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Short paper

Helicopter emergency medical services (HEMS) response to out-of-hospital cardiac arrest (OHCA) in the United States

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Abstract

Introduction: Helicopter emergency medical services (HEMS) are used in the United States and globally to respond to patients with critical illness and victims of traumatic injury. Relatively limited research has examined their role in responding to out-of-hospital cardiac arrests (OHCA) in the United States. In this study, we compared OHCA treated by HEMS units with cardiac arrests treated by ground ambulances.

Methods: We queried a large national-level database of emergency medical services (EMS) activations in the United States (NEMSIS). Inclusion criteria were OHCA activations between January 1, 2022 and December 31, 2022 treated by either HEMS or ground ambulance. Key arrest data from both groups were then compared. Interfacility transfers and cardiac arrests after EMS arrival were excluded.

Results: A total of 1,233 cardiac arrests treated by HEMS and 341,096 cardiac arrests treated by ground ambulances met inclusion criteria. Comparing the two groups, cardiac arrests with HEMS response were more likely to be male (66.7% vs. 62.8%, $p < 0.01$), White (50.2% vs. 45.7%, $p < 0.01$), under 18 years old (10.9% vs. 2.7%, $p < 0.001$), associated with traumatic injury (19.1% vs. 5.7%, $p < 0.001$), witnessed (72.7% vs. 37.3%, $p < 0.001$), and initially-shockable (24.7% vs. 11.1%, $p < 0.001$).

Conclusion: Our comparison of cardiac arrests treated by HEMS with cardiac arrests treated by ground ambulance reveals significant differences between the two groups. Further research is needed to better characterize HEMS' ideal role in the response to OHCA as new prehospital resuscitative techniques for non-traumatic and traumatic cardiac arrest are developed.

Keywords: Cardiac arrest, Emergency medical services, Prehospital care, Helicopter emergency medical services, Helicopter air ambulance, Sudden cardiac death, Out-of-hospital, HEMS

Background

In the United States and many countries, helicopter emergency medical services (HEMS) are utilized to provide advanced prehospital care and rapid transport to victims of critical illness and traumatic injury, including out-of-hospital cardiac arrest (OHCA).[1] Helicopters were first used to transport patients in battlefield settings, however, their usefulness led to the creation of civilian-oriented HEMS programs in the United States.[2]

Several studies offer some insight into HEMS' current role in OHCA. For example, Skogvoll et al. (2001) describe 424 cardiac arrest patients responded to by HEMS in central Norway. In this study, HEMS provided assistance in the following areas: 1) identifying/treating reversible causes of cardiac arrest; 2) airway/ventilation management of the post-arrest patient; and 3) complex medical management of the post-arrest patient.[3] Similarly, Lyon & Nelson (2013) describe 64 cardiac arrest patients responded to by HEMS in the United Kingdom and concluded HEMS may be most beneficial only if a patient achieves return of spontaneous circulation (ROSC). Additional research in the specific context of traumatic cardiac arrest found administration of blood products and rapid-sequence intubation (RSI) by HEMS were associated with improved rates of ROSC.[4] Given that much of the current literature is based on single-center or

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regional data, further research is needed to understand the differences in OHCA patients treated by HEMS as compared with ground ambulances at a broad level. Such research will hopefully help clarify HEMS' role in OHCA management.

In this study, we utilized a large and nationally-representative database of EMS activations in the United States to directly compare selected key parameters between cardiac arrests treated by HEMS with cardiac arrests treated by ground ambulances.

Methods

The National Emergency Medical Services Information System (NEMSIS) is a large and nationally-representative database containing millions of EMS activations within the United States. Data are extracted directly from patient care reports produced by EMS crew members. NEMSIS contains nearly all EMS activations in the United States, and specific details about the database and the information standard used by EMS personnel for documentation have been previously published.[5,6] We examined OHCA patients treated by HEMS crews between January 1, 2022 and December 31, 2022. Only primary responses ("scene flights") involving helicopter air ambulance crews were included – interfacility transfers from one healthcare facility to another were excluded. Similarly, cardiac arrests taking place after EMS arrival (EMS-witnessed cardiac arrest) were also excluded.

We compared this cohort of cardiac arrests treated by HEMS crews with cardiac arrests treated by ground ambulances. It is worth noting that cardiac arrests treated by HEMS likely also had some kind of ground-based EMS response, so the key distinction between groups is whether the ground EMS was supplanted by a HEMS crew. Identical inclusion/exclusion criteria were applied when building the ground ambulance cohort, including exclusion of interfacility transfers and arrests occurring after EMS arrival. From each cohort, specific cardiac arrest data were extracted, including patient demographic information, arrest etiology, whether the arrest was witnessed, and the first monitored arrest rhythm. Two-tailed, two-proportion Z tests were used to compare these data between cardiac arrests treated by HEMS crews and ground ambulance crews. Fig. 1 depicts the derivation of our study population from the database.

Results

From January 1, 2022 to December 31, 2022, there were a total of 1,233 cardiac arrests treated by HEMS crews and 341,096 cardiac arrests treated by ground ambulance crews at time of analysis (Table 1). A number of significant differences were seen when comparing key arrest data across both groups. In terms of demographics, cardiac arrests treated by HEMS crews were significantly more likely to be male (66.7% vs. 62.8%, $p < 0.01$) and White (50.2% vs. 45.7%, $p < 0.01$). Furthermore, HEMS cardiac arrests involved a greater share of patients under the age of eighteen (10.9% vs. 2.7%, $p < 0.001$) and significantly less likely to involve patients over the age of sixty (47.0% vs. 59.1%, $p < 0.001$). HEMS cardiac arrests were significantly more likely to involve traumatic etiologies (19.1% vs. 5.7%, $p < 0.001$), be witnessed (72.7% vs. 37.3%, $p < 0.001$), and involve a shockable first monitored arrest rhythm (24.7% vs. 11.1%, $p < 0.001$).

Discussion

Our comparison of OHCA treated by HEMS crews with cardiac arrests treated by ground ambulance crews reveals several noteworthy findings. First, we show significant demographic differences across groups. A larger share of HEMS cardiac arrests involved male patients and White patients than ground ambulance cardiac arrests. When considering patient age, HEMS cardiac arrests were around four times more likely to involve pediatric patients under the age of eighteen than ground cardiac arrests. This may reflect HEMS units being specifically activated to transport critically-ill children to specialty pediatric care centers. Conversely, HEMS cardiac arrests were less likely to involve elderly patients than ground cardiac arrests.

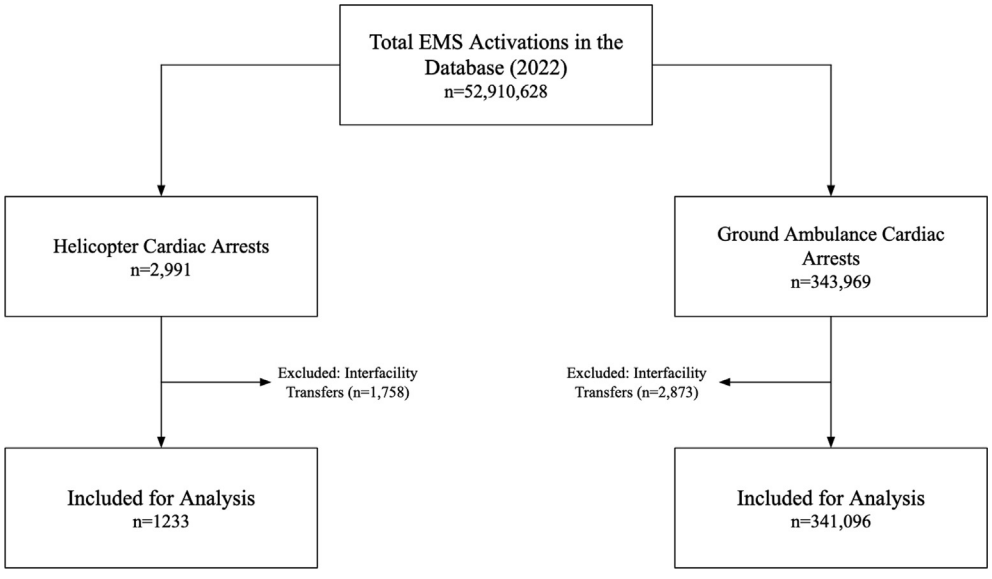

Fig. 1 – Study Population. Shows the derivation of our study population. Interfacility transfers between were excluded.

Table 1 – Key arrest parameters for HEMS-responded cardiac arrest in the united states.

Arrest Parameter	HEMS – n (%)	Ground – n (%)	p value
Total Number Analyzed	1,233 (100%)	341,096 (100%)	
Male	822 (66.6%)	214,189 (62.8%)	p < 0.01
Sex Data Missing	*29 (2.4%)*	*2,533 (0.7%)*	
White	619 (50.2%)	155,938 (45.7%)	p < 0.01
Race/Ethnicity Date Missing	*472 (38.3%)*	*108,196 (31.7%)*	
Older Than 60 Years	580 (47.0%)	201,605 (59.1%)	p < 0.001
Younger Than 18 Years	135 (11.0%)	9,078 (2.7%)	p < 0.001
Between 18 and 60 Years	485 (39.4%)	126,010 (36.9%)	p = 0.08
Age Data Missing	*33 (2.7%)*	*4,403 (1.3%)*	
Traumatic Etiology	235 (19.1%)	19,447 (5.7%)	p < 0.001
Etiology Data Missing	*182 (14.8%)*	*15,692 (4.6%)*	
Witnessed	896 (72.7%)	127,085 (37.3%)	p < 0.001
Witnessed Status Data Missing	*125 (10.1%)*	*16,190 (4.7%)*	
Shockable Initial Rhythm	304 (24.7%)	37,815 (11.1%)	p < 0.001
Rhythm Data Missing	*220 (17.8%)*	*58,098 (17.0%)*	

Second, interesting differences in cardiac arrest etiology were noted. Namely, HEMS cardiac arrests were more likely to involve traumatic etiologies than ground cardiac arrests. Historically, traumatic etiologies are associated with the lowest survival among all types of cardiac arrest.[7,8] However, the additional resources that HEMS crews may bring may offer a greater improvement over the care provided by ground ambulances in the context of traumatic cardiac arrest than in medical cardiac arrest. As an example, HEMS crews may bring blood products, ultrasound, invasive hemodynamic monitoring/cannulation, thoracostomy, thoracotomy, and resuscitative endovascular balloon occlusion of the aorta (REBOA).[9–13] It may also be possible that HEMS units were "auto-launched" or requested for major trauma accidents that ultimately ended up involving patients who had entered traumatic cardiac arrest by the time HEMS arrived. Third, HEMS arrests were almost twice as likely to be witnessed and have a shockable first monitored arrest rhythm – predictors of improved outcomes.[14] HEMS crews may respond to more witnessed and shockable cardiac arrests because requestors are more likely to call them when they feel a given cardiac arrest patient has the best chance of survival. In other words, requestors may be less likely to activate HEMS if an arrest is unwitnessed or non-shockable, considering the lower likelihood of survival.

HEMS is often used to transport patients who may be far away from a tertiary or quaternary care hospital quickly. Because of this, HEMS units may be key in improving access to comprehensive high-quality post-arrest care – a concept emphasized in the cardiac arrest "chain of survival".[15] However, there is ongoing controversy as to whether prehospital critical care results in improved survival for non-traumatic cardiac arrest.[16,17] As such, the resources HEMS crews bring might not provide a dramatic improvement in survival for all patients. Moreover, HEMS is both a limited and costly resource to use, and every helicopter flight introduces risk to the crew and the patient.[18] Given this, more work needs to be done to identify the specific patients who may benefit most from HEMS.

New technologies – such as extracorporeal membrane oxygenation (ECMO) – are emerging for cardiac arrest, especially those with refractory shockable-rhythms.[19,20] Due to their advanced skill set and access to rapid air transport, HEMS teams may be uniquely positioned to aid in prehospital deployment of ECMO. This may involve HEMS being requested to cannulate cardiac arrest patients meeting criteria indicating they are likely to benefit from ECMO or being called to transport already-cannulated patients to facilities capable of advanced care for a post-arrest ECMO patient.

Limitations

Our study does have a few limitations. Firstly, EMS data from NEMSIS cannot be easily linked with the subsequent hospital outcomes of patients transported, so we do not have long-term outcomes. Thus, we cannot precisely quantify whether HEMS was independently associated with improved outcomes when compared with ground EMS. Second, our analysis is limited to the United States, which has unique operational differences when compared with different locales. Although our manuscript echoes what has been reported in other countries, caution should be exercised when generalizing our findings. Furthermore, there are region-specific differences even within the United States (e.g. capabilities, protocols, etc.) that cannot be accounted for with a broad, national-level analysis.

Conclusion

Our analysis of a large and nationally-representative database of EMS activations in the United States shows differences in the cardiac arrests treated by HEMS crews versus cardiac arrests treated by ground ambulance crews. Further research is needed to better characterize HEMS' ideal role in the response to OHCA, especially as future prehospital resuscitative technologies (eg. ECMO) are developed.

CRediT authorship contribution statement

Aditya C. Shekhar: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Michael Auten:** Writing – review & editing, Methodology, Conceptualization. **Ethan E. Abbott:** Writing – review & editing, Methodology. **Michael McCartin:** Writing – review & editing, Methodology, Conceptualization. **Ira J. Blumen:** Writing – review & editing, Supervision, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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