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Original Contribution

Relationship between drowning location and outcome after drowning-associated out-of-hospital cardiac arrest: nationwide study☆

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ABSTRACT

Purpose: Accidental drowning can cause out-of-hospital cardiac arrest (OHCA). We investigated the effect of drowning location on outcomes of individuals who experienced drowning-OHCA.
Methods: All cases of emergency medical service–treated drowning-OHCA in South Korea from January 2006 to December 2013 were analyzed. Cases were excluded if there was a preceding injury, no information on event location, or suicide. Cases were divided into 4 groups: recreational water with mandatory safety regulations (group 1, public swimming pool; group 2, beach) and nonrecreational water without mandatory safety regulations (group 3, natural freshwater; group 4, seawater). The main outcome was survival to hospital discharge. Multiple logistic regression analysis was conducted using natural freshwater as the reference location.
Results: We analyzed 1691 drowning-OHCAs (public swimming pools, 3.4%; public beaches, 5.2%; unsupervised seawater, 33.8%; and unsupervised open freshwater, 57.6%). The rate of survival to discharge was 4.6% for all cases, 17.5% for cases in public swimming pools, 9.1% for cases in public beaches, 4.9% for cases in unsupervised seawater, and 3.3% for cases in unsupervised open freshwater ($p < 0.01$). The adjusted odds ratios (95% confidence intervals [CIs]) for survival relative to natural freshwater were 3.97 (95% CI, 1.77-8.89) for public swimming pools, 2.81 (95% CI, 1.22-6.45) for public beaches, and 1.54 (95% CI, 0.88-2.70) for unsupervised seawater.
Conclusion: Individuals who experience drowning-OHCA in public locations with safety regulations had a better rate of survival. There should be improved public awareness of the significantly greater risk of drowning-OHCA in locations that have no safety regulations.

1. Introduction

Drowning is the third leading cause of death due to unintentional injury, and an estimated 372 000 people worldwide died by drowning in 2012 [1]. Globally, approximately 1.3 million disability-adjusted life years were lost due to premature death or disability by drowning, and this accounts for about 7% of disability-adjusted life years due to all injuries [2]. Previous research reported that drowning is a major cause of out-of-hospital cardiac arrest (OHCA) among young people in many developing and developed countries [3].

There are limited population-based surveillance data on drowning-induced OHCA (drowning-OHCA) and predictors of outcomes. Previous research examined the association of several predictors with outcome, such as presence of a witness, duration of the drowning event, shockable rhythm, and time until emergency medical service (EMS) treatment [4–7]. The inaccessibility of a drowning victim greatly limits resuscitation efforts because of challenges related to recognition, rescue, and basic life support. The recommended guidelines for uniform reporting of data from drowning-OHCA suggest that location of the event can affect outcome [8]. Previous studies reported the locations of drowning events as baseline characteristics, but the sample sizes were too small to test the association with outcome [4,6,7,9–12].

A water safety plan that is reinforced by public policy and regulations may help to prevent drowning, and some countries are developing such plans [1]. However, as far as we know, no studies have examined the effect the different public locations on drowning-OHCA outcomes.

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This study examined the association between location and drowning-OHCA outcomes in South Korea. We hypothesize that drowning-OHCA cases that occur in locations where water safety regulations are enforced have better outcomes than those in nonregulated locations, such as natural waters and nonregulated water spaces.

2. Methods

2.1. Study design and setting

This cross-sectional study used a nationwide OHCA registry in South Korea. Korea has a population of 50 million people who live in 16 provinces. The Korean EMS system, a single-tiered response model with a basic-to-intermediate service level of ambulances, is operated by the 16 provincial headquarters of the National Fire Department. All ambulance crews can perform cardiopulmonary resuscitation (CPR) at a scene and during transport, and can also provide care comparable to that of an intermediate-level emergency medical technician (EMT) in the United States. This includes administration of intravenous fluids, endotracheal intubation, and laryngeal mask airway insertion under direct medical control [13]. However, medications for advanced cardiac life support (ACLS) are not widely available, and ACLS is only available in hospitals in most areas. The EMTs cannot declare death or stop CPR in the field or during transport unless they are under direct medical supervision from a physician via telephone in cases of apparent death, such as decapitation, rigor mortis, decomposition, and dependent lividity. The national protocol of prehospital field management for OHCA in South Korea states that ambulance crews should perform CPR in the field for at least 5 minutes. After delivery of more than 5 minutes of chest compression, EMTs should transport an OHCA victim as soon as possible to the nearest emergency department (ED).

The water resources in Korea are 100 032 km^2 in area and include about 358 beaches designated by national and local governments, 62 national rivers and 3776 local rivers according to the National Statistics Office, and 902 approved indoor and outdoor pools according to the Ministry of Homeland. The Water-related Leisure Activities Safety Act classifies activities requiring a mandatory safety program to prevent drowning [14]. All recreational water facilities including swimming pools (indoor and outdoor) and coastal beaches approved by the government are required to abide by this Act and to establish mandatory safety programs. For example, a supervising lifeguard must be on site when a beach or swimming pool is open to the public. The Installation and Utilization of Sports Facilities Act requires a minimum number of lifeguards to be present according to water type; a swimming pool requires at least 2 lifeguards, whereas a coastal beach requires 5 lifeguards per 300 000 visitors [15]. The Emergency Medical Services Act mandates lifeguards to complete basic life support training, including chest compression and rescue ventilation [16]. All lifeguards must complete 4 hours of training every year, which includes CPR and first aid for trauma.

2.2. Data source

All data were from a nationwide, population-based observational registry of OHCA patients who were assessed and treated by EMSs in South Korea from 2006 to 2013. The OHCA cases in this registry were collected from ambulance run sheets (completed by EMS providers who assisted with cardiac arrest) and from review of hospital medical records by the Korea Centers for Disease Control and Prevention (CDC). Ambulance run sheets, which include basic information on OHCA cases, are electronically stored on a computer server managed by the National Fire Department. Trained medical record reviewers of the Korea CDC visited all hospitals (approximately 700) that received OHCA patients and reviewed individual medical records to complete the registry with clinical information on hospital care and resuscitation outcomes [17]. A data quality management committee, which consists of emergency medicine physicians, cardiologists, epidemiologists, and biostatisticians, reviews these data and other variables collected by the medical record reviewers to maintain data quality through monthly committee meetings. In cases when a variable cannot be determined, the committee provided decisions with medical record reviewers.

2.3. Study population

Drowning-OHCA cases from 2006 to 2013 were collected from the registry where external causes for noncardiac etiology were coded. The etiology of a cardiac arrest was determined from review of the medical record, mostly recorded by emergency physicians at the ED. External causes were classified as trauma, poisoning, burn (flame, chemical, and electrical), hanging, asphyxia, and drowning. If there was any such external event, the cause of the OHCA was regarded as noncardiac. Unless there was a definite external cause, the case was presumed to be of noncardiac etiology. Drowning-OHCA events were excluded if there was a preceding traffic accident, suicide attempt, missing data on location, missing data on clinical outcome, or if neither EMS nor ED physicians provided treatment.

2.4. Data variables

We classified the event location (the main variable) into four categories: (i) recreational public swimming pools with a mandatory regulation program as required by the Installation and Utilization of Sports Facilities Act (public swimming pools); (ii) recreational public beaches with a mandatory regulation program as required by the Installation and Utilization of Sports Facilities Act (public beaches); (iii) natural locations with freshwater, such as lakes, rivers, creeks, or bayous, that have no mandatory safety regulation program (unsupervised open freshwater); and (iv) natural locations with seawater, such as the ocean, that have no mandatory safety regulation program (unsupervised seawater).

We collected demographic variables and examined the effect of numerous potential confounders: age, sex, presence of a witness, bystander CPR, urbanization level (metropolis [>5 million people] vs nonmetropolis), EMS response time (from call to ambulance arrival at the scene), EMS scene time (from arrival to departure), EMS transportation time (from departure to arrival at the ED), primary electrocardiogram (ECG) type at the scene (ventricular fibrillation or ventricular tachycardia, pulseless electrical activity [PEA], and asystole), prehospital defibrillation, and level of ED (1, 2, or 3). Witnesses and bystanders included laypersons and lifeguards without specific classification. The primary end point was survival-to-hospital discharge and was measured by medical record review of the Korea CDC. This study was approved by the institutional review board of the Seoul National University Hospital (number: 1103-153-357).

2.5. Statistical analysis

Demographic findings were compared between different event locations using the χ^2 test for categorical variables and the independent *t* test for continuous variables. A *P* value less than .05 was regarded as significant. To estimate the effect of different event locations on study end points, multivariable logistic regression analysis was used to calculate unadjusted and adjusted odds ratios (aORs) and 95% confidence intervals (CIs). Two models were developed to measure the effect of drowning location on survival to discharge with adjustment for confounders: model 1 adjusted for confounding by variables present before rescue (age, sex, metropolis, and witness); model 2 adjusted for all potential confounders including prehospital variables and the confounders considered in model 1 (primary ECG at the scene, bystander CPR, defibrillation by EMS, response time interval, scene time interval, transport time interval, and level of ED). SAS 9.4 (SAS Institute, Cary, North Carolina) was used for statistical analysis.