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Clinical paper

Does experience in prehospital post-resuscitation critical care affect outcomes? A retrospective cohort study

Anssi Saviluoto [a,b], Helena Jäntti [c], Aki Holm [d], Jouni O. Nurmi [a,e,*]

[a] Research and Development Unit, FinnHEMS, WTC Helsinki Airport, Lentäjäntie 3, FI-01530 Vantaa, Finland
[b] University of Eastern Finland, Kuopio, Finland
[c] Kuopio University Hospital, Center for Prehospital Emergency Care, P.O. Box 100, FI-70029 Kuopio, Finland
[d] Faculty of Medicine, University of Helsinki, Helsinki, Finland
[e] Emergency Medicine and Services, Helsinki University Hospital and University of Helsinki, Helsinki, Finland

Abstract

Aims of the study: Helicopter Emergency Medical Services (HEMS) often provide post-resuscitation care. Our aims were to investigate whether physicians' frequent exposure to prehospital post-resuscitation care is associated with differences in (1) medical management, (2) achieving treatment targets recommended by resuscitation guidelines, (3) survival.

Methods: We conducted a retrospective cohort study using data from a national HEMS quality register. We included patients between January 1st, 2012 and September 9th, 2019 who received post-resuscitation care by a HEMS physician. We excluded patients <16 years old. For each patient we determined the number of post-resuscitation cases the physician had attended in the previous 12 months. Patients were divided in to three groups: low (0–5), intermediate (6–11) and high exposure (≥12 cases). Medical management and proportions within treatment targets were compared. Survival at 30-days and 1-year was analysed by multivariate logistic regression analysis, controlling for known prognostic factors.

Results: 2272 patients were analysed. Patients in the high exposure group had mechanical ventilation and vasoactive medications initiated more often ($P < 0.001$ and $P = 0.008$, respectively) and on-scene times were longer ($P < 0.001$). The target for blood pressure was achieved more often in this group ($P = 0.026$), but targets for oxygenation and ventilation were not. We did not see an association between survival and physicians' exposure to post-resuscitation care (odds ratio 0.96, 95% confidence interval 0.70–1.33 for low and 0.78, 0.56–1.08 for intermediate, compared to high exposure).

Conclusions: Physicians with more, frequent exposure take a more active approach to post-resuscitation care, but this does not seem to improve survival.

Keywords: Advanced life support (ALS), Haemodynamics, Oximetry, Post-resuscitation period, Vasopressor therapy, Ventilation

Introduction

During out-of-hospital cardiac arrest (OHCA) survival is dependent on the parts in the chain of survival.[1] Timely, good quality cardiopulmonary resuscitation (CPR) and early defibrillation are crucial for a good outcome.[1] Some studies have shown paramedics prior experience with OHCA to be associated with survival.[2,3] After return of spontaneous circulation (ROSC) the objectives of post-resuscitation care are to reverse any treatable cause for cardiac arrest and stabilize vital functions to prevent end organ damage.[4,5] The European Resuscitation Council (ERC) has published guidelines for post-resuscitation care,[6] adherence to which has been associated with improved outcomes.[7,8]

* Corresponding author at: Helsinki University Hospital, Emergency Medicine and Services, FinnHEMS 10, Vesikuja 9, 01530 Vantaa, Finland.
E-mail address: jouni.nurmi@hus.fi (J.O. Nurmi).

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One main objective of Helicopter Emergency Medical Services (HEMS) are to concentrate advanced prehospital critical care, such as post-resuscitation care, to specialized teams. Centralizing care to cardiac arrest centers has been linked to better adherence to guidelines and improved survival.[9–11] Physician-staffed HEMS units are rarely first on-scene, but work with ground-based EMS, units.[12] Therefore, the emphasis of HEMS, is in post-resuscitation critical care.[12] It is not yet clear, if the quality of this care depends on the physician's familiarity with pre-hospital post-resuscitation.[12]

It seems, that experience might be a factor affecting survival in cardiac arrest through the chain of survival. Due to this rational, OHCA is one of the most common missions for HEMS around the world.[13–16] We hypothesized that a physician with frequent experience in prehospital post-resuscitation care might achieve treatment goals, recommended by guidelines, more often and that this experience might be associated with better outcomes.

The aims of this study were to investigate whether a physician's exposure to prehospital post-resuscitation care in the previous 12 months was associated with: (1) differences in medical management, (2) how often treatment targets were achieved and (3) 30-day and 1-year survival.

Methods

Ethics approval

The Ethical Committee of Helsinki University Hospital approved the study protocol. Permissions to use patient data were applied and granted separately from each university hospital district (Oulu University Hospital 200/2019 2.7.2019, Helsinki University Hospital HUS/280/2019 9.7.2019, Turku University Hospital J30/19 4.8.2019, Hospital District of Lapland 32/2019 22.8.2019, Kuopio University Hospital RPL 102/2019 22.8.2019 and Tampere University Hospital RTL-R19580). The study did not affect patient treatment and therefore patient consent was not required nor acquired. Reporting adheres to the Strengthening the Reporting of Observational studies in Epidemiology statement.[17]

Study design

We conducted a retrospective cohort study using data from a national HEMS quality register.[15] We did two separate analyzes

1. We compared patient survival and the proportion of patients for whom treatment targets for vital sign where achieved, according to the number of post-resuscitation cases attended by the treating physician in the preceding 12 months.
2. A logistic regression analysis to asses if the number of a physician's post-resuscitation cases in the previous twelve months is associated with survival at one year and 30 days.

Setting

Finland has a national, publicly funded, HEMS with six units around the country. Five are staffed with a physician. During the study period 70% of physicians were specialized in anaesthesiology and intensive care while 25% entered HEMS during their last year of specializing. The rest had specialized in internal medicine or completed their specialty in emergency medicine during the study period. At the time of writing, there are no uniform requirements for HEMS physicians experience or training. The five university hospital districts decide on physician staffing of the HEMS-unit in their area.

Finland has population of 5.5 million and the incidence of EMS-attempted resuscitation is 51/100,000 inhabitants per year.[18] HEMS units are dispatched directly by a national emergency response center at the same time as EMS on predetermined criteria. These include OHCA when, estimated on map, the patient can be reached within 30 min and the arrest was witnessed or patient was known to be alive within 20 before the call. The physician may cancel HEMS when, according to information from the scene, the patient is thought not to benefit (e.g. futile prognosis, unfavorable logistics). According to a previous study in Finland, HEMS attended 41% of EMS-attempted resuscitations.[18]

Finland is sparsely populated, and HEMS may land on private or public property without acquiring permission from the landowner. In most cases HEMS can land in the immediate vicinity of the patient. If necessary, a separate ground-based unit is dispatched to transport HEMS crew from the nearest suitable landing site to the patient. In cities near HEMS bases a rapid response car is used whenever the patient can be reached faster by ground. In these cases, transportation is done using an ambulance, where the physician accompanies ground-based EMS.[15]

The country has ground-based EMS units capable of basic life support (BLS), and advanced life support (ALS).[18] Both units perform resuscitation by the same principles and can administer amiodarone and adrenaline. ALS may also perform endotracheal intubation, whereas extra glottic devices or bag-valve ventilation may be used by BLS.[18] ALS may also initiate vasoactive medication after consulting a physician. Resuscitation and stabilization after ROSC are almost always done on-scene and resuscitation during transport is reserved for special circumstances (e.g. hypothermia). HEMS usually joins the mission on-scene, but if ROSC is achieved and the patient is deemed ready for transport, a rendezvous with HEMS is planned on route to hospital.

FinnHEMS is an administrational, government owned, company, providing the infrastructure for operation (e.g. helicopters and property). FinnHEMS also provides a national database, FinnHEMS Database (FHDB), where data on all HEMS mission, since the beginning of the national service at the beginning of 2012, has been entered. The national HEMS and emergency medical services (EMS) are described in a previous paper.[15]

Data sources

The study material consisted of data in the FHDB. Using unique patient identifiers stored in the database, mortality data was acquired from the Finnish digital and population data services agency until the end of October 2019.

Participants

For this study we included all patients from 1st January 2012 until 9th September 2019 who received CPR, ROSC was achieved, and a HEMS physician escorted the patient to hospital. Sample size was determined by the data available. We excluded patients younger than 16 years and patients whose survival status could not be determined. For the first year of the databases existence, physicians' exposure to post-resuscitation care in the preceding year could not be determined. Therefore, survival was not analyzed for patients encountered during 2012, but all cases of post-resuscitation care were counted when determining physicians' exposure in the proceeding years.

Variables

Post-resuscitation care was defined as a mission where CPR was performed, ROSC was achieved, and the patient was escorted to hospital by a physician. For each mission we determined the physician's exposure to prehospital post-resuscitation care by counting number of cases the physician had attended in the preceding twelve months. According to this exposure patient were divided in to three groups: low (0−5), medium (6−11) and high exposure (≥12 cases). We compared these groups in terms of achieving the recommended physiological targets. The targets were defined as recommended in the national resuscitation guidelines, based on the European Resuscitation Council advanced life support: systolic blood pressure over 100 mmHg, oxygen saturation (SpO_2) of 94−98% and end tidal CO_2 ($ETCO_2$) of 30−34 mmHg.[19] For $ETCO_2$, the ERC guidelines recommend “normocapnia” without a specific threshold.[6] Therefore, we used the definition recommended by the national guidelines.[19] The values used where the last values recorded by the HEMS team before handover at hospital. No adjustments were made for the type of airway used. Missing values were excluded from analysis for the variable in question.

The initial rhythm was classified as ventricular fibrillation (VF), ventricular tachycardia (VT), asystole (ASY) or pulseless electrical activity (PEA). For analysis we combined VT and VF into single group, shockable rhythms. If the initial rhythm was missing or classified ‘unknown’ the patients were excluded from analyses. Identification was done by the very first responder after electrocardiographic monitoring was achieved.

We reported the use of any vasoactive medications and mechanical ventilation in the three groups. Vasoactive medication was defined as any medicine intended to increase blood pressure by constricting blood vessels (e.g. noradrenaline). Mechanical ventilation was defined as any case where the airway was secured, and the patient was connected to a respirator. Manual bag-valve ventilation only, was not considered mechanical ventilation.

On-scene time (OST) was defined as the time between arrival at scene and the beginning of transport. When the at-scene time was not available, ‘at patient’-timestamp was used instead, if available. Time to ROSC was determined as the time from the time of cardiac arrest to ROSC. Time of ROSC was recorded by the provider on-scene at the time. The beginning of the emergency call was used as the time of cardiac arrest unless witnessed by EMS or first responders. In the latter, times recorded by the providers were used instead.

Statistical methods

Patients were categorized in to three groups according to the physician's exposure to post-resuscitation care. For each group, we calculated the proportion of cases where vasoactive medication or mechanical ventilation was initiated. The proportions were calculated by dividing by the number of all cases where the aforementioned vital sign was recorded. *P*-values for all proportions were calculated using the Pearson Chi-Square test. All proportions are reported as n, proportion (%) and 95% confidence interval (CI). All continuous variables are reported as median, 25th to 75th percentile. *P*-values for continuous variables were calculated using the Kruskal−Wallis test for independent samples.

We assessed the association between survival and physicians' post-resuscitation exposure by performing two separate logistic regression analyzes. 30-day and 1-year survival were used as the dependent variables. We used the patients age and sex, time to ROSC, presence of bystander CPR, whether the arrest was witnessed, initial rhythm, presumed cardiac cause for arrest, whether the patient was transported to a university hospital and the physicians' exposure to post-resuscitation as covariates.

Guidelines recommend reporting survival separately in patients with witnessed collapse and shockable initial rhythm.[20] We therefore repeated the logistic regression in this group. The results were reported as odds ratios (OR) with 95% CIs. Because timestamps for other units than HEMS are often not available, we decided not to include delay to first responder in the main model. Instead, we performed a sensitivity analysis adding it as a covariate to the main model for cases where the information was available.

Cases with missing values for any covariates were excluded from multivariate analyses. Goodness of fit for all models were evaluated by calculating Nagelkerke's R^2 values. All statistical analyses were performed using SPSS Statistics for Mac, Version 25.0 (IBM Corp., Armonk, NY, USA).

Results

During the study period 2 272 patients, treated by 91 physicians were analyzed (Fig. 1). Patient characteristics are presented in Table 1. A sustained ROSC was achieved in 1174 (52%) cases prior to HEMS arrival. For these, the median time from ROSC to HEMS arriving to scene was 9 (5−17) minutes. For the remainder ROSC was achieved in the presence of HEMS. 72 (3.2%) patients went into cardiac arrest while HEMS was already on scene. 30-day and 1-year follow up was completed for 2270 (99.9%) and 2147 (94.5%) patients, respectively. The median number of post-resuscitation cases a physician had attended in the preceding twelve months was 6 (3−10). The group with low exposure included 1062 patients while the groups with intermediate and high exposure had 836 and 374 patients, respectively (Table 2).

The groups with low, medium and high exposure did not differ in age [65 (56−74), 66 (56−74) and 66 (56−73) years, respectively] or proportion of males (74%, 73% and 71%, respectively). The proportion of witnessed collapse with a shockable initial rhythm was also similar between the groups (43%, 45% and 41%, respectively). OST was longest in the group with high exposure. These patients also received vasoactive medications and mechanical ventilation more often (Table 2).

Target blood pressure was reached more often in groups with higher exposure to post-resuscitation care, whereas targets for SpO_2 and $ETCO_2$ were not (Fig. 2A−C). The last value for SpO_2 could not be measured or was missing for 234 (10%) patients, while the last $ETCO_2$ and blood pressure were not available for 355 (16%) and 124 (5.5%) patients, respectively.

Of all patients 49% were alive 30-days after cardiac arrest and 42% were alive at one year. The median age of patients alive after one year was 63 (52−71) years and 76% were male. For comparison, of the 376 patients that were excluded from the study, because they were transported without a HEMS physician, 39% were alive at 30-days and 30% after one year. Survival among patients with witnessed collapse and a shockable initial rhythm were 68% at 30-days and 62% at one year, respectively. Survival in the three groups according to

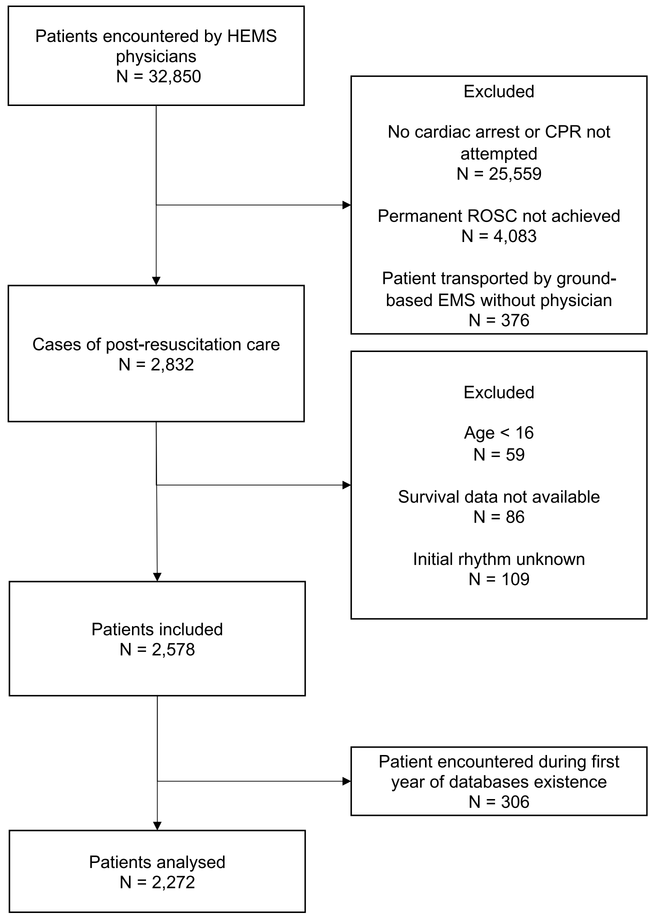

Fig. 1 – Patient selection flowchart.

Table 1 – Patient characteristics. Data are presented as median (Q1–Q3) or n (proportion).

	All patients *N* = 2272	Witnessed arrest with shockable initial rhythm *N* = 989
Age, years	66 (56–74)	65 (56–73)
Sex, male *n*, (%)	1663 (73)	806 (82)
Time to ROSC (min)	20 (12–28)	21 (15–29)
Unit dispatch to patient (min)	20 (15–31)	20 (14–30)

Table 2 – Comparison of on-scene time (OST) and proportion of patients with medical interventions according to physician's exposure to prehospital post-resuscitation care in the preceding twelve months (low exposure: 0–5 cases, intermediate exposure: 6–11 cases and high exposure: ≥12 cases). Data are presented as median (Q1–Q3) or number and percentage (95% confidence interval).

	Low exposure *N* = 1062	Intermediate exposure *N* = 836	High exposure *N* = 374	*P*-value
On-scene time (min)	32 (21–45)	36 (25–48)	37 (25–48)	<0.001**
Mechanical ventilation *n*, (%)	574 54 (51–57)	568 68 (65–71)	255 68 (63–73)	<0.001*
Use of vasoactive medications *n*, (%)	730 69 (66–72)	608 73 (70–76)	287 77 (72–81)	0.008*

* Pearson Chi-Square test.

** Independent samples Kruskal–Wallis test.

physicians' exposure to post-resuscitation care did not differ for 30 days [50% (47–53%) for low, 49% (45–52%) intermediate and 49% (44–55%) for high exposure, respectively, $P = 0.89$] or one year [43% (39–46%), 40% (36–43%) and 45% (40–50%), respectively, $P = 0.19$)]. A logistic regression analysis did not show an association between physicians' frequent exposure to post-resuscitation care and patient survival (Fig. 3). The model had a R^2 value of 0.44. Delay to first responder was available for 1146 (50%) patients. Adding this to the

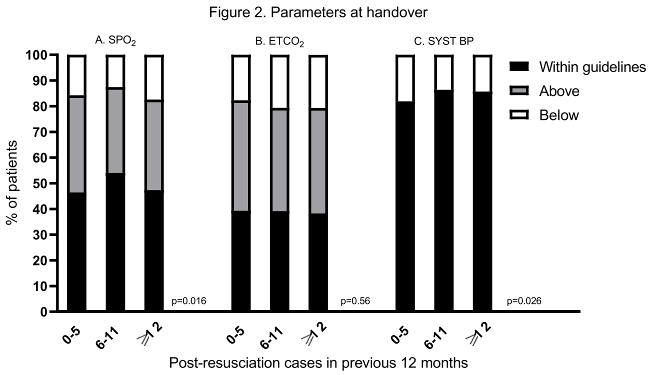

Fig. 2 – (A–C) Proportion of patients with treatment targets achieved according to national guidelines for post-resuscitation care.[19] Guidelines recommend a SpO_2 of 94–98%, $ETCO_2$ of 30–34 mmHg and systolic blood pressure over 100 mmHg.

model increased the R^2 to 0.46, but no association between physicians' exposure to post-resuscitation care and survival could be seen here either. All regression analysis results are presented in an online supplement (Appendix A).

Discussion

We found that physicians with more, frequent, exposure to prehospital post-resuscitation care were more aggressive in initiating treatment and spent more time on-scene. In these cases, blood pressure treatment goals were achieved more often, but no association was seen in how often other treatment goals were achieved or in survival of the patients.

In our study almost half of the patients survived over a month, which is exceptional for a study of patients with OHCA.[25] This is undoubtedly, in large part, due to stringent patient selection. Physicians in the Finnish HEMS routinely cancel or deny missions where the prognosis is grim, and resuscitation is also interrupted or withheld when a good neurological outcome seems very unlikely. A previous study of OHCA in Finland saw the presence of a physician to be associated with a fivefold increase in odds for survival.[18] We also selected only patients with a permanent ROSC achieved and escorted to hospital. Therefore, survival numbers should not be compared to studies that include unsuccessful resuscitations. The aim of our study was not to investigate the effect of physician-staffed HEMS per se but discern the effect of exposure within the service instead. Nonetheless, the survival rate is very high in all groups, demonstrating a well-functioning chain of survival. We did not see a difference in outcomes, but it is unclear if a survival much higher can even be achieved in such a critical cohort of patients.

The fact, that more active management did not lead to better outcomes may be due to several factors. It is well known that treatment delays, initial rhythm, early defibrillation and good quality CPR greatly affect outcomes.[1] However, post-resuscitation treatment goals are based on less robust evidence and the effect size seen has been small compared to the aforementioned factors.[6,21–24] Therefore, the effect of a physician's experience might be quite minute compared to factors in initial CPR, and hard to discern even in a large study. For some patients, the treatment goals may be unobtainable due to underlying pathology. Also, most of the physicians with less exposure to post-resuscitation in the prehospital environment were senior anesthesiologists, many of whom work regular shifts in the intensive care unit and provide in-hospital post-resuscitation care often. These skills might translate to a prehospital setting unifying the groups.

We saw differences in patient management according to the experience of the physician. Uniform standard operating procedures (SOPs) might help unify practice patterns.[26] Also, oxygenation and ventilation goals were frequently not reached, and a goal-directed, aggressive algorithm might help achieve treatment goals more often.[27] However, no high-quality evidence about the effect of strict normalization of physiology on the outcome of the patients exists and further study is needed to better determine optimal targets for prehospital post-resuscitation care.

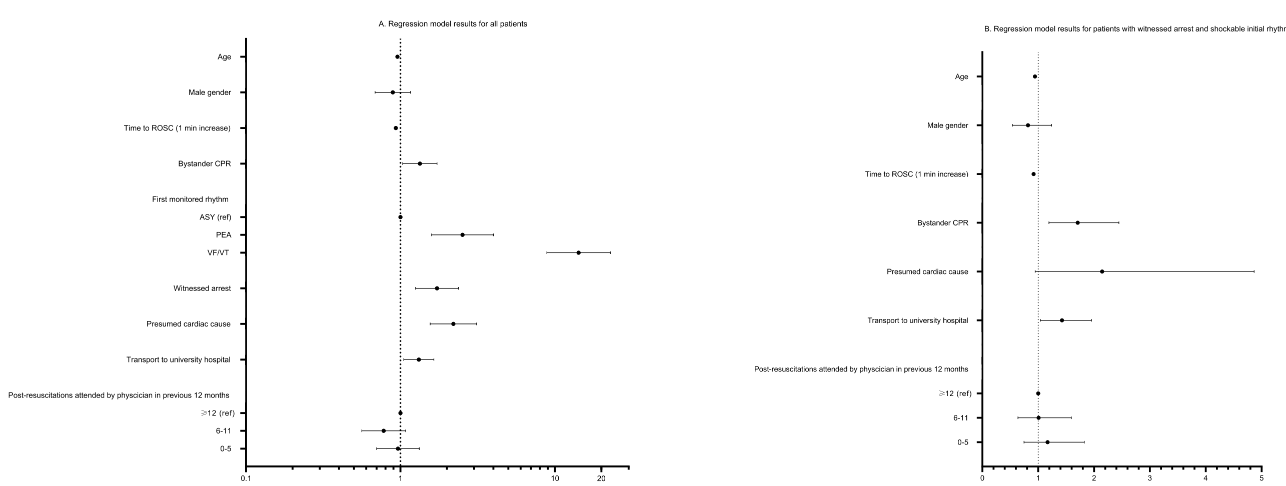

Fig. 3 – Logistic regression analysis results for survival at one year after post-resuscitation care for all patients (A) and patients with witnessed collapse and a shockable initial rhythm (B). ROSC: Return of spontaneous circulation; CPR: Cardiopulmonary resuscitation; VF: Ventricular fibrillation; VT: Ventricular tachycardia; PEA: Pulseless electric activity; OR: Odds ratio; CI: Confidence interval.

Generalizability

We surmise the results to be generalizable to other physician-staffed HEMS units where physicians are routinely involved in post-resuscitation care in- or out-of-hospital. Physicians may cancel or deny missions with poor prognosis and therefore any service without this liberty may find different results. In Finland, the patient is usually transported only once ROSC is achieved. Recent evidence suggests this might be preferable and, hence become more common.[28] Our results might not apply to services that often transport with ongoing CPR.

Strengths and limitations

There is only one, national, HEMS in the country and all missions are logged in a shared database, with low rates of missing data,[15] constituting a strength of the study. However, data is not separately validated after entry and is therefore subject to errors during input. HEMS is dispatched to a large proportion of OHCA cases in the country, but the physician on call often cancels or denies the mission,[15] constituting a considerable risk for selection bias. However, we think this is exactly the patient group of interest when considering the study question, as here we are most likely to see deterioration in outcome if post-resuscitation care is substandard in any aspect.

During the study period, no uniform SOPs were in place to guide cancellations or post-resuscitation care. Hence, both may vary considerably between the HEMS units and providers. We did not control the previous health or functional status of the patients. Furthermore, no data on the neurological outcome of the patients were available. Thus, a potential association of the frequent exposure of physicians and the functional outcome cannot be excluded.

Conclusions

Physicians with more, frequent exposure to prehospital post-resuscitation care treat patients more actively, but this does not seem to improve survival. The recommended physiological targets are met only in a moderate proportion of the cases.

Conflict of interest

None.

Credit author statement

AS was involved in conception of the study and contributed substantially to study design, did the primary analysis of the data and drafted the manuscript. HJ participated in the conception of the study and made important contributions to study design. She provided critical revisions to the manuscript providing important intellectual content. AH made substantial contributions in the analysis and interpretation of the data. He produced the figures for the manuscript with critical input from all other authors. AH provided critical revision of the manuscript adding important intellectual content. JN came up with the original concept of the study and made substantial contributions to study design. JN made significant contributions to interpretation of the data and participated in drafting the manuscript and provided important critical revisions. All authors have read and approved the final version of the manuscript that is being submitted. None of the authors received writing assistance.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2021.03.023.

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