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Helicopter Emergency Medical Services (HEMS): Impact on On-Scene Times

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Abstract

Background This study compared prehospital on-scene times (OSTs) for patients treated by nurse-staffed emergency medical services (EMS) with OST for patients treated by a combination of EMS and physician-staffed helicopter emergency medical services (HEMS). A secondary aim was to investigate the relationship between length of OST and mortality.

Methods All trauma patients treated in the priority 1 emergency room of a Level I trauma center between January 2002 and 2004 were included in the study. To determine OST and outcome, hospital and prehospital data were entered into the trauma registry. OSTs for EMS and combined

EMS/HEMS-treated patients were compared using linear regression analysis. Logistic regression analysis was used to compare mortality rates.

Results The number of trauma patients included for analysis was 1,457. Of these, 1,197 received EMS assistance only, whereas 260 patients received additional care by an HEMS physician. HEMS patients had longer mean OSTs (35.4 vs. 24.6 minutes; $p < 0.001$) and higher Injury Severity Scores (24 vs. 9; $p < 0.001$). After correction for patient and trauma characteristics, like the Revised Trauma Score, age, Injury Severity Scores, daytime/night-time, and mechanism of trauma, the difference in OSTs between the groups was 9 minutes ($p < 0.001$). Logistic regression analyses showed a higher uncorrected chance of dying with increasing OST by 10 minutes (OR, 1.2; $p < 0.001$). This apparent effect of OST on mortality was explained by patient and trauma characteristics (adjusted OR, 1.0; $p = 0.89$).

Conclusions Combined EMS/ HEMS assistance at an injury scene is associated with longer OST. When corrected for severity of injury and patient characteristics, no influence of longer OST on mortality could be demonstrated.

Introduction

Trauma is the fourth overall cause of mortality and leading cause of death under the age of 29 years in the Netherlands[1]. As trauma patients in the Netherlands are mostly young adults (average age of 41 years[2]), trauma causes considerable losses of productivity, and hence causes social and economic damage[3]. The impact of injuries on health care costs in the Netherlands is similar to the costs of cancer and stroke[3, 4]. It is vitally important to determine the factors that influence the outcome for patients with multiple injuries, because reductions in mortality and morbidity could result in social and economic gains. Many studies have attempted to identify prehospital and in hospital factors related to the outcome of severely injured patients. One of these factors is time.

In trauma care, the timing of intervention is essential. Much of “the golden hour”, the time after a trauma in which swift and adequate treatment is of vital importance to improving patients’ outcomes, usually passes in the prehospital phase. Current prehospital trauma systems focus on delivering patients, without unnecessary delay, to hospitals within the golden hour. However, scientific evidence supporting these systems, based on the principle of “the golden hour”, is lacking[5].

The influence of prehospital trauma care and the level of medical expertise needed (Pre-Hospital Trauma Life Support [PHTLS] vs. Advanced Trauma Life Support [ATLS]) are the subjects of discussions all over the world. On-site physician-provided ATLS is often associated with invasive, time-consuming interventions, leading to increased on-scene times (OSTs). Increased OSTs may be associated with increased mortality in severely injured patients[6, 7]. Other authors, however, found that specific prehospital ATLS procedures increase patients’ chances for survival[8].

In the Netherlands, all emergency medical services (EMS) paramedics are PHTLS certified. Since 1997, prehospital trauma care has been expanded to include an ATLS-trained physician-staffed helicopter emergency medical service (HEMS). In contrast, in the United States, only 18% of HEMS units are physician-staffed[9].

For severely injured patients, HEMS dispatches in addition to the EMS, providing advanced trauma care at the crash. An HEMS physician at the scene may initiate interventions such as tube thoracostomy, intubation with anesthesia, and cricothyroidotomy[10].

HEMS have been shown to increase the chances of survival for these patients, especially in the case of blunt trauma[2, 11]. HEMS physicians are trained anesthesiologists or trauma surgeons. These physicians come in frequent contact with severely injured patients, both in the field and in the emergency room, giving them a high level of practical experience. Currently, the Dutch HEMS teams (in Amsterdam, Rotterdam, Nijmegen, and Groningen) can reach about 80% of the Dutch population within 15 minutes, but only during daylight hours. This study aimed to compare prehospital OST for patients treated by EMS only and for patients treated by a combination of EMS and HEMS. A secondary aim was to investigate the relationship between length of OST and mortality.

Methods

All trauma patients aged 15 and older arriving in the emergency room between January 2002 and 2004 were included in this study. Victims of drowning, strangulation, and suffocation were excluded, as were patients with missing prehospital data. Prehospital (EMS) and inhospital data were entered into the trauma registry. With HEMS assistance, OSTs were obtained from the pilot time registry of the HEMS flight operator (ANWB-Medical Air Assistance).

The primary outcome of this study was OST. OST was defined as the time between the arrival of the first EMS unit and the patient's departure from the crash scene. Secondary outcome was mortality. Mortality was defined as death within the first month after trauma. The population consisted of two subgroups: an EMS-treated patient group and a combined EMS- and HEMS-treated (EMS/HEMS) patient group. The EMS/HEMS group consisted of all patients who, in addition to EMS care, received physician-staffed HEMS assistance at the crash scene. Because all patients in this study were transported to the emergency department by ambulance, HEMS assistance had no effect on transportation time, making it irrelevant to this comparison.

To obviate any bias in the comparison between the EMS and the HEMS groups, only variables unaffected by the presence of HEMS or EMS were used for analysis. Therefore, the Revised Trauma Score and the Glasgow Coma Scale (GCS) score, obtained upon the arrival of EMS before any prehospital intervention, were used to indicate the patients' vital condition. OSTs were compared between both subgroups.

Additional subgroup analyses were performed for three trauma and treatment modalities: "scoop-and-run" (OST <10 minutes), "stay-and-treat" (OST >10 x <50 minutes), and "entrapment" (OST >50 minutes).

Statistical Analysis

Mean OSTs between groups were compared using Student's *t* tests. A custom-fitted regression model was defined to compensate for the selection bias[2]. All commonly used predictive variables were evaluated for their contribution to the model. Finally, the variables Revised Trauma Score, age, Injury Severity Score (ISS), whether the trauma occurred inside or outside the uniform daylight period, and mechanism of trauma were found to have significant predictive value and were fitted into the model. In these regression models, factors were considered not to be affected by the presence of the HEMS, and were considered possible influences on mortality. The logistic regression models were used to analyze the influence of OST on mortality. Significance was defined as p <0.05. The software used for analysis was SPSS (version 12.1, SPSS, Chicago, IL).

Results

During the 2 study years, EMS transported 1,774 patients to the high-care emergency room. Three hundred and seventeen patients were excluded, 313 because of incomplete prehospital data (predominantly OST). The mean ISS of excluded patients was 14. The majority of excluded patients (n = 309) belonged to the EMS group. The other four patients were excluded because they were victims of drowning, suffocation, or strangulation.

The number of trauma patients included for analysis was 1,457. Of these, 1,197 had received EMS care only, whereas 260 had received additional assistance by the HEMS physician. General characteristics are depicted in Table 1. All trauma-related parameters differed significantly between the groups: a lower mean GCS score was found in the EMS/HEMS group (10.3 vs. 13.8) and ISS was higher in the EMS/HEMS group, whereas the majority of patients had sustained blunt trauma in both groups. Hardly any patients with penetrating trauma were seen in the EMS/HEMS group.

On-Scene Times

Mean overall OST was 26 minutes: 24.6 minutes for the EMS group and 35.4 minutes for the EMS/HEMS group (p < 0.001) (Table 2). When stratified into the scoop-and-run, stay-and-treat, and entrapment groups, differences in OSTs were lower. Mean ISS was significantly higher for the EMS/HEMS group in all three time-modality groups.

The overall difference in mean OST between the EMS and the EMS/HEMS group was 10.8 minutes (Tables 2 and 3). After adjusting for confounding variables, HEMS assistance was still associated with a 9.3-minutes longer OST. In trauma patients with an ISS > 15, an adjusted increase in OST of 9.3 minutes was observed. In subgroup analysis, HEMS assistance did not influence OSTs in both the scoop-and-run and the entrapment groups. The stay-and-treat group showed an adjusted average increase of 5.2 minutes associated with HEMS assistance.

Mortality

The number of patients who died as a result of their injuries was 117 (8%). Fifty-four (46%) of these patients received EMS assistance only, whereas 63 (54%) received EMS/HEMS care. Three patients with an OST shorter than 10 minutes, 102 patients with an OST between 10 minutes and 50 minutes (stay-and-treat), and 12 patients classified as entrapped died. In all subgroups mentioned above, more patients died in the EMS/HEMS group than in the EMS group. After adjusting for the characteristics of the patient and the trauma, mortality was equal for the EMS and EMS/HEMS groups (odds ratio [OR], 1.0).

A 10-minute increase in OST was associated with an unadjusted higher chance of mortality (Table 4). However, after adjusting for severity of injury and patient characteristics (i.e., selection bias), the effect of prolonged OST on mortality disappeared.

Discussion

Many factors influence the outcome of trauma care. HEMS assistance is often associated with longer OST. To investigate the effect of OST on the survival of patients with multiple injuries, we quantified prehospital EMS and HEMS OSTs and analyzed their effect on patient mortality. Because transportation time does not depend on HEMS presence in the Netherlands, and all patients in this study were transported by EMS, the OST was used instead of out-of-hospital time (OST + transportation time). HEMS assistance was found to be associated with prolonging OST by 11 minutes. However, patients in the EMS/HEMS group had a significantly lower mean GCS score, a higher mean ISS, and relatively more blunt trauma than did patients in the EMS group. When correcting for these patient and trauma characteristics, HEMS assistance was still associated with an increase in OST of 9.3 minutes. To determine which patient category (i.e., treatment modality) was most responsible for these prolonged OSTs, patients were divided into subgroups associated with the aforementioned treatment modalities. This showed the stay-and-treat category to be associated with the highest adjusted increase in OST, because of factors concerning HEMS dispatch (i.e., additional therapeutic interventions).

Looking at mortality, an increase in OST by 10 minutes seemed to be associated with a 20% greater chance of dying. However, after adjusting for patient and trauma characteristics (Revised Trauma Score, age, ISS, whether the trauma occurred inside or outside the uniform daylight period, and mechanism of trauma), the apparent effect of OST on mortality disappeared. Therefore, even though HEMS assistance leads to prolonged OSTs for specific patients groups, HEMS assistance does not lead to increased mortality. This suggests that the set of added therapeutic options brought to the scene by a physician does lead to increased survival and that the supposed negative effect of prolonged OST is neutralized.

Another interpretation of the data could be that the EMS obviates the need for HEMS by simply transporting sooner. Or formulated differently, longer OST to stay-and-treat does not improve outcomes but returns the mortality to that of the rapidly transported group. However, there is no reason to transport any sooner than currently indicated in the “stay and- treat” group because no increased mortality could be demonstrated. Furthermore, the Dutch EMS has to comply with Dutch regulations or law and cannot obviate the need for HEMS by simply transporting sooner. Strict dispatch criteria and protocols are to be maintained and deviations need to be explained or reported.

The effects of OST and out-of-hospital time on mortality have been studied before. In 2001, Lerner et al. studied the background of the golden hour and found little evidence to support the concept[5]. Several studies found that a decrease in out-of-hospital time resulted in improved patient survival[12-17]. However, these studies did not correct for the characteristics of the patient and the trauma, or the level of prehospital care (ATLS vs. PHTLS). Consequently, the actual influence of out-of-hospital time on individual patients remained unclear. Because outcome is influenced by a multitude of factors, it is essential in trauma care to correct for confounding variables. Other investigators have disputed the concept of the golden hour[18-20]. However, either these studies focused on patients with very long OSTs only, or they had a clear selection bias. The concept that shorter out-of-hospital times improve survival has not yet been demonstrated in studies of adequate size or appropriate statistical control[5], nor does the current study show such an effect.

It should be noted that the 313 patients excluded because of incomplete prehospital data (predominantly OSTs) were not the patients at risk of dying (mean ISS of 14). The majority of excluded patients belonged to the EMS group, because significantly more prehospital data were missing in this group. It is therefore unlikely that these exclusions biased our results.

Limitations of the Study

This study uses the ISS as a major determinant in the models. A weakness of the ISS is estimating the severity of neurologic injuries. Furthermore, the ISS could fail to differentiate severe injury from mismanagement of injury[21]. As the ISS mixes outcome data with the injury severity, ISS could incorrectly assign increased injury severity to the lesser injuries of mismanaged patients. However, it still remains the default method to indicate the severity of injury sustained. Hence, residual confounding may be present in the current “adjusted” analyses.

Another limitation is caused by limited data registration and the subsequent large number of patients not included for analyses. Limited power surrounds the conclusions concerning mortality with uncertainty. Further study is required before more definitive conclusions can be drawn on the complex issues associated with HEMS care. The differences in mechanism of trauma between both groups underline that in case of penetrating injury the treatment modality “scoop-and-run” is chosen, meaning that the EMS does not wait for the HEMS to arrive but rushes to the nearest Level I trauma center (as this is the treatment modality of choice in case of penetrating injury). Because the group with penetrating injuries was too small, separate analyses of patients with the blunt or penetrating injuries could not be made.

In conclusion, this study has demonstrated that EMS/HEMS assistance at the scene of the crash is associated with an increase in OST for specific patient groups, possibly because of additional prehospital therapeutic interventions. However, when corrected for severity of trauma and other patient characteristics, no influence of longer OST on mortality could be demonstrated.

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Table 1. Demographics and injury characteristics for both patient groups

	EMS (n = 1,197)	EMS/HEMS (n = 260)	p
male (n =)	838 (70%)	205 (79%)	
penetrating trauma (n =)	147 (12%)	8 (3%)	< 0.001‡
blunt trauma (n =)	1,050 (88%)	252 (97%)	< 0.001‡
mean age (years)	35.1	39.2	
mean GCS	13.8	10.3	< 0.001†
mean ISS	9.1	23.6	< 0.001†

\EMS indicates patients that were treated by ambulance personnel only. EMS/HEMS indicates patients treated by a combination of EMS and HEMS.
GCS: Glasgow coma score; ISS: injury severity score; †: student t-test;
‡: chi-square test

Table 2. On-scene times and injury severity scores for pre-hospital trauma care, divided into the categories scoop and run, stay and treat, and entrapment

	EMS (n=1,197)	EMS/HEMS (n =260)	p
Mean OST overall (min)	24.6	35.4	< 0.001†
Mean ISS overall	9.1	23.6	< 0.001†
Scoop and run (< 10 min)			
n	95	3	
Mean OST (minutes ± SD)	6.4 (±2.0)	4.7 (±1.3)	ns†
Mean ISS	11.5 (±11.8)	29.7 (±12.7)	0.01†
Stay and treat (10–50 min)			
n	1,062	216	
Mean OST (minutes ± SD)	24.8 (±9.3)	31.3 (±8.7)	< 0.001†
Mean ISS	8.9 (±9.9)	23.7 (±15.3)	< 0.001†
Entrapment (> 50 min)			
n	40	41	
Mean OST (minutes ± SD)	61.8 (±16.6)	59.4 (±12.2)	ns†
Mean ISS	9.6 (±11.6)	23.0 (±15.9)	< 0.001†

† = student t-test; SD = standard deviation; ns = not significant

Table 3. Differences (in minutes, with their confidence intervals) in on-scene times between the EMS and EMS/HEMS group (unadjusted and adjusted)

	Δ OST	95% CI	p
All patients			
Unadjusted	10.8	[9.1 - 12.6]	< 0.001
Adjusted	9.3	[9.3 - 11.2]	< 0.001
Patients ISS > 15			
Unadjusted	11.3	[8.7 - 13.9]	< 0.001
Adjusted	9.3	[6.7 - 12.0]	< 0.001
Scoop and run			
Unadjusted	-1.8	[-4.1 - 0.6]	ns
Adjusted	-0.6	[-3.3 - 2.1]	ns
Stay and treat			
Unadjusted	6.6	[5.1 - 7.8]	< 0.001
Adjusted	5.2	[3.7 - 6.7]	< 0.001
Entrapment			
Unadjusted	-2.4	[-8.8 - 4.0]	ns
Adjusted	-2.5	[-10.4 - 5.4]	ns

adjusted: adjusted for revised trauma score, age, injury severity score, daytime/night-time, and mechanism of trauma; ns: not significant; CI: confidence interval; Δ OST: change in on-scene time.

Table 4. Influence of prolonged OST on mortality (per 10 minutes)

	OR	*95% CI*	*p*
Influence of longer OST on mortality, unadjusted	1.2	[1.0 - 1.3]	< 0.001
Influence of longer OST on mortality, adjusted*	1.0	[0.8 - 1.3]	0.89

* Adjusted for revised trauma score, age, injury severity score, daytime/night-time, and mechanism of trauma