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Clinical paper

Out-of-hospital cardiac arrest following trauma: What does a helicopter emergency medical service offer?

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Abstract

Introduction: Helicopter emergency medical services (HEMS) are often dispatched to patients in traumatic cardiac arrest (TCA) as they can provide treatments and advanced interventions in the pre-hospital environment that have the potential to contribute to an increased survival. This study, aimed to investigate the added value of HEMS in the treatment of TCA.

Methods: We performed a retrospective cohort study of all patients with a pre-hospital TCA who were attended by a non-urban HEMS (Kent, Surrey and Sussex Air Ambulance trust) between July 1st 2013 and May 1st 2018. We investigated how many patients got return of spontaneous circulation (ROSC) at scene, which HEMS specific advanced interventions were performed in these patients, and how these interventions were related to ROSC.

Results: During the study period 263 patients with a TCA were attended by HEMS with an average response time of 30 min [range 13–109]. 51 patients (20%) regained ROSC at scene (28 before- and 23 after arrival of HEMS). The HEMS specific interventions of blood product administration (OR 8.54 [2.84–25.72]), and RSI (2.95 [1.32–6.58]) were positively associated with ROSC. Most patients who had a ROSC had one or more HEMS specific interventions being performed– RSI (n = 19, 37%), blood product administration (n = 32, 62%), thoracostomies (n = 36, 71%) and thoracotomy (n = 1, 2%). HEMS also delivered other important interventions to these patients as IV/IO access (n = 20, 39.2%) and endotracheal intubation without drugs (n = 9, 17.6%).

Conclusion: HEMS teams should be involved in the treatment of patients with a TCA, even in non-urban areas with prolonged response times, as they provide knowledge and skills that contribute to regaining and maintaining a sustained ROSC in this critically ill and injured cohort of patients.

Keywords: Traumatic cardiac arrest, HEMS, Interventions

Introduction

Every year around 30,000 patients experience a cardiac arrest in the UK.[1] The aetiology of the majority of cardiac arrest cases is medical, whereas less then 5% have a cardiac arrest as a result of trauma (traumatic cardiac arrest, TCA).[2] TCA is a clinical diagnosis rather than a disease state, and should be regarded as the end result of various different mechanisms. The most common causes for TCA (accounting for 90% of the cases) are hypovolemia and severe head injury, while a smaller number of patients suffer from upper airway obstruction, hypoxia, tension pneumothorax, pericardial tamponade, direct myocardial damage or disruption of the great vessels.[3] While some injuries are untreatable, other

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injuries are potentially survivable when recognized and treated in a timely manner.

Prognosis of TCA is generally poor, although survival rates vary considerably across different populations.[3–6] Factors associated with a favourable outcome are the nature of the injury (penetrating versus blunt trauma), the presence of an organized cardiac rhythm on arrival of the first emergency medical services (EMS), a short CPR duration and a short pre-hospital time.[4,7–9]

Helicopter emergency medical services (HEMS) are frequently dispatched to patients in TCA, since they can often deliver specific advanced interventions to address the cause of the arrest that standard ground ambulance crews are unable to provide. Examples of these are thoracostomies to relieve a tension pneumothorax, advanced airway management to relieve an obstructed airway and/or to improve oxygenation and the transfusion of blood products to treat ongoing blood loss. HEMS teams can also perform resuscitative thoracotomy in the event of suspected cardiac tamponade. However, HEMS teams are seldom first on scene and may be faced with prolonged response times, especially in rural areas, whilst most injuries resulting in TCA are time-critical.[10]

In the present study, we aimed to investigate the added value of HEMS teams in the treatment of TCA in a well-established EMS system by examining which patients in TCA regain return of spontaneous circulation (ROSC) at scene, which interventions are provided by the HEMS teams and how ROSC is related to these advanced interventions.

Methods

Study setting and design

This is a retrospective study of all patients with a TCA who were attended by the Kent, Surrey & Sussex Air Ambulance trust (KSSAAT) between July 1st 2013 and May 1st 2018. KSSAAT is a HEMS covering three counties in the southeast of England with a resident population of 4.5 million and transient population of up to 8 million. Two doctor/paramedic teams respond in either a helicopter or response car from one base. The service attends approximately 2000 patients per year. Most patients attended by the HEMS service are first seen by a ground ambulance crew and/or a critical care paramedic. Ground ambulances in the HEMS catchment area are staffed by paramedics and/or emergency technicians. Their skill set includes the insertion of airway adjuncts, supraglottic airway devices (SGA's), endotracheal intubation (ETI) without medication, needle chest decompressions, intravenous (IV) and intraosseous (IO) access and the provision of advanced life support (ALS) care according to the most recent resuscitation guidelines.[4]

Study population

Patients were eligible for participation in the study if they met the criteria for a traumatic cardiac arrest, defined as "any cardiac arrest following a trauma." This included patients who had a cardiac arrest as a result of burns, hanging, traumatic asphyxia, electrocution, and drowning. Excluded were patients who had a medical arrest with a trauma as a result of their arrest and when patients for whom outcome data were unavailable. Classification of out of hospital arrests (OHCA's) as either medical or traumatic was done by the treating physician at the time of the treatment, and documented as a mandatory binary entry in the bespoke electronic patient clinical record system KSSAAT uses (HEMSbase 2.0, Medic One Systems Ltd, UK). Classifications were reviewed by one of the investigators (EtA) and compared against clinical information (including any available post mortem reports and follow-up notes) available in HEMSbase. In case of disagreement with the classification as given by the treating physician, the case was discussed with a second reviewer in order to establish final classification.

Data acquisition

The following data were retrieved from the HEMSbase electronic patient record: Patient identification number, timings (999 time, dispatch time, and transit time to scene), mechanism of injury, patient characteristics (age, gender, weight), injuries, clinical findings on arrival of HEMS (ROSC [y/n], central- and radial pulse [y/n], airway [obstructed/managed], breathing [spontaneous/ventilated]), and interventions provided by ground ambulance crews and HEMS.

For all interventions it was established whether they were provided by the ground ambulance crews or by the HEMS crew. Interventions were subdivided in HEMS-specific and non-specific (other) interventions. For the purpose of the study, HEMS specific interventions were defined as interventions that could only be provided by the HEMS crews: Rapid sequence induction (RSI), transfusion of blood products (packed red blood cells, freeze dried plasma (LyoPlasN), and prothrombin complex concentrate (beriplex®)), thoracostomies, chest drain insertion, clamshell thoracotomy and surgical airway. Non-HEMS interventions recorded were: CPR, airway management [airway adjuncts, supraglottic airway, endotracheal tube insertion without the use of anaesthesia], ventilation, needle or pneumofix chest decompression, splintage [Kendrick traction splint, pelvic binder], IV–IO access, and fluid administration.

Clinical endpoints

The endpoints of interest in this study were defined as:

- The number of TCA patients attended by HEMS who regained a sustained ROSC at scene.
- The number of TCA patients attended by HEMS who survived until hospital discharge.
- The number and type of HEMS (specific) interventions performed by HEMS teams in patients with TCA who regained ROSC.
- The association of (HEMS) interventions with ROSC.

Ethical considerations

This project met National Institute for Healthcare Research (NIHR, UK) criteria for service evaluation and formal ethical approval was therefore not required. The project was approved by the KSSAAT Research & Development Committee.

Statistical analysis

Descriptive statistics are given as mean [95% CI] or median [IQR]. Comparisons across groups were made using Fisher's exact test and ANOVA Kruskall Wallis test where appropriate. Univariate correlation analysis with calculation of Spearman correlation coefficients was performed to evaluate the association of clinical- and treatment factors with the primary outcome. Multivariable regression analyses that included those factors with a significant correlation with an r > 0.2 was performed to determine which factors were independently related to the primary outcome measure. Missing values are reported in the results section of the manuscript according to the STROBE guideline.[11] A *p*-value <0.05 was regarded as statistically significant. All statistical analyses were conducted using SPSS 23.0 for Windows statistical package and the Vassarstats web based statistical program.

Results

Patient characteristics

Between July 1st 2013 and May 1st 2018 263 patients with a TCA were attended by the HEMS. Follow-up on outcome was available for 262 patients, and further results refer to this group. In total, 51 patients (20%) regained a sustained ROSC at scene and were transported to hospital. Patients who did not regain ROSC at scene were more often male, had more often greater than one body region involved, and were more often apnoeic on HEMS arrival (Table 1). Hangings were relatively over-represented in the group that regained ROSC, although statistical significance was not reached.

Treatment on scene

Interventions provided by the ambulance crew and the HEMS team on scene are presented in Table 2. In total, the HEMS team provided 387 HEMS specific interventions to 227 patients (86.3% of all patients with TCA). Thoracostomies were the most prevalent HEMS intervention delivered (84.0%), followed by the prehospital transfusion of blood products (42.9%). Whereas thoracostomies were less often delivered in patients who regained a sustained ROSC compared to those who did not (69.2% vs. 87.7%, $p = 0.001$), they resulted in a release of air and/or blood from the thoracic cavity in a similar percentage of patients. RSI was more often performed in patients who regained a sustained ROSC (36.5% vs. 11.4%, $p < 0.001$), as was the administration of blood products (61.5% vs. 38.4%, $p = 0.005$). Other (non-HEMS) interventions were provided by both the ambulance service and the HEMS team. Most of these interventions were as often provided to patients who regained ROSC as to those who did not, except for IV access and BVM ventilation who were both more often established in patients who regained a sustained ROSC (Table 2).

Association of treatment variables with ROSC

Univariate correlation coefficients of treatment variables with the primary outcome (sustained ROSC) are represented in Supplementary Table I. BVM ventilation ($r = 0.21$, $p = 0.001$), Surgical airway ($r = 0.17$, $p = 0.006$), IV access ($r = 0.26$, $p < 0.001$), RSI ($r = 0.27$, $p < 0.001$) and blood product administration ($r = 0.20$, $p < 0.001$) all showed a positive association with ROSC, while thoracostomies were negatively associated with ROSC ($r = -0.19$, $p = 0.002$). In multivariate analysis, BVM, RSI, blood product administration and thoracostomies remained independently associated with ROSC. Odds ratios for the primary outcome of these variables are represented in Table 3.

Table 1 – Characteristics of TCA patients attended by HEMS stratified by patient outcome, n = 262.

	Total group (n = 262)	Sustained ROSC (n = 51)	No ROSC (n = 211)	*p***
Patient characteristics median (range) or N (%)				
Age (year)	45 (5–93)	33 (5–93)	46 (14–93)	0.38
Gender (male)	196 (75)	33 (63.5)	63 (77.3)	0.005
Weight (kg)	80 (25–150)	75 (25–100)	80 (50–150)	0.036
Mechanism of injury (n)				
Blunt trauma	226 (85.9)	43 (82.7)	183 (87.7)	0.91
Sharp trauma	17 (6.5)	2 (3.8)	15 (7.1)	0.75
Hanging	10 (3.8)	4 (7.7)	6 (2.8)	0.12
Drowning	7 (2.7)	1 (1.9)	5 (2.4)	1
Electrocution	1 (0.4)	0 (0.0)	1 (0.5)	1
Burns	2 (0.8)	1 (1.9)	1 (0.5)	0.36
ABCD on HEMS arrival				
Airway open or managed	205 (77.9)	38 (74.5)	166 (78.6)	0.92
Breathing spont or ventilated	157 (59.7)	35 (68.6)	71 (33.6)	0.007
Pulse present	51 (19.4)	51 (100)	0 (0)	<0.001
GCS > 9	7 (2.6)	3 (5.8)	4 (1.9)	0.15
Injuries				
Intracranial head injury	116 (44.1)	31 (59.6)	85 (40.2)	0.14
Neck	64 (24.3)	12 (23.1)	52 (24.6)	1.0
Chest	185 (70.3)	25 (48.1)	160 (75.8)	0.12
Abdomen/pelvis	115 (43.7)	27 (51.9)	88 (41.7)	0.41
Femur	52 (19.8)	12 (23.1)	40 (19.0)	0.57
Only one body region affected	184 (70.0)	34 (65.4)	61 (28.9)	0.001
HEMS response time				
999 to patient (min)	30 (13–109)	37 (18–80)	29 (13–109)	<0.001
HEMS first on scene (n)	6 (2.2)	1 (1.9)	5 (2.3)	1

Values are depicted as median (range) or n (%). GCS, Glasgow Coma Scale.

** Fisher exact test and ANOVA Kruskall Walis-test used for comparisons across groups.

Table 2 – Interventions provided by the ground ambulance crew and by the HEMS team on scene for patients with a TCA (n = 262) stratified by patient outcome.

	Total group (n = 262)	Sustained ROSC (n = 51)	No ROSC (n = 211)	Missing	p
Patients with one or more HEMS specific interventions	227 (86.3)	40 (76.9)	187 (88.6)		0.007
RSI	43 (16.3)	19 (36.5)	24 (11.4)		<0.001
Blood products	113 (42.9)	32 (61.5)	81 (38.4)		0.005
Thoracostomies	221 (84.0)	36 (69.2)	185 (87.7)		0.001
Release of blood or air	152 (57.8)	27 (52.9)	125 (59.2)		0.38
Thoracotomy	8 (3.0)	2 (3.8)	6 (2.8)		0.98
Surgical airway	2 (0.8)	2 (3.8)	0 (0)		0.015
Other interventions					
CPR	181 (68.8)	36 (69.2)	145 (68.7)		0.79
Airway adjuncts	218 (82.9)	42 (80.8)	176 (83.4)		0.76
Supraglotic airway	38 (18.0)	7 (13.7)	44 (20.8)		0.91
ETT without medication	172 (65.4)	29 (55.8)	143 (67.8)	1	0.17
Oxygen administration	260 (99.2)	51 (100)	209 (99.1)		0.78
BVM ventilation	120 (45.6)	35 (67.3)	85 (40.3)		0.002
Needle chest decompression	102 (38.8)	17 (32.7)	85 (40.3)		0.48
Pneumofix chest decompression	23 (8.7)	3 (5.8)	20 (9.5)		0.68
IV access	168 (63.9)	46 (88.5)	122 (57.8)	1	0.002
IO access	157 (59.7)	27 (51.9)	130 (61.6)	1	0.56
Pelvic binder	127 (48.3)	24 (46.2)	103 (48.8)	1	0.87
Kendrick traction splint	26 (9.9)	6 (11.5)	20 (9.5)	1	0.96
Non-blood IV fluids	164 (62.6)	34 (66.6)	130 (61.6)	1	0.52

Values depicted as n (%). RSI, rapid sequence induction; CPR, cardiopulmonary resuscitation, ETT, endotracheal intubation; BVM, bag valve mask; IV, intravenous; IO, intraosseous.

Table 3 – Treatment variables independently associated with a sustained ROSC.

Variable	Adjusted R^2	OR	*p*
BVM ventilation	0.031	2.45 [1.19–5.02]	0.015
RSI	0.101	2.95 [1.32–6.58]	0.008
Blood products	0.110	8.54 [2.84–25.72]	<0.001
Thoracostomies	0.052	0.06 [0.02–0.22]	<0.001

BVM, bag valve mask; RSI, rapid sequence induction; OR, odds ratio.

Interventions in patients who regained ROSC

HEMS interventions provided to the 51 patients who regained a sustained ROSC on scene are represented in Table 4. In order to establish the relative contribution of HEMS in the treatment of these patients, they were stratified based on the moment of ROSC (before/after arrival of HEMS). 28 patients had a sustained ROSC on arrival of the HEMS, whereas 23 patients regained ROSC after arrival of the HEMS team. HEMS specific interventions were more often provided to patients who regained ROSC after arrival of HEMS (n = 23, 93%), compared to patients who already had a ROSC on arrival (n = 19, 67%), $p = 0.043$. Especially blood products and thoracostomies were more often administered/delivered to patients who did not yet have ROSC on arrival of HEMS (Table 4).

Other (non-HEMS) interventions were provided by ground ambulance crews in the majority of patients who regained ROSC (Table 5). However, HEMS was involved in gaining IV/IO access in 39.2% of the patients (11 IV and 9 IO), and provided a definitive airway through endotracheal intubation without drugs in 17.6% of the patients (this in addition to the 19 patients who received an RSI).

Table 4 – HEMS interventions performed on scene in patients who regained ROSC (n = 51) stratified by the moment of ROSC (before or after arrival of HEMS).

	ROSC before arrival of HEMS (n = 28)	ROSC after arrival of HEMS (n = 23)	p
HEMS intervention			
RSI	9	10	0.29
Blood products	12	20	<0.001
Thoracostomies	15	21	0.003
Release*	11	16	0.57
Thoracotomy	0	1	0.70
Surgical airway	1	1	0.70

P value for comparison of frequency distribution of HEMS intervention in patients who regained ROSC respectively before- and after HEMS arrival. RSI, rapid sequence induction. Release of blood and/or air as noted by the treating team.
* Release of air and/or blood from thoracotomies.

The majority of the non-HEMS interventions provided by HEMS was provided to patients who did not yet have a ROSC upon arrival of HEMS.

Final outcome of patients with ROSC

Of all patients who regained a sustained ROSC, only 7 survived until hospital discharge. As for all patients in our cohort, blunt trauma was the predominant mechanism (6/7). All but one survivor received bystander CPR before arrival of the first ambulance crew, and all survivors regained ROSC before arrival of HEMS. HEMS interventions were performed in all survivors (Table 6).

Table 5 – Non-HEMS interventions performed on scene in patients who regained ROSC (n = 51) stratified by provider of the intervention (HEMS or ambulance service).

	Ambulance service	HEMS				p#
	Total (n = 51)	Total (n = 51)	ROSC on arrival (n = 28)	ROSC after arrival (n = 23)	p*	
Other interventions						
CPR*	47	0	0	0	NA	<0.001
Airway adjuncts	23	3	1	2	0.59	<0.001
SGA	13	3	0	3	0.10	<0.001
ETI w/o drugs	27	8	1	7	0.05	<0.001
Oxygen	48	3	1	2	0.59	<0.001
BVM ventilation	44	4	1	3	0.33	<0.001
Needle chest dec	17	1	0	1	0.46	<0.001
Pneumofix	6	0	0	0	NA	<0.001
IV	37	11	6	5	1	<0.001
IO	16	9	1	8	0.03	<0.001
Pelvic binder	23	5	2	3	0.41	<0.001
Kendrick	6	1	0	1	0.46	<0.001

p*; p-value for Fisher exact test comparing frequency distribution of variables between patients with ROSC before-and after arrival of HEMS. p#; p-value for Fisher exact test comparing frequency distribution of interventions performed by ground ambulance and HEMS. SGA; supra glottic airway; ETI, endotracheal intubation; BVM, bag valve mask; Needle chest dec, needle chest decompression; IV, intravenous; IO, intraosseous. * 4 patients did not receive CPR as they were thought to have unsurvivable injuries by the attending ambulance crew and HEMS team.

Discussion

In this study, we investigated the added value of a HEMS team in the treatment of patients with a TCA. The results demonstrate that HEMS teams made a significant contribution in gaining ROSC and in providing (HEMS specific) interventions to those patients who already had ROSC on arrival of the HEMS team.

Although the prognosis of TCA nowadays is better than it was 20 years ago,[13] chances of survival are still relatively small. In our study, ROSC was reached in 20% of the patients attended. However, only 7 patients (2.6%) survived until hospital discharge. Other studies reported higher ROSC rates of up to 40%[6,14,15] and higher survival rates (up to 17.2%).[3–6] These differences are likely explained by the relative overrepresentation of blunt-compared to sharp injuries in our population and by the fact that most other studies also included patients who had their cardiorespiratory arrest in hospital.

The study demonstrates that early interventions are important in patients with TCA. It was found that basic interventions such as BVM ventilation and establishing IV access which were mostly provided by ground ambulance were more often provided to patients who regained ROSC. From an etiological perspective, it is likely that these interventions increase the chances of ROSC in some patients, e.g. hypovolemia is the most common cause of preload dependent TCA,[12] and getting (early) IV access is a prerequisite for correcting intravascular volume. The importance of early interventions is further stressed by the finding that none of the patients survived until hospital discharge when ROSC was not obtained before arrival of HEMS. Since many potentially treatable causes of a TCA are time critical, it is important that ground ambulance crews arriving on scene before

Table 6 – Patient and treatment characteristics of patients who survived TCA until hospital discharge (n = 7).

	1	2	3	4	5	6	7
Age	52	40	61	39	19	21	28
Gender	Male	Male	Female	Female	Male	Male	Male
999-to scene (min)	19	50	27	41	66	59	39
MOI	Blunt	Blunt	Blunt	Blunt	Hanging	Blunt	Blunt
Injuries	-Head -Chest	-Chest -Pelvis	-Head	-Chest -Pelvis	-Head -Neck	-Head -Chest -Pelvis	-Head -Chest -Pelvis -Legs
Bystander CPR (y/n)	y	y	y	n	y	y	y
ROSC before HEMS arrival (y/n)	y	y	y	y	y	y	y
Most likely cause of arrest	Brain impact apnea	Tension Ptx	Brain impact apnea	Tension Ptx	Hypoxic brain injury	Tension Ptx	Hypovolemia
HEMS interventions	-RSI -Thoracost.	-Thoracost.	-RSI -Thoracost.	-Blood -Thoracost.	-RSI	-RSI -Blood, -Thoracost.	-Blood -Thoracost.

MOI, mechanism of injury; CPR, cardio pulmonary resuscitation; ROSC, return of spontaneous circulation; RSI, rapid sequence induction; Tension Ptx, tension pneumothorax; Thoracost., thoracostomies.

HEMS are familiar with TCA treatment algorithms[4,9,12,16] and initiate all interventions within their scope of practice as early as possible.

Despite that HEMS was seldom first on scene and had an average response time of 30 min, HEMS made a significant contribution to the treatment of patients in TCA: HEMS specific interventions were performed in the vast majority (86%) of the patients in TCA. In addition, HEMS teams provided numerous non-HEMS interventions. Although ground ambulance crews are normally trained to provide these interventions, circumstances in patients in TCA may be challenging, and the experience of HEMS crews with interventions as ETI without drugs or gaining venous access may be of added value. Finally, although not quantified in this study, the experience of HEMS teams in the treatment of TCA patients may result in an improvement of the job flow by the delivery of critical decision-making by experienced clinicians, not only to those patients who are salvageable, but also to those who are unlikely to survive.[17]

HEMS teams had an important role in the care of patients who regained ROSC. 28 patients regained ROSC before arrival of HEMS. Although one can debate whether or not all of these patients had suffered from a complete cardiorespiratory arrest (as the HEMS crew had to rely on ambulance crew handovers), 49 HEMS specific interventions were performed in these patients on scene. Even though these interventions did not contribute to getting ROSC, they have the potential to increase the chance of maintaining ROSC until arrival in hospital, especially when transport times to the nearest trauma centers are long, as in non-urban HEMS systems. The ability to treat critical hypovolemia (e.g. by blood product transfusion) and to optimise ventilation and oxygenation (e.g. by performing an RSI) likely contributes to final outcome of these patients.

23 patients regained ROSC after arrival of HEMS. Whether or not this was the direct result of the high number of HEMS specific interventions provided to these patients is difficult to establish, as exact timings of interventions in relation to ROSC were not registered, and could not be subtracted from the database. However, HEMS specific interventions may well have played a role. The average response time for HEMS for the subgroup of patients who did not have ROSC on arrival of HEMS was as long as 37 min. Despite this, ROSC was obtained in 23 out of the 234 patients (9.8%). Compared to non-traumatic OHCA data, this is a higher than anticipated percentage, as chances of getting ROSC after an OHCA are almost negligible after 40 min of CPR.[18] It is likely that the higher than anticipated ROSC rate results from specific interventions addressing underlying treatable causes of TCA that could not be provided by ground ambulance crews before HEMS arrival.[5,19,20] Especially blood product transfusion (given in 21 out of the 23 patients) is worth mentioning in this regard, as some patients thought to be in TCA actually have a low cardiac output state.[21]

In our study, the HEMS team was comprised of a paramedic and physician. In a recently published study,[22] treatment of TCA patients after blunt trauma, with care led by a physician (as compared to a standard ground ambulance crew) was associated with a better survival. Our findings are compatible with these results, as they dissect which interventions are brought by our physician-paramedic HEMS team that might contribute to this observed survival benefit. However, it should be stressed that our study focuses were on interventions rather than profession, hence what the ideal composition of a HEMS team should be is outside the scope of this study.

Limitations

Our study has several limitations, some of them being inherent to the retrospective design. Most importantly, we had to rely on the data as provided by the HEMS teams. Although there were some missing data, overall data completeness was good due to the use of our electronic patient record with dedicated data entry fields for all patients with (traumatic) cardiac arrests. However, outcome data were incomplete in our study, as CPC-scores were unavailable for the 6/7 survivors. Furthermore, although we investigated the association of various treatment factors with outcome, no causal relations can be drawn. It is likely that some factors are more prevalent in patients with ROSC as they are simply not performed in patients without ROSC (i.e. RSI). ROSC was chosen as the primary endpoint, and not survival. This can be debated, as ROSC is futile when patients eventually do not survive. However, obtaining ROSC is the first important step in the chain of survival, as it is for non-traumatic arrests, and ultimate survival is not only dependent on early pre-hospital interventions, but also on the care provided in hospital thereafter. Our study primarily aimed to investigate the added value of non-urban HEMS teams in the treatment of TCA's. Whether or not HEMS teams should be dispatched to (all) TCA's in the first place was not a topic of investigation in the current study. Finally, our results cannot answer the question whether or not (all) HEMS-specific interventions should only be delivered by the HEMS team or whether some should be made available to other pre-hospital care providers as well, as this is highly dependent on the EMS system where the HEMS service is embedded in.

Conclusion

HEMS teams should be involved in the treatment of patients with a TCA, even in non-urban areas with prolonged response times, as they provide knowledge and skills that contribute to regaining and maintaining a sustained ROSC in this critically ill and injured cohort of patients.

Conflict of interest

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2018.12.019.

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