

Physician-staffed emergency helicopter reduces transportation time from alarm call to highly specialized centre

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ABSTRACT

BACKGROUND: Since 2007, the number of Danish emergency departments has decreased from 44 to 21. Longer distances to specialized treatment have increased the demand for advanced prehospital treatment. A Danish 24/7 Helicopter Emergency Medical System (HEMS) project in western Denmark was initiated on 6 January 2011. The HEMS provides prehospital care delivered by a specialized anaesthesiologist. This study evaluated the effect of HEMS on the time to treatment by a physician (time-to-doctor) and the time from a 112 emergency call to arrival at the highly specialized centre (time-to-centre) for patients with ST-elevation myocardial infarction (STEMI) or severe injury (Injury Severity Score > 15).

MATERIAL AND METHODS: In this prospective study with a matched historical control group, the time-to-doctor and the time-to-centre for patients with STEMI or severe injury transported by HEMS were compared with geographically matched patients with the same diagnoses and who were transported by ambulance.

RESULTS: Time-to-centre was reduced from 102 to 84 min. for STEMI and from 322 to 97 min. for severely injured patients after HEMS implementation. HEMS did not substantially reduce time-to-doctor, mainly because of increased availability of physician-staffed cars. In 56% of cases, HEMS was dispatched secondarily more than 30 min. after the ambulance had been dispatched.

CONCLUSION: Using HEMS reduced time to arrival at a highly specialized centre for patients with STEMI or severe injury. Simultaneous dispatch of an ambulance and HEMS shows potential for further reduction in the time-to-centre and the time-to-doctor.

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TRIAL REGISTRATION: The trial is registered at the Danish Data Protection Agency.

with regard to diagnostic capacities and treatment by specialized doctors in emergency departments.

The remodelling of emergency care has resulted in longer distances to hospitals with emergency departments and thus longer times before a specialized physician sees the patient. This has given rise to an intense public and political debate about the safety of the new system. The outcome is an increased demand for prehospital care and for prehospital physicians who can establish early diagnosis and initiate treatment.

Anaesthesiologist-staffed Mobile Emergency Care Units (MECUs) serve as the second tier in prehospital care. MECUs decrease the time from alarm call to a physician sees the patient (time-to-doctor), and this compensates for longer distances to the emergency department in case of severe emergencies.

The first Helicopter Emergency Medical System (HEMS) was introduced in 2005 in Southern Denmark. In 2007, the Danish National Board of Health recommended using a physician-staffed HEMS as an expedient supplement to the prehospital system. The goal was to secure early specialized physician care and swift transportation in sparsely populated areas where distances to specialized treatment had become larger [1]. Another HEMS was privately funded in May 2010 as a time-limited trial in the Region of the Capital and the Region of Zealand. The same year, the government funded a HEMS trial in North-Western Denmark in response to logistical problems with increased distances to emergency care. On 1 June, 2011, this HEMS was introduced as a 13-month trial in the Region of Central Jutland.

The study aim was to evaluate whether HEMS reduced the time 1) from alarm call to initial assessment and treatment by a physician, at the prehospital level or at a hospital (time-to-doctor), and 2) from alarm call to treatment at a centre, i.e. the time from the alarm call to arrival at the highly specialized centre at Aarhus University Hospital (AUH) (time-to-centre). The two groups of patients were those who had ST-elevation myocardial infarction (STEMI) that had been treated at a primary percutaneous coronary intervention (PPCI) centre and severely injured patients with an Injury Severity Score (ISS) > 15 who were transferred to a Level-1 trauma centre, the Aarhus Trauma Centre.

ORIGINAL ARTICLE

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Major changes in the structure of emergency care have been introduced during the past five years in Denmark. Based on recommendations from the National Danish Board of Health in 2007, the number of hospitals treating acutely ill patients has been reduced from 44 to 21, which includes four level-1 trauma centres at the university hospitals [1]. The rationale for the change was an increased demand for up-to-date emergency care both

When the Helicopter Emergency Medical System is airborne, time to treatment is significantly reduced.



MATERIAL AND METHODS

Study design

This prospective study involved a matched historical control group comparing time-to-doctor and time-to-centre for severely injured patients and patients with STEMI, before and after HEMS. The control period with MECUs only was 1 December 2009 to 31 May 2011; the HEMS period was 1 June 2011 to 31 May, 2012.

Prehospital organization

The Region of Central Jutland has 1.2 million inhabitants and covers 13,124 km² with a varying population density from the rural western part to the more densely populated eastern part, including Aarhus with 315,000 inhabitants, the second largest city in Denmark. During the control period, seven MECUs were active 24 h a day, and an additional two were active during the day shift only. During the HEMS period, nine MECUs with 24-h coverage were active. These MECUs functioned as an important supplement to the 64 regional ambulances.

From May 2011, the Medical Emergency Dispatch Centre took over all alarm calls concerning disease and injury from the police-operated alarm centres (112 emergency calls). From that time, alarm calls were prioritized according to a criteria-based index, The Danish Index of Emergency Care [2].

The HEMS was dispatched in two ways: primary dispatch immediately after the alarm call in accordance with predefined criteria in The Danish Index of Emergency Care; or secondary dispatch after the first ambulance or other prehospital unit arrived on scene and requested assistance from the HEMS.

Patient inclusion

Included in the trial were emergency calls (112 calls) for patients in the Region of Central Jutland with the diagnosis of either STEMI and PPCI at AUH, or severe injury defined as an ISS > 15 [3] treated at Aarhus Trauma Centre. Inter-hospital transfers were included if they occurred within 24 h.

Groups were matched for diagnosis, treatment and

geographical location (**Figure 1**). Each HEMS patient was matched with one or more control patients from the same region. In STEMI patients, matching was done using postal codes. Severely injured patients were matched using larger geographical areas (municipalities) because of the lower number in this group. When a HEMS patient could be matched geographically to more than one control, the average times for time-to-doctor and time-to-centre in that area were calculated.

Data

Time-point data registered included alarm call, HEMS dispatch, ambulance/MECU and/or HEMS arrival to the patient, ambulance/MECU and/or HEMS departure with the patient, and ambulance or HEMS arrival at the hospital (regional hospital and university hospital). Data were collected from the automatic HEMS flight log and from the Emergency Medical Dispatch Centre database, in which arrivals and departures of all prehospital units are logged. Data concerning diagnosis and treatment were confirmed by consulting the Western Denmark Heart Registry database and the trauma database at the Aarhus Trauma Centre.

Statistical analysis

R (version 2.13.1) was used for statistical analysis. Data were not normally distributed according to QQ plots and normal distribution histograms and were thus analysed using the Mann Whitney Wilcoxon test. Significance was set at 5% when assessing results. A pseudo-median value was estimated using the Hodges–Lehmann statistic.

Trial registration: The trial is registered at the Danish Data Protection Agency.

RESULTS

During the first year of service in the Region of Central Jutland from 1 June 2011 to 30 May 2012, the HEMS transported and treated 662 patients of whom 567 were transported internally within the region; 118 were trauma patients, 51 of whom were transported to the trauma centre at the AUH. The 15 patients with an ISS > 15 were included (median ISS 22); 242 were cardiac patients, 151 of whom were transported to the PCI centre at the AUH. The 31 patients with both STEMI and PCI treatment were used as the STEMI patient population in this study. Two trauma patients had an incomplete data point: one with no time-to-doctor and one with no time-to-centre. The other valid data point for these two patients is included in the study.

The control group consisted of 31 severely injured patients with an ISS > 15 (median ISS 22) who were brought to the trauma centre at the AUH and 70 STEMI

patients who were treated with PCI at the AUH. Most patients were transported from the western part of the region, with 87% (13/15) of the trauma patients coming from four western regional municipalities. All of the STEMI patients originated from the western part.

In the HEMS period, the time-to-centre was significantly reduced. Of the 31 severely injured patients in the control group, 28 were initially brought to a local hospital before transfer to the trauma centre. For this reason, the time intervals were calculated both with and without time spent at the local hospital. In both cases, time-to-centre decreased significantly. The severely injured patients in the control group arrived at the trauma centre 322 min. after the alarm call ($n = 31$; 95% confidence interval (CI): 271-374). In the HEMS group, this was reduced to 97 min. ($n = 14$; 95% CI: 86-107), a mean reduction of 225 min. ($p = 0.0001$; 95% CI: 171-280) and a median reduction of 235 min. ($p = 0.0001$). The reduction achieved by subtracting the time spent at the regional hospitals was 16 min. ($p = 0.04$)

STEMI patients in the control group arrived at the PCI centre after 102 min. ($n = 70$; 95% CI: 97-108), which was reduced to 84 min. in the HEMS group ($n = 31$, 95% CI: 77-90), a mean reduction of 18 min. ($p = 0.0004$; 95% CI: 10-27) and a median reduction of 22 min. ($p = 0.0004$).

Time-to-doctor was also significantly reduced in the HEMS group compared with the control group; for the severely injured patients, time-to-doctor was reduced from 35 min. ($n = 31$; 95% CI: 24-45) to 17 min. ($n = 14$, 95% CI: 12-21). For STEMI patients, time-to-doctor was reduced from 80 min. ($n = 70$; 95% CI: 69-91) to 15 min. ($n = 31$; 95% CI: 13-17). In 12 of the 14 HEMS trauma patients for whom time-to-doctor was registered and in 29 of the 31 STEMI patients, the MECU physician was the first physician to see the patient, and this was the main reason for the time reduction. In 56% (25/45) of the cases, the HEMS was not dispatched primarily but was requested secondarily.

Time differences between primary and secondary dispatch of HEMS

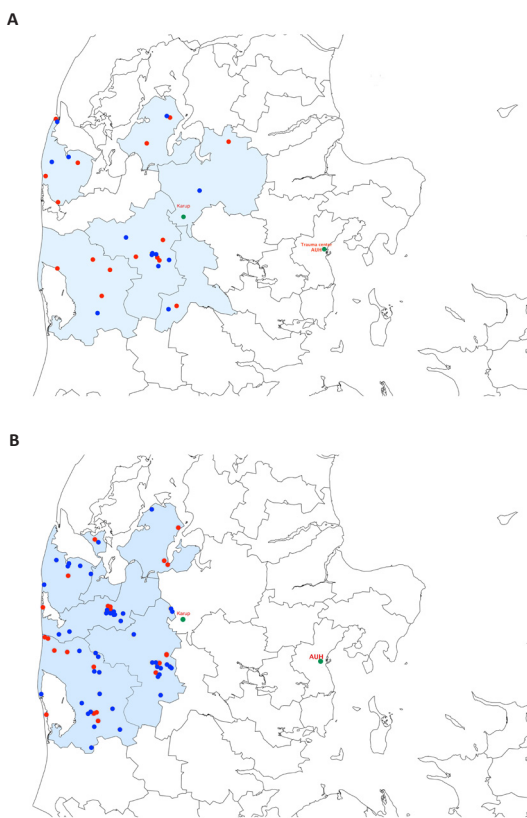
For the majority of the patients, 20 of the 31 STEMI patients and five of the 15 trauma patients, the HEMS was dispatched secondarily after arrival on scene by ambulance or MECU and assessment of the patient. The average delay due to this secondary dispatch of the HEMS for was 36 min. for the STEMI patients and 31 min. for the severely injured patients.

DISCUSSION

The main study finding was that the time from the alarm call to arrival at the PCI Centre or the trauma centre was reduced from 102 to 84 min. for STEMI patients and from 322 to 97 min. for severe trauma patients after

FIGURE 1

112 emergency call location for all patients included in the study. The map presents the municipalities in the Region of Central Jutland. Time parameters are based on a comparison of Helicopter Emergency Medical System and control patients from the same municipality. Severely injured patients (injury severity score > 15) (A) and ST-elevation myocardial infarction patients (B) are plotted.



Blue dots: Patients from the control group.
Red dots: Helicopter Emergency Medical System patients.

HEMS implementation. The time from the alarm call to the patient met the first physician was also significantly reduced, mainly owing to the greater coverage of the MECUs and a more uniform dispatch via The Danish Index of Emergency Care. We found a potential for additional reduction in both time intervals: The HEMS was not dispatched primarily in 56% of cases (25/45), causing a 17-54-min. delay of the HEMS depending on the geographical location of the patient (see **Table 1**).

Only a few other studies have studied time-to-doctor and time-to-centre, which are both key parameters of the infrastructure of emergency care. The patients included in this study were all diagnosed and treated for a critical emergency condition.

The small study population is a study weakness that arises partly because of our strict inclusion criteria which required a confirmed diagnosis and treatment, and

 TABLE 1

Calculated time reduction with immediate helicopter emergency medical system dispatch. Potential time gain from dispatching the helicopter emergency medical system immediately after the alarm call, instead of a secondary dispatch requested by other prehospital units (dispatch delay). Patients are grouped geographically into municipalities.

Municipality	Patients, n	Time-to-center, min.		Potential time gain, min.
		from alarm call	from HEMS alarm	
<i>Severely injured patients</i>				
Ringkøbing-Skjern	2	116	82	34
Herning	2	81	64	17
Viborg	1	132	78	54
<i>STEMI patients</i>				
Herning	7	89	46	43
Holstebro	6	85	55	30
Ringkøbing-Skjern	3	97	66	31
Lemvig	2	91	65	26
Skive	1	130	106	24

HEMS = Helicopter Emergency Medical System; STEMI = ST-elevation myocardial infarction.

partly because of the geographical location criterion. Time-stamp registration in the ambulances and MECUs was a manual procedure, and incomplete time data were the primary cause of patient exclusion.

Even though improvement in MECU response time was the primary driver of the reduction in time-to-doctor, the HEMS also contributed. The 567 patients transported by the HEMS within the region during the study period would otherwise have required a time-consuming escort from a MECU and an ambulance to the AUH. This would have meant one less available MECU and ambulance for several hours. Bruhn et al found that one HEMS can replace up to six MECUs and still improve both response time and personnel expenditures [4]. A recent study on Danish STEMI patients advocated the use of a HEMS for patients who had to be transported over a distance of more than 60 km. Furthermore, the HEMS makes it possible to undertake PPCI treatment within 2 h of the alarm call for patients living up to 150 km from the PCI centre [5].

A recently published study on HEMS in the Region of the Capital and the Region of Zealand had a comparable study design and geographical setting. This study found a similar reduction in "time to highly specialized treatment" for severely injured patients, viz. from 218 to 90 min. ($p = 0.002$). They also found a statistically significant decrease from 29% to 14% ($p = 0.02$) in 30-day mortality for severely injured patients in the HEMS group [6-8]. This result is in line with the existing literature, which indicates that efficient and goal-directed

measures and transport can increase survival rates for these patients [9-14].

For STEMI patients, the Zealand HEMS study from the Region of the Capital and the Region of Zealand identified a similar reduction from 104 to 84 min. ($p < 0.001$) in the time from the first diagnostic STEMI electrocardiogram to initiation of highly specialized treatment [5]. This finding is almost identical to our 22-min. improvement in time from alarm call to arrival at PCI facilities.

Primary or secondary dispatch

The average 35-min. delay associated with secondary HEMS dispatch leaves potential for considerable improvement through time reduction, which reflects a substantial increase in the effectiveness of prehospital preparedness for STEMI and trauma patients. If HEMS could be primarily dispatched more often, the effect would probably be more evident [15, 16].

Patients suffering other critical emergencies not included in this study might have benefitted from the HEMS. The description of these patients was beyond the scope of this study.

International perspective

Most of our neighbouring countries have had HEMS as an integrated part of their prehospital care in the emergency medical services for decades. The first civilian medical helicopter operated in Germany in 1970 [17]. Since 1978, Norway has staffed their medical helicopters with trained physicians as a part of their prehospital preparedness [18], and HEMS has later been introduced in many other European countries [19]. The current study and the results from the HEMS in the Region of the Capital and the Region of Zealand [6-8] support the use of HEMS in Denmark.

CONCLUSION

The HEMS reduced time to arrival to highly specialized treatment for patients in the Region of Central Jutland suffering from STEMI or severe injury. Simultaneous dispatch of an ambulance and HEMS has the potential for further reduction in both time-to-centre and time-to-doctor. Although the time effect can be further optimized, the intended role for HEMS as a useful supplement to existing preparedness was fulfilled for the patient groups investigated in this study.

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