)
Crushed between objects	12 (4.8)
Stabbing	10 (4)
Kicked by animal	4 (1.6)
Explosion and burn	3 (1.2)
Gunshot wound	3 (1.2)
Unspecified	14 (5.6)
<i>Injured body regions^b</i>	
Head	67 (26.8)
Spine	75 (30)
Thoracic	98 (39.2)
Abdominal	74 (29.6)
Pelvic	40 (16)
Extremity	37 (14.8)
Facial or cranial skull	41 (16.4)
Neck	5 (2)
Other	5 (2)

a) Missing data in 9 patients.

b) The % does not add up to 100 because patients could be registered with > 1 injured body region.

TABLE 2 / Characteristics of trauma patients undergoing interhospital transfer to our trauma centre (N = 250).

<i>Transportation mode to primary admission, n (%)^a</i>	
Private	43 (17.3)
Standard ambulance	162 (65.1)
Physician-staffed ambulance	29 (11.6)
Other	15 (6)
<i>Full trauma team activation at the primary facility, n (%)</i>	
Yes	166 (66.4)
No	71 (28.4)
Not known	13 (5.2)
<i>CT scan at the primary facility, n (%)</i>	
	200 (80)
<i>Treatment at the primary facility, n (%)</i>	
Pleural drainage performed	30 (12)
Surgery performed	6 (2.4)
<i>Transported from, n (%)</i>	
The Capital Region of Denmark	125 (50)
Region Zealand	122 (48.8)
Region of Southern Denmark	3 (1.2)
<i>Time spent at the primary facility, median (IQR), min.</i>	
	157 (115-222)
<i>Interhospital transfer time, median (IQR), min.</i>	
	32 (18-47)
<i>Time from injury to arrival at the trauma centre, median (IQR), min.</i>	
	255 (192-371)
<i>> 360 min. from time of injury to arrival at the trauma centre, n (% [95% CI])^b</i>	
	67 (27 [21.7-32.6])
<i>CT scan at the trauma centre, n (%)</i>	
	112 (44.8)
<i>Surgery performed, n (%)</i>	
	50 (20)
<i>Time until start of surgery after arrival at the trauma centre, median (IQR), min.</i>	
	113 (80-160)
<i>ICU stay, median (IQR), days^c</i>	
	1 (0-3)
<i>Hospital stay in total, median (IQR), days^c</i>	
	6 (4-12)
<i>30-day mortality, n (% [95% CI])</i>	
	15 (6 [3.6-9.7])

CI = confidence interval; ICU = intensive-care unit; IQR = interquartile range.

a) No information about transportation mode in one patient.

b) Reported as number of patients.

c) Excluding 15 patients who died during hospitalisation.

Patients arriving after 360 minutes were significantly older (56 years vs. 44 years; $p = 0.004$), and the proportion of patients having an ISS > 15 did not differ significantly between the two groups (> 360 minutes: 47 % vs. ≤ 360 minutes: 46.9 %; $p = 1$). There was no significant difference in 30-day mortality according to arrival before and after 360 minutes (6 % vs. 6 %; OR 1.01, 95 % CI 0.3-3.3) (Table 3).

TABLE 3 / Comparisons of trauma patients undergoing interhospital transfer regarding time from injury to arrival at our trauma centre between ≤ 360 min. and > 360 min.

	Time from injury to arrival		p-value	OR (95% CI)
	≤ 360 min. (n = 183)	> 360 min. (n = 67)		
Age, median (IQR), yrs	44 (23-62)	56 (40-69)	0.004	-
Sex, male, n (%)	128 (69.9)	43 (64.2)	0.35	-
Injury Severity Score > 15, n (%) ^a	82 (46.9)	31 (47)	1	-
Time at primary facility, median (IQR), min.	136 (89-176)	305 (219-444)	-	-
Interhospital transfer time, median (IQR), min.	30 (17-44)	40 (22-53)	-	-
30-day mortality, n (%)	11 (6)	4 (6)	0.99	1.01 (0.3-3.3)

CI = confidence interval; IQR = interquartile range; OR = odds ratio.

a) Missing data in 9 patients.

DISCUSSION

The main finding of our study was that 67 patients (27%) arrived more than 360 minutes after the time of injury at our trauma centre. This clearly exceeded our pre-established 10% quality level. Furthermore, we found that patients arriving more than 360 minutes after the time of injury were significantly older than patients who arrived before 360 minutes had passed. We found no significant impact on 30-day mortality for arrival after 360 minutes.

The strength of our study is that our facility is the only highly specialised trauma centre in the eastern part of Denmark. Therefore, all trauma patients within this area who require highly specialised treatment after the initial assessment at another hospital should be transferred to our facility. Our study had several limitations. First, we have no information about the patients who stayed at the local hospitals. At the primary hospital, the patients' condition may not allow for interhospital transfer within the initial 24 hours. It is also possible that the specialists in our facility did not consider transfer to be indicated because of a very small probability of survival. Finally, a patient who is severely injured and who is initially brought into the local hospital may not survive until an interhospital transfer is possible. These factors may introduce a selection bias causing an underestimation of mortality for transferred patients as 30-day mortality was relatively low (6%) despite an ISS > 15 in almost half of the patients. The database did not contain all variables that may be important for the prognosis, such as the Glasgow Coma Scale score and blood pressure [10]. This invites a cautious interpretation of 30-day mortality.

We found that patients spent a median 157 minutes at the primary hospital. This is similar to Meisler et al. [9], who reported that transferred patients from the eastern part of Denmark spent a median 150 minutes at the primary hospital in 2006. Previous studies have found that patients spent 107 to 233 minutes at the primary hospital [3, 11-13]. The median time from injury to arrival at our trauma centre was 255 minutes, whereas others reported a median time of 310-330 minutes [14, 15]. The distances, differences in geography and weather conditions are not taken into consideration for this comparison. Therefore, these factors may explain our results because Denmark is a relatively flat and small country. Hesselheldt et al.

[7] reported that a reduction in time to treatment was associated with a significant reduction of 30-day mortality after severe injury. Thus, the time to definitive care should be considered a crucial element in the treatment of severely injured trauma patients.

Surprisingly, we did not detect a difference in the ISS for our patients arriving before and after 360 minutes, respectively, but important prognostic factors like the Glasgow Coma Scale score or presence of shock were not taken into consideration. Prabhakaran et al. [8] found that mean time from injury to arrival at their Level 1 trauma centre was shorter in patients with severe head injury than in patients with mild injury (mild; 445 minutes versus severe; 371 minutes). Therefore, it seems that early transfer is prioritised in severely injured patients. This is in accordance with a study that found that significantly less time was spent at the primary hospital in patients with an ISS > 25 versus ISS < 25 [16]. In our study, the main factor explaining increased time to arrival at our trauma centre was the time spent at the primary facility (305 minutes versus 136 minutes) because the interhospital transfer time was comparable (40 minutes versus 30). It is also noteworthy that no full trauma team activation occurred in more than 30% of the transferred patients at the primary hospital. Thus, it is relevant to consider the delays in terms of perceived quality and it is possible that significant injuries may have been missed in the initial phase. This may represent an area with room for improvement

The patients in our study who arrived later than 360 minutes (56 years; IQR 40-69 years) were significantly older than those arriving before 360 minutes (44 years; IQR 23-62) had passed. Studies by Utter et al. [11] and Billeter et al. [17] reported that patients older than 65 years of age spent significantly more time in the emergency department before interhospital transfer: 32 minutes and 48 minutes, respectively. A possible explanation for this is that clinical symptoms and physiological responses may be different in the elderly. Furthermore, elderly patients may sustain severe injury at lower energy mechanisms. In addition, prehospital and emergency department healthcare staff may have a less active approach to this patient group where triage based on commonly used criteria is less accurate due, e.g., to how pain perception is affected by age [11, 18]. Furthermore, it is known that the age profile of trauma patients is rapidly changing, a trend also coined the 'silver tsunami' [19]. However, despite this, these patients may still be underestimated by the EMS and staff at the primary hospital, leading to lacking trauma team activation. This may explain why the need for interhospital transfer from smaller facilities was recognised later among elderly patients.

Consensus on exactly how soon patient transfer should occur after injury is lacking. We considered 360 minutes to be clinically relevant and similar to what other studies have established about time from injury to arrival at a Level 1 trauma centre. Even though we observed no difference in unadjusted mortality, we still suggest that attention should be given to keep reducing time from injury to arrival at a Level 1 trauma centre since our sample size does not allow firm conclusions, as illustrated by the wide confidence interval. The findings in this study should lead to an enhanced focus on minimising delays in the transfer through early identification of serious injury and contact to the trauma centre.

CONCLUSIONS

In conclusion, time from injury to arrival at our trauma centre exceeded 360 minutes for 67 patients (27%) who were significantly older than the remaining patients transferred.

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CONFLICT OF INTEREST: Disclosure forms provided by the authors are available with the full text of this article at

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