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Clinical paper

Trends in utilization of mechanical circulatory support in patients hospitalized after out-of-hospital cardiac arrest☆

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ABSTRACT

Objective: This study sought to examine the trends and predictors of mechanical circulatory support (MCS) use in patients hospitalized after out-of-hospital cardiac arrest (OHCA).
Background: There is a paucity of data regarding MCS use in patients hospitalized after OHCA.
Methods: We conducted an observational analysis of MCS use in 960,428 patients hospitalized after OHCA between January 2008 and December 2014 in the Nationwide Inpatient Sample database. On multivariable analysis, we also assessed factors associated with MCS use and survival to discharge.
Results: Among the 960,428 patients, 51,863 (5.4%) had MCS utilized. Intra-aortic balloon pump (IABP) was the most commonly used MCS after OHCA with frequency of 47,061 (4.9%), followed by extracorporeal membrane oxygenation (ECMO) 3650 (0.4%), and percutaneous ventricular assist devices (PVAD) 3265 (0.3%). From 2008 to 2014, there was an increase in the utilization of MCS from 5% in 2008 to 5.7% in 2014 ($P_{trend} < 0.001$). There was a non-significant decline in the use of IABP from 4.9% to 4.7% ($P_{trend} = 0.95$), whereas PVAD use increased from 0.04% to 0.7% ($P_{trend} < 0.001$), and ECMO use increased from 0.1% to 0.7% ($P_{trend} < 0.001$) during the study period. Younger, male patients with myocardial infarction, higher co-morbid conditions, VT/VF as initial rhythm, and presentation to a large urban hospital were more likely to receive percutaneous MCS implantation. Survival to discharge was significantly higher in patients who were selected to receive MCS (56.9% vs. 43.1%, OR: 1.16, 95% CI: (1.11–1.21), $p < 0.001$).
Conclusions: There is a steady increase in the use of MCS in OHCA, especially PVAD and ECMO, despite lack of randomized clinical trial data supporting an improvement in outcomes. More definitive randomized studies are needed to assess accurately the optimal role of MCS in this patient population.

Introduction

In the United States, each year approximately 360,000 people experience out of hospital cardiac arrest (OHCA) assessed by emergency medical service (EMS) [1]. There are several factors that play a role in determining survival after the OHCA i.e., age, initial rhythm, resuscitation delay, delays in intubation and defibrillation etc. [2–4]. Mortality within 24 h of return of spontaneous circulation (ROSC) typically is attributed to refractory shock leading to recurrent cardiac arrest or multi-organ system failure [5,6]. Cardiogenic shock (CS)

Abbreviations: OHCA, out of hospital cardiac Arrest; MCS, mechanical circulatory support; PVAD, percutaneous ventricular assist device; ECMO, extra corporeal bypass with membrane oxygenator; CS, cardiogenic shock; VT, ventricular tachycardia; Vfib, ventricular fibrillation; PEA, pulseless electrical activity

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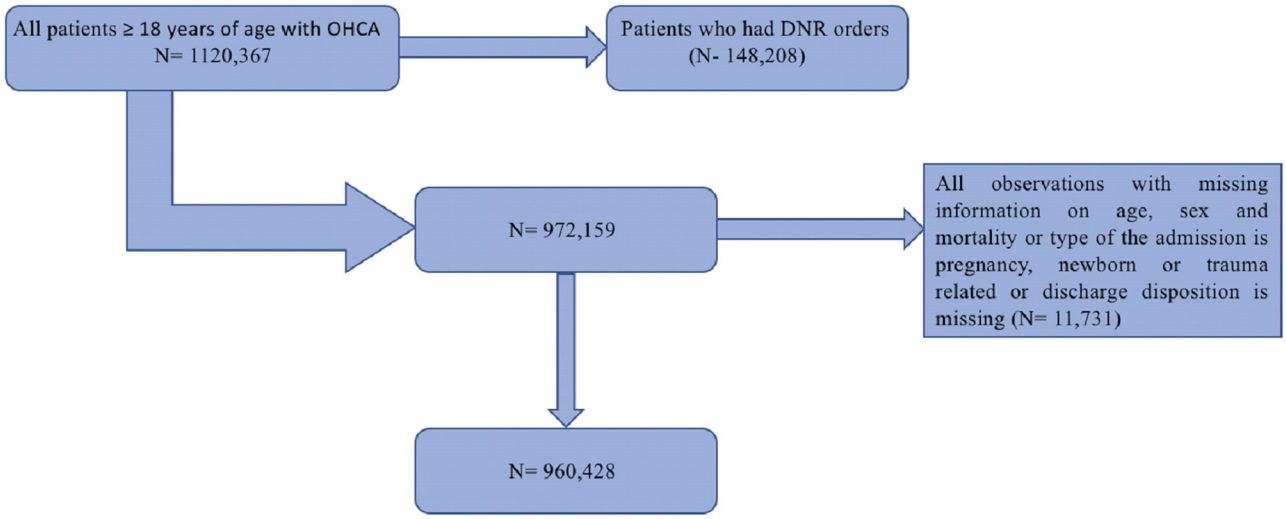

Fig 1. Study design and patient selection.

requiring vasopressor support is seen in up to 50% of the survivors of OHCA [7]. Higher mean arterial pressures after OHCA are associated with better survival [8]. Historically, mechanical circulatory support (MCS) was limited to intra-aortic balloon pumps (IABP) and ECMO [9–11]. Other MCS devices, such as Impella (Abiomed Inc., Danvers, Massachusetts), Tandem Heart (Cardiac Assist, Inc., Pittsburgh, Pennsylvania), and ECMO, which possess an ability to provide greater hemodynamic support than IABP, have a potential to improve clinical outcomes [12–14]. As defined by the 2015 Society for Cardiovascular Angiography and Interventions/American College of Cardiology/Heart Failure Society of America/Society of Thoracic Surgeons Clinical Expert Consensus on the use of percutaneous MCS in cardiovascular care, the primary objective of MCS is to reduce myocardial oxygen demand and left ventricular stroke work while providing adequate coronary perfusion [15]. There is a paucity of data with regards to the trends of MCS use after OHCA in the United States. We studied the national inpatient sample (NIS) database to examine the current trends of MCS use in patients with OHCA.

Methods

Data source

Data were obtained from 2008–2014 NIS databases. NIS database is a part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ). Details regarding NIS have been previously described [16]. In brief, NIS is the largest publicly available inpatient health care database in the United States and contains the data of 20% stratified sample of US community hospitals. Discharge weights are provided for each patient discharge record and can be used to obtain national estimates. Data in NIS are drawn from all the states participating in HCUP, which make up to 97% of the US population. NIS has the data from approximately 8 million hospitalizations. Each hospitalization is de-identified and maintained in the NIS as a unique entry with 1 primary discharge diagnosis and less than 24 secondary diagnoses during that hospitalization. Each entry also carries information on patient's demographics, insurance status, comorbidities, primary and secondary procedures, hospital charges and in-hospital outcomes.

Study population

Patients with OHCA were identified by the *International classification of Diseases, Ninth edition, Clinical Modification* (ICD-9 CM) code 427.5 if present in any diagnostic fields. This code has shown a positive predictive value up to 82% [17–19]. We further excluded patients with do not resuscitate (DNR) orders (N = 148,208), or records with missing data on age, sex, survival and/or discharge disposition, or type of admission as pregnancy or trauma related (N = 11,731). Our final study sample included 960,428 patients with OHCA (Fig. 1). Patients with ventricular tachycardia (VT) or ventricular fibrillation (VF) were identified by *ICD-9-CM* code 427.1 or 427.41 (n = 242,892, 25.3%). Patient records without either of these codes were considered to have pulseless electrical activity (PEA) or asystole as the cardiac arrest rhythm (n = 717,536, 74.7%). The *ICD-9-CM* codes 37.61, 37.68, and 37.65 were used to identify patients who underwent IABP, PVAD (included both Impella and Tandem Heart), and ECMO placement, respectively.

Outcomes of interest

The primary measure of interest was the use of MCS in patients with OHCA. We studied temporal trends in MCS use from 2008 to 2014 and the factors associated with their use. We also compared trends of survival to hospital discharge in patients with and without MCS use. These outcomes were assessed in subgroups of the patients with VT/VF and PEA/asystole as a cause of OHCA.

Definition of variables

We utilized the NIS variables to identify patient age, sex, and race. We divided race into white, black, Hispanic, and others (Asian or Pacific Islander, Native American, and others). We defined the severity of comorbid conditions by using the Deyo modification of the Charlson Comorbidity Index (Supplementary Table 1). This index contains 17 comorbid conditions with differential weightage. The score ranges from 0 to 33, with higher scores corresponding to greater burden of comorbid diseases. The facilities that had an American Medical Association–approved residency program, were a member of the Council of Teaching Hospitals, or had a full-time equivalent interns and resident to patient ratio of 0.25 or higher were considered to be teaching hospitals. Hospital location (rural/urban) and bed size were also recorded. The bed size cutoff points divided into small, medium, and large have been done so that approximately one-third of the hospitals in a given region, location, and teaching status combination would fall within each bed size category. A list of *ICD-9-CM* and Clinical Classifications Software codes provided by the AHRQ used to identify comorbidities is provided in Supplementary Table 2.