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Clinical paper

Bystander CPR is associated with improved neurologically favourable survival in cardiac arrest following drowning

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ABSTRACT

Background: Cardiac arrest associated with drowning is a major public health concern with limited research available on outcome. This investigation aims to define the population at risk, and identify factors associated with neurologically favourable survival.
Methods: The Cardiac Arrest Registry for Enhanced Survival (CARES) database was queried for patients who had suffered cardiac arrest following drowning between January 1, 2013 and December 31, 2015. The primary outcomes of interest were for favourable or unfavourable neurological outcome at hospital discharge, as defined by Cerebral Performance Category (CPC).
Results: A total of 919 drowning patients were identified. Neurological outcome data was available in 908 patients. Neurologically favourable survival was significantly associated with bystander CPR (Odds Ratio (OR) = 2.94; 95% Confidence Interval (CI) 1.86–4.64; $p < 0.001$), witnessed drowning (OR = 2.6; 95% CI 1.69–4.01; $p < 0.001$) and younger age (OR = 0.97, 95% CI 0.96–0.98; $p < 0.001$).

Public location of drowning (OR = 1.17; 95% CI 0.77–1.79; $p = 0.47$), male gender (OR = 0.9, 95% CI 0.57–1.43; $p = 0.66$), and shockable rhythm (OR = 1.54; 95% CI 0.76–3.12; $p = 0.23$), were not associated with favourable neurological survival. AED application prior to EMS was associated with a decreased likelihood of favourable neurological outcome (OR = 0.38; 95% CI 0.28–0.66; $p < 0.001$).

In multivariate analysis, bystander CPR (adjusted OR 3.02, 95% CI 1.85–4.92, $p < 0.001$), witnessed drowning (adjusted OR 3.27, 95% CI 2.0–5.36, $p < 0.001$) and younger age (adjusted OR 0.97, 95% CI 0.96–0.98, $p < 0.001$) remained associated with neurologically favourable survival.
Conclusions: Neurologically favourable survival after drowning remains low but is improved by bystander CPR. Shockable rhythms were uncommon and not associated with improved outcomes.

Introduction

Drowning is an important global public health concern, resulting in an estimated 380,000 deaths per year worldwide. Unlike the adult with cardiac ventricular fibrillation (VF), the drowning patient in cardiac arrest has suffered anoxia during the drowning episode as well as during the period of removal from the water. There may, therefore, be different factors affecting outcomes for drowning victims compared to those suffering cardiac collapse. Unfortunately, there are few studies addressing the prehospital care and factors associated with improved outcomes of victims of cardiac arrest following drowning [1–9]. The importance of timely and efficient initiation of cardiopulmonary resuscitation (CPR) in cardiac arrest is well described. A delay of even a few minutes can have devastating consequences on survival and long-term outcome [10,11]. The rate of bystander CPR can vary significantly among regions and even among aetiologies of arrest (e.g.; trauma vs myocardial infarction vs drowning). To date little is known on the rates of bystander CPR in cardiac arrest after drowning.

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Factors such as the performance of bystander CPR and prompt defibrillation for shockable rhythms are associated with improved outcomes for out-of-hospital cardiac arrests. The impact of theses therapies in improving outcomes in drowning, however, is unclear. Moreover, the few studies that do exist disagree as to the role of bystander CPR on overall outcomes [12]. If bystander CPR for drowning improves outcome, then public awareness campaigns promoting bystander response could increase survival and spur research to determine the optimal type of CPR (i.e.; compressions-ventilations vs compressions only).

This study describes key prehospital factors associated with favourable outcomes of cardiac arrest following drowning via analysis of a large national cohort of drowning patients in the Cardiac Arrest Registry to Enhance Survival (CARES). The aim of this investigation is to determine the overall incidence of bystander CPR in cardiac arrest in the United States following drowning and to test the hypothesis that bystander CPR is associated with neurologically favourable survival. Secondary aims include definition of the prevalence and treatment of shockable versus non-shockable initial cardiac rhythms, and their association with neurologically favourable outcomes in cardiac arrest following drowning.

Methods

The CARES database was developed in 2004 as part of collaboration between Emory University and the Centers for Disease Control and Prevention to improve outcome in out-of-hospital-cardiac arrest (OHCA). The CARES database includes 62 communities in 23 of the 50 United States, in addition to 17 state-wide registries. Its catchment area includes 100 million people, with over 1100 Emergency Medical Service (EMS) agencies and more than 1500 hospitals. Participating programs enter their data via a secure website, then compare their performance to aggregate de-identified data from the CARES database. In this investigation, the CARES Database was queried for variables related to cardiac arrest between January 1, 2013 and December 31, 2015.

Patients were identified in the database who had suffered cardiac arrest following drowning. Those patients were then stratified according to those who had received bystander CPR (i.e.; CPR initiated by someone prior to the arrival of EMS personnel or first responders such as lifeguards, police officers, fire fighters) and those who had not received bystander CPR (i.e.; CPR was initiated by responding EMS personnel or first responders). Survivors were further stratified according to cerebral performance category (CPC) as a measure of neurological outcome.

Favourable neurologic outcome was defined by the variables: (a) CPC 1 – good cerebral performance; or (b) CPC 2 – moderate cerebral disability at hospital discharge. Unfavourable neurologic outcome was defined by the variables: (a) CPC 3 – severe cerebral disability; (b) CPC 4 – coma or vegetative state; (c) CPC 5 – brain death; or (d) death.

Evaluated risk factors available in the database included presence of bystander CPR, AED application prior to EMS, location (Public vs. Non-public), gender, arrest witnessed status, first monitored rhythm type (shockable vs. non-shockable) and age.

Differences in continuous variables were evaluated using Student's *t*-test, while chi-square tests were used to evaluate differences in categorical measures. If cell counts were less than five, then Fisher's exact test was applied to categorical variables. The sample size was based on the available cases in CARES. A two-sided test of significance was used where $p < 0.05$ represented statistically significant findings. Odds ratios and 95% Confidence Intervals were calculated.

All risk factors were loaded into a multivariate logistic regression analysis and included: (a) bystander CPR, (b) AED application prior to EMS, (c) location, (d) gender, (e) witnessed arrest status, (f) shockable rhythm and (g) age. Lastly, the Hosmer-Lemeshow goodness of fit test was used which produced a $P = 0.45$.

Due to the use of de-identified data in the study an expedited review was granted through the Indiana University Institutional Review Board.

Table 1
Baseline Characteristics.

Characteristics	Frequency (Percentage)		
	CPC1/2	CPC3/4/5/Dead	Total
Bystander CPR			
Yes	68 (7.49%)	360 (39.65%)	428 (47.14%)
No	29 (3.19%)	451 (49.67%)	480 (52.86%)
AED Applied Prior to EMS			
Yes	16 (1.76%)	278 (30.62%)	294 (32.38%)
No	81 (8.92%)	533 (58.70%)	614 (67.62%)
Location			
Public	55 (6.06%)	491 (54.07%)	546 (60.13%)
Non-public	42 (4.63)	320 (35.24)	362 (39.87%)
Gender			
Male	69 (7.60%)	594 (65.42%)	663 (73.02%)
Female	28 (3.08%)	217 (23.90%)	245 (26.98%)
Witnessed			
Yes	43 (4.74%)	190 (20.93%)	233 (25.66%)
No	54 (5.95%)	621 (68.39%)	675 (74.34%)
First Rhythm			
Shockable	10 (1.1%)	57 (6.28%)	67 (7.39%)
Nonshockable	86 (9.48%)	754 (83.13%)	840 (92.61%)
Age (years)			
N	97	808	905
Mean ± Std.	19.41 ± 23.42	36.47 ± 25.68	34.64 ± 25.98
Min, Max	0.17, 82	0.003,105	0.003, 105

Cerebral Performance Category (CPC), Cardiopulmonary Resuscitation (CPR), Automated External Defibrillator (AED), Emergency Medical Services (EMS).

Results

A total of 919 drowning patients who suffered cardiac arrest were identified between January 1, 2013 and December 31, 2015 in the CARES database (Fig. 1). After excluding 11 patients in whom CPC data were not available, 908 patients remained.

Bystander CPR was provided in 428 (47.14%) patients (Table 1). An AED was not applied in most cases (n = 614; 67.62%). Drowning most commonly occurred at a public place (e.g.; place of recreation, public/commercial building, street/highway, transport centre, other; n = 546; 60.13%). The majority of patients were male (n = 663; 73.02%) and drownings were most often unwitnessed (n = 675; 74.34%). The first rhythm recorded in the majority of cases was non-shockable (n = 840; 92.61%). The mean age of patients was 34.64 years (+/− 25.98 years).

A total of 123 patients (13.53%) survived to hospital discharge, with 79.51% of survivors (n = 97) having a favourable neurological outcome (Table 2).

Several factors were significantly associated with neurologically favourable survival (Table 3). These included bystander

Table 2
Survival to Hospital Discharge.

Died	Survived	
786 (86.47%)	123 (13.53%)	
	CPC 1/2	CPC 3/4/5
	97 (79.51%)	25 (20.94%)

Cerebral Performance Category (CPC).
Note: 1 missing value.