Prehospital interventions before and after implementation of a physician-staffed helicopter

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ABSTRACT

INTRODUCTION: Implementation of a physician-staffed helicopter emergency medical service (HEMS) in eastern Denmark was associated with increased survival for severely injured patients. This study aimed to assess the potential impact of advanced prehospital interventions by comparing the proportion of patients who received those interventions before and after the HEMS implementation.

METHODS: A post-hoc analysis of a prospective before-after study. We included trauma patients with Injury Severity Scores above three who had been admitted to seven emergency departments or one level 1 trauma centre in the course of a five-month period before and a 12-month period after the HEMS implementation. We compared the proportion of patients receiving at least one of 14 predefined advanced interventions between the two periods.

RESULTS: We included 189 patients before and 548 patients after the implementation. The proportion of patients who had interventions done increased from 24.3% to 36.1% (difference (95% confidence limits (CL)); 11.9% (4.6-19.3%), $p = 0.003$). In patients with a Glasgow Coma Scale score below nine and/or an Abbreviated Injury Score above three in the head region, endotracheal intubation was done prior to hospital arrival in 28.1% (9/32) before versus 48.6% (35/72) after (difference (CL); 20.5% (1.1-39.9%)). The proportion of patients who received opioids increased from 11.1% to 21.8% ($p < 0.01$).

CONCLUSIONS: A higher proportion of trauma patients received advanced prehospital interventions after the implementation of a physician-staffed HEMS.

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TRIAL REGISTRATION: not relevant.

The role of helicopter emergency medical services (HEMS) in prehospital resuscitation of trauma patients remains controversial. A HEMS could benefit trauma patients in two ways; by faster transport and by providing earlier advanced treatment delivered by a highly experienced physician. It is unclear which of the two mentioned factors is the more important [1-5].

A before-after study evaluating the implementation of the first Danish HEMS found that 30-day mortality was significantly lower in the group of severely injured patients after the HEMS had become part of the system [6]. Patients were transported faster to a level 1 trauma centre, primarily because a higher proportion of patients was transported directly, bypassing local hospitals and avoiding time-consuming secondary transfers. Changes in advanced prehospital interventions were not examined in detail.

Our aim was to investigate whether the implementation of the physician-staffed HEMS was associated with more trauma patients receiving advanced prehospital treatment.

METHODS

This was a post-hoc analysis of a previously published prospective before-after study [6]. The patients were trauma patients who triggered trauma team activation in any of the seven emergency departments in Region Zealand or one level 1 trauma centre from 1 December 2009 to 30 April 2010 (before the HEMS implementation) and from 1 May 2010 to 30 April 2011 (after the HEMS implementation). Patients were registered prospectively in an electronic database containing information on prehospital and in-hospital treatment.

The Emergency Medical System

The regional ground emergency medical service (GEMS) was a two-tiered system consisting of ambulances staffed with emergency medical service (EMS) providers on three competence levels, and mobile emergency care units (MECU) staffed with consultant anaesthesiologists or anaesthetic nurses, trained in endotracheal intubation. The EMS providers were all trained in basic life support. Level 2 and 3 providers were all certified in providing prehospital trauma life support. Level 3 providers had authority to administer intravenous medication and to insert laryngeal masks. Ground ambulances were manned by a level 1 provider in addition to either a level 2 or 3 provider. The GEMS remained the same after the HEMS implementation, but four out of five MECU units were omitted from 1 March 2011 (the last two months of our study). The HEMS team consisted of a consultant anaesthesiologist, a HEMS paramedic and a pilot. During the observation period, the HEMS operated in daylight hours in addition to the existing EMS. HEMS could be ac-

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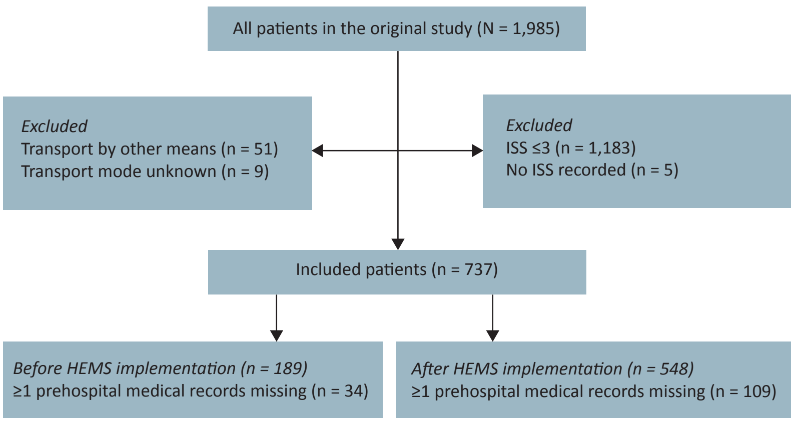
FIGURE 1

Flow chart presenting the patient inclusion before and after the implementation of a physician-staffed helicopter emergency medical service.



HEMS = helicopter emergency medical service; ISS = Injury Severity Score.

Trauma patients attended to by the Helicopter Emergency Medical Service receive more advanced treatment on site.

tivated in case of severe injury, mass casualty or if paediatric trauma (< 2 years) was suspected based on the alarm call, or as secondary dispatch based on request from the EMS at the scene of injury. Moreover, the estimated transport time from the scene to the level 1 trauma centre by ground ambulance should exceed 30 minutes. We divided patients into four groups based on the highest competence level present at the scene of injury; level 2 provider, level 3 provider or MECU nurse, MECU physician or HEMS physician.

Data collection

Two authors recorded data on prehospital treatment from prehospital and emergency department medical records using a data extraction form. We recorded interventions performed either on scene or during transportation. Advanced interventions were defined as; minithoracostomy, also known as finger thoracostomy, needle chest decompression, tube thoracostomy, repositioning of fractures, application of tourniquet, use of pelvic binder, intraosseous access, cricothyroidotomy, endotracheal intubation, and other advanced airway management defined as suctioning, bag-valve-mask ventilation, and placement of a nasopharyngeal, an oropharyngeal, or a supraglottic airway. We also collected data on administration of opioids, sedatives and hypertonic fluids. All other data were available in the preexisting electronic database.

Inclusion/exclusion

We included patients with an Injury Severity Score (ISS) above three. This is equivalent to an Abbreviated Injury Score of at least two, corresponding to a fracture or other injury of similar severity. We excluded patients transported by other means than ambulance or helicopter as well as patients for whom no transport mode was recorded.

Statistics

Our primary analysis was a comparison of the proportion of patients receiving one or more of the predefined interventions. Secondarily, we stratified the primary outcome by highest competence level present on scene. In order to investigate differences in possibly life-saving prehospital interventions in certain patient groups, we planned three subgroup analyses. The first compared the proportions of the patients who either suffered traumatic brain injury (TBI) or had a prehospital Glasgow Coma Scale (GCS) score below nine, who were intubated prior to hospital arrival. We defined TBI as an Abbreviated Injury Scale severity score above three in the head region. The second subgroup analysis compared the proportions of hypotensive patients (defined as prehospital systolic blood pressure < 90 mmHg) who had a pelvic binder placed. The third compared the proportions of hypoxaemic patients (SpO_2 < 90%) who were intubated and/or had a needle chest decompression and/or a minithoracostomy performed. However, due to incomplete recordings of prehospital vital signs and a low number of prehospital interventions, only the TBI/GCS subgroup analysis was meaningful. In order to investigate potential bias due to missing data, we compared all outcomes between patients with complete prehospital medical records and patients for whom some or all data were missing.

We reported categorical data as counts and percentages and compared groups by χ^2-tests or Fisher´s exact test, as appropriate. We reported continuous data by medians and 5-95% range and compared groups using the Wilcoxon-Mann-Whitney test. We estimated differences in primary and secondary outcomes with 95% confidence limits (CL). We performed all data analyses using SAS Enterprise Guide software, version 7.1 for Windows (SAS Institute Inc., Cary, NC, USA.). We considered p-values < 0.05 statistically significant.

Data collection and handling for this study was included in the approvals by the Danish Data Protection Agency (R. no: 2009-41-4122) and the National Health Authority (R. no: 7-604-04-2/128/HKR) for the original study. Ethics committee approval was not required according to Danish law.

Sample size

Around 500 patients would be needed to detect a difference between 16% and 26% in the proportion receiving advanced prehospital interventions with 80% power and a significance level of 0.05. This was approximately the detected change in the proportion of severely injured patients who underwent tracheal intubation in our initial study.

Trial registration: not relevant.

RESULTS

We identified 1,985 patients in the preexisting database who were eligible for inclusion. In the before period, 189 were included for analysis and in the after period 548 patients were included (**Figure 1**).

We found no significant differences between the two groups with regard to age, gender or injuries. Likewise, on-scene times were not significantly different (23 minutes before versus 25 minutes after HEMS implementation, p = 0.09) (**Table 1**).

The proportion of patients receiving at least one of the predefined prehospital interventions increased significantly from 24.3% (46/189) in the before period to 36.1% (198/548) in the after period (difference (CL); 11.9% (4.6-19.3%), p = 0.003) (**Table 2**). **Table 3** presents physician-specific interventions.

We identified 104 patients (32 patients before and 72 patients after) with TBI or a prehospital GCS below nine. In this group, intubation prior to hospital arrival was done in 28.1% (n = 9) in the before HEMS period, and 48.6% (n = 35) in the after period; difference (CL); 20.5% (1.1-39.9%), p = 0.05.

Anaesthetics were used for intubation in 37 (84%), while no drugs were used in three patients who had cardiac arrest (7%) and in one other patient (2%). In three (7%) cases, medical records did not hold data on the use of anaesthetics for intubation.

Use of opioids increased from 11.1% before HEMS implementation to 21.8% (p < 0.01) after.

Needle decompression was done in 0% before versus 0.7% after (4/548, p = 0.6) and tube thoracostomy in 0% versus 0.5% (3/548, p = 0.6), respectively. A pelvic binder was used in 0% versus 1.5% (8/548, p = 0.1).

Prehospital records were missing in a substantial proportion of patients; however, there was no significant difference between the periods (18% versus 19.8%, p = 0.6). Patients with incomplete data had a lower ISS; 8 (4-17) versus 9 (4-34), p < 0.0001), a higher GCS score (15 (9-15) versus 15 (3-15), p = 0.01), and were more likely to be attended by a MECU physician (p < 0.0001) than patients with complete datasets.

DISCUSSION

We found that more patients received advanced interventions after a physician-staffed HEMS was implemented. This was primarily owing to a higher proportion of patients receiving opioids. However, there was also an increase in the use of pelvic binder, tracheal intubation and treatment of suspected pneumothorax.

Strengths and limitations

The main strength of our work is the prospective design of the original study, which decreases the risk of both information and selection bias. Including all patients trans-

TABLE 1

Characteristics of patients in the two study groups before versus after implementation of a physician-staffed helicopter emergency medical service.

	HEMS implementation			
	before (N = 189)	after (N = 548)	Missing data	p-value[a]
Age, yrs, median (95% CI)	45 (10-79)	41 (14-79)	0	0.1
Male sex, n (%)	129 (68.3)	379 (69.2)	0	0.8
ISS, median (95% CI)	10 (4-34)	9 (4-29)	0	0.4
NISS, median (95% CI)	13 (4-45)	11 (4-43)	1	0.1
Prehospital GCS < 9, n (%)	22 (12.5)	54 (11.1)	72	0.6
Head AIS > 3, n (%)	20 (10.6)	46 (8.4)	0	0.4
Type, n (%)			0	0.2
Blunt	179 (94.7)	533 (97.3)	–	–
Penetrating	9 (4.8)	13 (2.4)	–	–
Other	1 (0.5)	2 (0.4)	–	–
Mechanism, n (%)			0	0.2
Road traffic accident	118 (62.4)	323 (58.9)	–	–
Fall > 2 m	27 (14.3)	92 (16.8)	–	–
Fall < 2 m	22 (11.6)	43 (7.9)	–	–
Assault	3 (1.6)	23 (4.2)	–	–
Sports	2 (1)	10 (1.8)	–	–
Other	17 (9)	57 (10.4)	–	–
Highest competence level on scene			0	–
Level 2 provider, n (%)	56 (29.6)	171 (31.2)	–	–
MECU nurse or level 3 provider, n (%)	37 (19.6)	86 (15.7)	–	–
MECU physician, n (%)	96 (50.8)	168 (30.7)	–	–
HEMS physician, n (%)	0	123 (22.5)	–	–
On-scene time, min., median (95% CI)	23 (7-46)	25 (9-52)	55	0.09

AIS = Abbreviated Injury Score; CI = confidence interval; GCS = Glasgow Coma Scale; HEMS = helicopter emergency medical service; ISS = Injury Severity Score; MECU = mobile emergency care unit; NISS = New Injury Severity Score.
a) Groups are compared by χ^2-test or Fisher's exact test.

TABLE 2

Frequency of patients who received advanced prehospital interventions before and after the implementation of a physician-staffed helicopter emergency medical service[a].

Intervention, highest competence level on scene	Frequency, n (%) pre-HEMS (N = 189)	post-HEMS (N = 548)	p-value[b]
All advanced interventions[c]	46 (24.3)	198 (36.1)	0.003
HEMS physician	–	88 (71.5)	–
MECU physician	29 (30.2)	60 (35.7)	0.4
MECU nurse or level 3 provider	10 (27)	29 (33.7)	0.5
Level 2 provider	7 (12.5)	21 (12.3)	1
Analgesia, all patients	21 (11.1)	119 (21.8)	< 0.01
HEMS physician	–	55 (44.7)	–
MECU physician	10 (10.4)	37 (22)	0.02
MECU-nurse or level 3 provider	9 (24.3)	21 (24.4)	1
Level 2 provider	2 (3.6)	6 (3.5)	1
Sedatives, all patients	3 (1.6)	15 (1)	0.4
HEMS physician	–	6 (4.9)	–
MECU physician	2 (2)	7 (4.2)	0.4
MECU nurse or level 3 provider	1 (2.7)	2 (2.3)	0.9
Level 2 provider	–	–	–
Intubation, all patients	13 (6.9)	45 (8.2)	0.5
HEMS physician	–	25 (20.3)	–
MECU physician	12 (12.5)	19 (11.3)	0.8
MEC nurse or level 3 provider	1 (2.7)	1 (1.2)	0.5
Level 2 provider	–	–	–
LMA or other airway[d]*, all patients*	6 (3.2)	22 (4)	0.6
HEMS physician	–	0 (0)	–
MECU physician	3 (3.1)	3 (1.8)	0.5
MECU nurse or level 3 provider	1 (2.7)	8 (9.3)	0.2
Level 2 provider	2 (3.6)	11 (6.4)	0.4

HEMS = helicopter emergency medical service; LMA = laryngeal mask airway; MECU = mobile emergency care unit.
a) Numbers are shown for all patients and stratified by the highest competence level on scene.
b) Time periods are compared by χ^2-test or Fisher's exact test.
c) Advanced prehospital interventions are defined as endotracheal intubation, supraglottic airway, other airway management, cricothyroidotomy, minithoracostomy, needle chest decompression, tube thoracostomy, fluid infusion, repositioning of fractures, tourniquet, pelvic binder, intraosseous cannulation, analgesia, or sedatives.
d) Other airways defined as suctioning, bag-valve-mask ventilation, or nasopharyngeal/oropharyngeal/supraglottic airway.

TABLE 3

Frequency of patients who received physician-specific prehospital interventions before and after the implementation of a physician-staffed helicopter emergency medical service (HEMS).

Physician specific interventions	Frequency, n (% of all patients) pre-HEMS (N = 189)	post-HEMS (N = 189)	p-value[a]
Minithoracostomy	0	0	–
Needle chest decompression	0	4 (0.7)	0.6
Tube thoracostomy	0	3 (0.5)	0.6
Repositioning of fractures	7 (3.7)	16 (2.9)	0.6
Tourniquet	1 (0.5)	0	–
Pelvic binder	0	8 (1.5)	0.1
Intraosseous cannulation	3 (1.6)	8 (1.5)	1
Cricothyroidotomy	0	0	–
Intravenous hypertonic fluid	4 (2.1)	8 (1.5)	0.6

a) Time periods are compared by χ^2-test or Fisher's exact test.

ported to any of the emergency departments in the region and triggering a trauma team activation reduced the risk of selection bias.

However, our study also has limitations. Registration of prehospital vital signs as well as entire prehospital medical records were missing for a substantial number of patients, and we cannot be sure that personnel registered all performed interventions. Missing records and registrations pose a challenge to both patient care, quality assurance and service improvements. Also incorrect registrations were found; medical records stated that in eight cases in which a level 2 provider was registered as highest competence level on scene, patients received opioid analgesics, although the personnel is not authorised to administer opiods. It is most likely that this is due to missing registration of the presence of a level 3 provider.

The number of patients was restricted to that of the original study. A larger study with greater statistical power could have justified subgroup analyses of the severely injured with an ISS above 15. Another potential limitation is that the difference in the duration of the two study periods could increase the risk of selection bias. The shorter before-period included only winter and spring months, and one could speculate that the lower proportion of patients receiving advanced interventions may be due to crude weather conditions leading to a more "load and go" approach on scene, but we found that on-scene times were comparable in the two groups. A before and after study design is prone to confounding by temporal changes such as new recommendations. That could potentially have affected the incidences of interventions in either direction regardless of the HEMS implementation. To the best of our knowledge, HEMS and MECU physicians as well as prehospital anaesthetic nurses worked by the same set of guidelines and these were not changed during the study period.

Interpretation

Due to differences in case mix as well as EMS systems, it does not seem reasonable to compare the observed frequency of interventions in our study directly with frequencies reported in similar studies [4, 5, 7, 8]. Our findings suggest that patients who were attended to by HEMS crew had more interventions performed. This may be because patients who were attended to by HEMS crews were more severely injured or because HEMS physicians intervene more aggressively. Once airborne, HEMS physicians may have difficulty performing interventions and therefore intervene more proactively. The difference might also, in part, be a reflection of the missing and incorrect prehospital medical records from patients who were attended to by MECU physicians or of interventions performed by GEMS while waiting for the HEMS. However, on-scene times were not significantly different between the two groups (Figure 1).

In our study, a mix of all the above explanations seems likely. However, the trend is in line with those reported in other studies, which have associated HEMS attendance with more aggressive prehospital treatment and improved patient outcomes [2, 9, 10].

Among patients with TBI or low GCS, we found an increased intubation rate in the after period. Patients in this subgroup are comparable to those included in the HIRT trial, which found an intubation rate of 49% in the group of patients randomised to be attended by a HEMS physician prehospitally [11]. That trial was not conclusive, but suggested a reduction in 30-day mortality. Although the exact value of prehospital intubation is still discussed, we believe that the observed increase in intubation rate represents a true benefit of adding a physician-staffed HEMS to the EMS system. A meta-analysis investigating prehospital intubation of TBI patients found an insignificant trend towards a favourable outcome when prehospital intubation was performed by experienced personnel such as anaesthetic nurses or anaesthesiologists, while intubation performed by EMS personnel inexperienced in advanced airway management was associated with a higher mortality [12]. Since intubation is only performed by trained anaesthesiologists or anaesthetic nurses in our region, trauma patients may benefit from an increase in the intubation rate.

We believe that the presented results may contribute to the ongoing debate on a physician-staffed HEMS as a part of the prehospital system for trauma patients.

CONCLUSIONS

We found that more patients had advanced interventions performed after the HEMS implementation; this may possibly be explained by a more aggressive prehospital treatment by HEMS physicians.

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