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Regional impact of cardiac arrest center criteria on out-of-hospital transportation practices

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Abstract

Background—Cardiac arrest center (CAC) criteria are not well defined, nor is their potential impact on current emergency medical services (EMS) transportation practices for post-arrest (PA) patients. In addition to the availability of emergent cardiac catheterization (CATH) and therapeutic hypothermia (TH), high-volume centers and those with PA protocols have been associated with improved outcomes.

Objectives—This study identified the PA treatment capabilities of receiving hospitals in a 10-county regional EMS system without official CAC designation. Secondly, this study determined the proportion of PA patients who are transported to hospitals meeting three proposed CAC definitions. We hypothesized that a majority of patients are already transported to hospitals that meet proposed CAC criteria.

Methods—We distributed a survey to 34 receiving hospitals to determine availability and volume of CATH, TH, a PA protocol, and a 24-hour intensivist. We conducted a retrospective study of adult, non-trauma cardiac arrest patients for 16 EMS agencies transported with a pulse from 2006 to 2008. The proportions of patients transported to hospitals meeting three CAC criteria were compared: Criteria A (availability of CATH and TH), Criteria B (Criteria A, >200 CATHs per year, and a PA protocol), and Criteria C (Criteria B and a 24-hour intensivist).

Results—Data were obtained from 31 of 34 hospitals (91.1%), of which 10 (32.3%) met Criteria A, 7 (22.6%) met criteria B, and 6 (19.4%) met criteria C. Of 1,193 cardiac arrest patients, 46 (3.9%) were excluded due to transport to a pediatric, closed, or out-of-region hospital. There were 335 patients (81.1%) with return of spontaneous circulation and a pulse present upon arrival at the destination facility transported to hospitals meeting criteria A, 304 patients (73.6%) transported to hospitals meeting criteria B, and 273 (66.1%) transported to hospitals meeting criteria C.

Conclusions—In a region without official CAC designation, only one-third of hospitals meet basic CAC criteria (CATH and TH) but those facilities receive 81% of PA patients. Fewer patients

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Presentation

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Conflicts of Interest

JCR and CWC are steering committee members for a Zoll Medical trial under development. CWC has been loaned a cooling device from Medevance for preclinical trials. CWC has also received funding from Laerdal Medical or the Laerdal Foundation for Acute Medicine and also holds a patent related to defibrillation currently licensed to Medtronic ERS. CWC is compensated by the American Heart Association as a committee co-chair and worksheet reviewer.

(66%) are transported to hospitals meeting more stringent CAC criteria. These data describe the potential impact of developing a CAC policy based on current transportation practices.

Keywords

Emergency medicine; cardiac arrest; emergency medical services; regionalization

INTRODUCTION

Sudden cardiac arrest is a significant clinical and public health problem affecting more than 450,000 people annually.¹ Historically, the majority of research aimed at improving outcomes after out-of-hospital cardiac arrest (OHCA) focused on obtaining a return of spontaneous circulation by optimizing defibrillation, cardiopulmonary resuscitation, and medication administration. While there continues to be an emphasis on high quality CPR and early defibrillation in the prehospital setting, there is also growing evidence of the impact of interventions delivered after return of spontaneous circulation (ROSC) on survival to hospital discharge, which has been termed the 5th (missing) link in Cummin's "Chain of Survival".² This shift has been stimulated by research showing significant regional differences in out-of-hospital cardiac arrest outcomes,³ as well as inter-hospital differences in survival after ROSC.⁴⁻⁸ While regional differences in outcome may be a result of differing baseline characteristics of the population, including prehospital response times, incidence of bystander CPR or early defibrillation, inter-hospital variations in post-resuscitation interventions and capabilities may also affect survival.⁴⁻⁸

Due to the limited availability and delivery of these interventions, it has been suggested that prehospital post-arrest patients be preferentially transported to specialized hospitals with these capabilities.⁹⁻¹⁴ Certain health care systems have already moved toward the creation of specialized Cardiac Arrest Centers (CACs), which have largely focused on the availability of therapeutic hypothermia, cardiac catheterization, and standardized protocols.¹⁵ However, for many regional prehospital systems there are no data on what proportion of hospitals have specific post-cardiac arrest capabilities and whether the majority of patients are already being transported to hospitals with these capabilities. Therefore, we cannot ascertain whether a change in current prehospital transport practice is warranted, or the proportion of patients who would be impacted by selected transport of OHCA patients to specialty centers.

This study describes the regional capabilities for treating post-cardiac arrest patients in a 10-county regional EMS system without established Cardiac Arrest Centers by identifying the treatment capabilities of individual receiving hospitals through a survey instrument. In order to evaluate the potential impact of a CAC policy, this study determined the proportion of post-arrest patients with ROSC who are transported currently to hospitals that meet three proposed CAC criteria. We hypothesized that a large proportion of patients are already transported to hospitals that meet proposed CAC criteria.

METHODS

Regional Hospital Assessment Survey

We distributed a survey to all 36 acute care hospitals in a 10-county region of Southwestern Pennsylvania to assess capabilities for the management of adult post-arrest patients, excluding one pediatric hospital. This survey was distributed in collaboration with the Emergency Medical Services Institute, a regional EMS agency that is responsible for quality improvement of Emergency Medical Services and represents the interests of the Pennsylvania State Department of Health for the region. Surveys were sent to all Emergency

Department (ED) Directors, as well as the Directors of Interventional Cardiology and/or Critical Care for facilities with these services. Directors of Interventional Cardiology or Critical Care were identified by contacting the medical staff office or the specific hospital unit. Surveys were initially distributed by standard mail. A second survey was distributed by mail to non-responders, followed by contact by telephone, fax, or email. Surveys were completed between June 1, 2009 and December 31, 2009. Two hospitals that closed during the survey period were excluded from analysis.

Surveys asked for the availability of 24-hour cardiac catheterization (CATH), number of cardiac catheterizations (acute and scheduled) in the preceding calendar year, availability of therapeutic hypothermia (TH), a TH protocol, an overall post-arrest protocol, and availability of 24-hour intensivist coverage. Hospitals were then classified as meeting any of three proposed CAC criteria: Criteria A (availability of CATH and TH), Criteria B (Criteria A, >200 catheterizations per year, and a PA protocol), or Criteria C (Criteria B and 24-hour intensivist coverage). Criteria A were developed based on the Pennsylvania Statewide EMS protocol for post-resuscitation care, which was amended in November 2008 to suggest transport of these patients to facilities with CATH and TH capabilities.¹⁶ Criteria B and C were developed based on additional factors that have been demonstrated to improve outcomes in post-arrest patients,^{17, 18} patients requiring emergency percutaneous coronary intervention,^{19–23} and other critically ill patients.^{24–28} A facility was identified as providing TH if they reported capability for TH and had a TH protocol in place. An intensivist was identified as either an in-house attending or fellow physician.

Regional OHCA Destination Practices

The destinations of all adult out-of-hospital cardiac arrest patients who were transported to a hospital by a cohort of 16 EMS agencies in a regional EMS system from 2006 to 2008 were determined using retrospective chart review. Interfacility transports were excluded. Except for the last two months, this time period preceded the new Pennsylvania Statewide EMS protocol for post-resuscitation destination selection. These Advanced Life Support (ALS) agencies were selected due to their medical command affiliation with the study institution throughout the study period and the availability of patient care records for that period. These agencies provide approximately 31% of the 488,000 total yearly patient care contacts in the 10-county region of Southwestern Pennsylvania. Data were collected from electronic patient care reports identified as cardiac arrests or where cardiopulmonary resuscitation was performed. Excluded were patients less than 18 years of age and those with traumatic cardiac arrest. Data obtained from the patient care report included age, sex, cardiac arrest rhythm, whether there was return of spontaneous circulation at any time, presence of a pulse at the receiving facility, and the destination facility. We compared the proportion of EMS patients transported to hospitals meeting Criteria A, B or C.

Data Analysis & IRB Approval

Standard Utstein criteria were recorded.²⁹ Data were entered into a commercially available spreadsheet (Microsoft Excel 2007, Microsoft Corporation, Redmond, WA) and analyzed using descriptive statistics with this software. This study was approved by the Institutional Review Board of the University of Pittsburgh.

RESULTS

Surveys were completed by at least one Director at 29 of 34 facilities (85.3%) and 13 facilities completed more than one survey. Of the facilities with more than one respondent, there was a discrepancy between respondents in five facilities, two of which would impact CAC classification. At one of these facilities, the ED and Cardiology Directors differed in

response to the availability of a TH protocol, but both noted the capability to provide therapeutic hypothermia and that a TH protocol was being developed for completion before the end of the survey period. This facility was categorized as being able to provide TH. At the other facility with a discrepancy, the ED Director responded that a TH protocol was in place, but the Cardiology Director responded that while there is the capability to provide TH, no protocol was in place. This facility was classified as not meeting this criterion due to the inability to continue TH through a standardized protocol in the inpatient setting. Of the five facilities that did not complete a survey, two facilities declined participation and contact with two facilities revealed no cardiac catheterization capabilities, thus excluding them from meeting Criteria A, B or C. The fifth facility had cardiac catheterization capabilities, but could not provide additional data needed for classification. These data allowed classification of 31 of 34 hospitals (91.1%), of which 10 (32.3%) met Criteria A, 7 (22.6%) met Criteria B, and 6 (19.4%) met Criteria C.

A total of 1,322 patient care records were reviewed, of which 129 involving pediatric or trauma patients were excluded. Of 1,193 medical adult cardiac arrest patients, we excluded 3 patients (0.3%) transported to hospitals outside of the 10-county study region, of which none had ROSC. Excluded were also 43 patients (3.6%) transported to a pediatric or recently closed hospitals, which were excluded from the hospital survey, of which 15 patients had ROSC. Surveys were completed by all receiving facilities (N=19) for the remaining cohort of patients. Characteristics of this cohort of 1,147 patients are summarily described in Table 1. Of these patients, 501 (43.6%) had return of spontaneous circulation at any time and 413 (36.0%) had a pulse at the destination hospital. There were 335 (81.1%) of the 413 patients with a pulse at the destination transported to hospitals meeting criteria A, 304 patients (73.6%) transported to hospitals meeting criteria B, and 273 patients (66.1%) transported to hospitals meeting criteria C (Figure 1). The proportion of patient with any ROSC transported to hospitals meeting these criteria varied by quarter over the study period, but we did not identify a trend in transportation practices over the 3-year time period (Figure 2).

DISCUSSION

In 2006, the Institutes of Medicine Report *Emergency Medical Services: At the Crossroads* highlighted a need to develop a “regionalized, coordinated, and accountable” system of emergency care to provide beneficial therapies to patients who may not otherwise have access to them in their local communities.³⁰ Such systems should be accessible, cost-effective, and integrated within a regional health care system. Building on the trauma, stroke, and STEMI center models, post-cardiac arrest management is the most recent target for regionalized care. While therapeutic hypothermia can be started in the prehospital setting or most hospitals through simple interventions such as the infusion of chilled IV fluids,^{31–36} continued therapeutic hypothermia, emergent cardiac catheterization, and aggressive intensive care management are not available universally. This has led to the development of Cardiac Arrest Centers in some regions¹⁵ and a call to more widely develop regional systems for post-cardiac arrest care.^{10–13} In two separate studies, Spaite demonstrated that transport time does not appear to be associated with patient outcomes after out-of-hospital cardiac arrest, and the benefits of aggressive post-resuscitation interventions may outweigh the effects of a lengthier transport time.^{9, 37} However, the criteria that CACs should meet have not been rigorously studied, nor has the impact of specific criteria on current transportation practices.

A variety of therapies and hospital capabilities that are not available at all hospitals have been associated with improved survival for post-cardiac arrest patients. For example, therapeutic hypothermia and prompt cardiac catheterization for select patients have shown the most promise in improving post-cardiac arrest patient survival,^{17, 18, 38–43} but remain

underutilized after cardiac arrest.^{44–46} Implementation of standardized treatment protocols for post-resuscitation care increases the use of these and other post-resuscitation procedures and is associated with improved survival.^{17, 18} High-volume centers have also been associated with improved outcomes after cardiac arrest,^{5, 7} which is consistent with volume-related outcomes associated with percutaneous coronary intervention,^{19–23} trauma,⁴⁷ and other disease processes.⁴⁸ Finally, critical care physician staffing of intensive care units and 24-hour staffing by intensivists have been associated with improved outcomes for critically ill patients.^{24–28}

In November 2008, the Pennsylvania Department of Health Statewide EMS protocol for cardiac arrest management was updated to include a recommendation to “consider transport to center capable of PCI or therapeutic hypothermia” and incorporates the optional administration of prehospital therapeutic hypothermia through cold saline infusion.¹⁶ However, which hospitals have these capabilities and the impact this may have on current transportation practices for OHCA patients was unknown. Thus, we determined the proportion of patients already being transported to hospitals with these capabilities. Additionally, we aimed to compare three proposed criteria for cardiac arrest centers. Criteria A were based on the new Pennsylvania Department of Health Statewide EMS protocol. Criteria B and C were based on those hospital capabilities that have been associated with improved outcomes for post-arrest or similarly critically ill patients, as discussed above. Criteria C, inclusive of a 24-hour intensivist, is similar to the Level 1 Cardiac Arrest Center concept proposed by Lurie et al, though we did not specify whether a critical care team is available to respond to the emergency department when an OHCA patient arrives.¹² Additionally, we agree on the need for a unified data collection and quality improvement program among these facilities similar to statewide trauma registries, but since this is not currently in existence in Pennsylvania, this was not included in our survey or comparison of specific criteria. By assessing these graded criteria, we aimed to provide further information on the numbers of OHCA whose transportation destination would need to be impacted by the establishment of CACs in this or similar regions.

We found that a minority of hospitals (32.3%) met the most basic CAC criteria of 24-hour cardiac catheterization and therapeutic hypothermia capabilities. An additional 6 facilities (19.4%) with 24-hour cardiac catheterization capabilities would meet Criteria A with the addition of therapeutic hypothermia, which can be easily implemented with the use of inexpensive external cooling methods or a variety of commercially available devices.⁴⁹ Two of these facilities reported having the capability to provide therapeutic hypothermia, and were in the process of developing a therapeutic hypothermia protocol, though this was not already in place.

In spite of a minority of hospitals meeting any CAC criteria, a majority of post-arrest patients who have return of spontaneous circulation and a pulse on arrival to the emergency department are already being transported to facilities with these capabilities. However, only 66.1% of these patients are currently transported to facilities with the most stringent of our criteria for CACs. Our data also reveal that a greater proportion of patients transported to hospitals that do not meet any CAC criteria are those who do not have any ROSC (74.7% versus 45.1% of those transported to hospitals meeting Criteria A). This suggests that EMS providers may already be preferentially transporting patients with ROSC to hospitals that have additional capabilities for PCA care, while transporting those who do not have ROSC but have ongoing resuscitation to the closest facility. These data may assist similar EMS regions in identifying the proportion of patients with out-of-hospital cardiac arrest whose transportation destination may be impacted by the development of similar Cardiac Arrest Center criteria and selective transportation policies.

We also explored differences in transportation practices of post-arrest patients over the study period, including the last two months when new post-resuscitation guidelines were enacted by the State of Pennsylvania (Figure 2). Though transportation practices varied quarter-to-quarter, we did not see a consistent trend toward a change in transportation practices during the study period. While there appeared to be an increase in transportation of post-arrest patients to hospitals meeting Criteria A in the fourth quarter of 2008, additional research would be needed to determine if this was a related and sustained effect associated with the protocol update.

The finding that the majority of patients are already transported to hospitals with basic post-arrest treatment capabilities suggests that most PA patients have access to the minimum post-arrest care common to the Pennsylvania Statewide EMS protocols and other systems' criteria for Cardiac Arrest Centers.^{15, 16, 50} However, fewer patients have access to additional resources and experience that may improve these patients' care. Further research is needed to identify what capabilities are most important for post-arrest patients, in order to best define CACs, given the impact of such criteria selection on current transportation patterns.

LIMITATIONS

Limitations of this study include the self-reporting nature of the hospital survey instrument. The discrepancy in data obtained from 5 facilities highlights that there may be interdepartmental inconsistencies in protocols and interventions available within hospitals. However, discrepancies that would impact classification of facilities were present in only two facilities. Additionally, there may have been inter-hospital discrepancies attributed to differential interpretation of what is referred to as a therapeutic hypothermia protocol or a post-resuscitation protocol. These were not defined in the survey instrument and may have been interpreted differently by different facilities or providers within facilities. Another limitation is that the selection of cardiac arrest cases for analysis was limited to classification as provided by the EMS providers when completing the patient care report, or the report of cardiopulmonary resuscitation being performed, both of which were captured electronically. While we believe that based on our system's documentation program and practices this would capture the vast majority of cardiac arrest cases, there may have been cases that were misclassified and not captured. The 16 EMS agencies used for this study, which provide 31% of all patient transports in this region, may not be representative of the entire group of EMS agencies in this region. However, we believe that this sample provides the best available information about a region without existing cardiac arrest centers, which does not have a structured data collection program to specifically track the disposition of cardiac arrest patients. Finally, this study identified only those facilities to which patients were initially transported and does not take into account whether patients were transferred to a regional hospital with additional post-cardiac arrest capabilities after initial stabilization.

CONCLUSION

In a region without official Cardiac Arrest Center designation, only one-third of hospitals report meeting basic CAC criteria (CATH and TH) but 82% of patients with ROSC are already transported to one of these hospitals. Fewer patients with ROSC are transported to hospitals meeting more stringent CAC criteria (66% to facilities with availability of CATH, TH, >200 catheterizations per year, a PCA protocol, and a 24-hour intensivist). System changes from current practice and PA patient disposition will vary greatly depending on the formal definition of CAC hospitals.

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Figure 1. Prehospital Outcomes by Facility Type

Criteria A: Cardiac catheterization (CATH) and therapeutic hypothermia (TH)

Criteria B: CATH, TH, >200 cath/yr, PCA protocol

Criteria C: CATH, TH, >200 cath/yr, PCA protocol, 24H intensivist

Non-CAC: Does not meet Criteria A or B

ROSC: Return of spontaneous circulation

Figure 2. Percent of patients with ROSC transported to hospitals meeting proposed CAC criteria over time

Criteria A: Cardiac catheterization (CATH) and therapeutic hypothermia (TH)

Criteria B: CATH, TH, >200 cath/yr, PCA protocol

Criteria C: CATH, TH, >200 cath/yr, PCA protocol, 24H intensivist

ROSC: Return of spontaneous circulation

Table 1

Characteristics of transported OHCA patients of presumed cardiac etiology (N=1,147)

Demographics	n	%
Age		
Mean	65.2	
Median	66.0	
Sex		
Male	735	64.1%
Female	412	35.9%
Location of Arrest		
Out-of-hospital	1,147	100%
Home	687	59.9%
Public place	217	18.9%
Other	236	20.6%
Unknown	7	0.6%
In-hospital	0	0.0%
Arrest witnessed		
By layperson/bystander	553	48.2%
By healthcare personnel	169	14.7%
Arrest not witnessed	358	31.2%
Unknown	67	5.8%
CPR before EMS arrival	511	44.6%
First monitored rhythm		
Shockable	299	26.1%
VF or VT	174	15.2%
AED-Shockable	125	10.9%
Nonshockable	780	68.0%
Asystole	402	35.0%
PEA	258	22.5%
AED-Nonshockable	120	10.5%
Unknown	68	5.9%
Prehospital Outcome		
Any ROSC		
Yes	501	43.7%
No	642	56.0%
Unknown	4	0.3%
Pulse at Destination		
Yes	413	36.0%
No	730	63.6%
Unknown	4	0.3%