



Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajemThe
American Journal of
Emergency Medicine

Cardiac arrest while exercising on mountains in national or provincial parks: A national observational study from 2012 to 2015

Eujene Jung, MD^a, Jeong Ho Park, MD^b, So Yeon Kong, PhD, MPH^c, Ki Jeong Hong, MD, PhD^d,
Young Sun Ro, MD, DrPH^c, Kyoung Jun Song, MD, PhD^b, Hyun Ho Ryu, MD, PhD^{a,*}, Sang Do Shin, MD, PhD^b

^a Department of Emergency Medicine, Chonnam National University Hospital, Gwang-ju, Republic of Korea

^b Department of Emergency Medicine, Seoul National University College of Medicine, Seoul, Republic of Korea

^c Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Institute, Seoul, Republic of Korea

^d Department of Emergency Medicine, Seoul National University Boramae Medical Center, Seoul, Republic of Korea

ARTICLE INFO

Article history:

Received 3 November 2017

Received in revised form 10 December 2017

Accepted 15 December 2017

Available online xxxx

Keywords:

Out-of-hospital cardiac arrest

Exercise

Mountain

ABSTRACT

Background: Previous studies on cardiac arrest in mountainous areas were focused on environmental features such as altitude and temperature. However, those are limited to factors affecting the prognosis of patients after cardiac arrest. We analyzed the cardiac arrests in national or provincial parks located in the mountains and determined the factors affecting the prognosis of patients after cardiac arrest.

Methods: This study included all emergency medical service (EMS) treated patients over the age of 40 experiencing out-of-hospital cardiac arrests (OHCAs) of presumed cardiac etiology during exercise, between January 2012 and December 2015. The main focus of interest was the location of cardiac arrest occurrence (national mountain parks and provincial parks vs. other sites). The main outcome was survival to discharge and multivariable logistic regression was performed to adjust for possible confounding effects.

Results: A total 1835 patients who suffered a cardiac arrest while exercising were included. From these, 68 patients experienced cardiac arrest in national or provincial parks, and 1767 occurred in other locations. The unadjusted and adjusted ORs (95% CI) for a good cerebral performance scale (CPC) were 0.09 (0.01–0.63) and 0.08 (0.01–0.56), survival discharges were 0.13 (0.03–0.53) and 0.11 (0.03–0.48).

Conclusions: Cardiac arrests occurring while exercising in the mountainous areas have worse prognosis compared to alternative locations.

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1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a serious public health concern with a low survival rate [1,2]. The reported survival rate of OHCA varies considerably across communities, but generally ranges between 5 and 10% [1,2]. Despite efforts of modern resuscitation science, improvements in the OHCA survival rate have been minimal for almost 30 years [3]. The chain of survival refers to a series of actions that it performed properly may lead to improved survival outcomes in OHCA. It involves early access, early cardiopulmonary resuscitation (CPR), early defibrillation, early advanced care and post-resuscitation care [4]. Therefore, the quality of each process, from emergency medical service

(EMS) access to post-resuscitation care, has a decisive influence on the prognosis of patients experiencing cardiac arrest.

A healthy lifestyle including exercise has been recommended for the general population to reduce the risk of cardiovascular disease. Regular exercise has been shown to play an important role in the primary and secondary prevention of cardiovascular diseases and major cardiovascular events [5]. The number of tourists enjoying hikes in mountainous areas is increasing worldwide with approximately 100 million tourists visiting the mountains annually around the globe [6,7]. On the other hand, hiking or climbing mountains usually involves exposure to low temperatures, and as the altitude increases, the oxygen concentration in air decreases. The low temperature and lack of oxygen cause cardiac ischemia and increase the likelihood of cardiac arrest [8]. In addition, the risk of an acute cardiac event is transiently increased during and immediately after acute, vigorous exercise [9]. Cardiac arrest during exercise has a greater impact on the family and community because of the sudden unexpected death as victims are more likely to be healthy and more active. In some studies, cardiac arrest during moderate exercise is associated with favorable survival outcomes [10]. However, in the

* Corresponding author at: School of Medicine, Chonnam National University, 42 Jebong-ro, Dong-gu, Gwangju 61469, Republic of Korea.
E-mail address: oriryu@cnuh.com (H.H. Ryu).

case of cardiac arrest in mountainous areas, even if EMS is activated quickly after a cardiac arrest incident, the patient's prognosis deteriorates as much more time is spent in locating the incidence site and arrival times are much longer than with a typical location.

Previous reports studying cardiac arrest in mountainous areas were focused on environmental features such as altitude and temperature [7, 11]. Even though the environmental characteristics of mountains affect the occurrence of cardiac arrest, we suggest that there are several factors that influence the prognosis of cardiac arrest patients after the event itself [12].

We aimed to compare the outcomes of patients with cardiac arrest while exercising in the mountainous area with those patients with cardiac arrest while exercising in non-mountainous areas to determine whether prognosis differs according to the location of cardiac arrest occurrence and if that is the case, to investigate what causes such differences in outcome.

2. Methods

2.1. Study design and setting

This study is a retrospective observational study based on a nationwide, population-based registry, which involves all patients who experienced OHCA and were transported to hospital by EMS with resuscitation efforts in South Korea from 2012 to 2015.

The total territory of Korea is 100,284 km², 65% of which is entirely comprised of mountains. Within the mountains, there are currently 16 national parks and 19 provincial parks designated by certain standards such as total area and topographic features. Visitors to national parks and provincial parks increase annually, with >50 million people visiting each year as of 2015. This has had an effect of raising the number of cases of cardiac arrest in national and provincial parks. Currently, for national and provincial parks employees, Basic Life Support (BLS) training is emphasized and actively conducted, as a result, 74% of all employees completed training by 2014. New employees are required to submit documentary evidence about their completion of education and CPR is included in the evaluations at the time of their hire. In addition, approximately 250 automated electric defibrillators (AEDs) are installed on the main access roads and shelters and managed by a designated administrator in the park every year. Parks where incidents occur regularly are covered by rescue teams composed of specialized rescue personnel. In order to reduce incidents occurring during nighttime hiking or climbing, limits to the time of entry are increasingly being applied. Once a cardiac arrest occurs in the mountains, bystanders call the park offices or 119 (The Korean Emergency Number), and trained park staff and 119 rescue workers are dispatched to the scene.

The Korean EMS is a single tiered, government-based system that provides basic-to-intermediate level ambulance services [13,14]. The public access AED program in South Korea began in 2009, and its deployment and training are in progress [15]. Upon activation of the EMS, the fire department judges the accessibility of the location of the incident and an ambulance is dispatched. However, if the location is >30 km from the hospital, or it is expected transport will take more than one hour, a helicopter will be dispatched. The current EMS CPR protocol calls for emergency medical technicians (EMTs) to perform on scene CPR, using an AED every 2 min, for at least 5 min. Intravenous fluid administration and advanced airway management may be optionally performed by level-1 EMTs. Epinephrine and other intravenous medication for advanced cardiac life support (ACLS) are not available at the scene. EMTs cannot declare death at the scene unless there are signs of irreversible death (rigor mortis, dependent rigidity, decapitation, transection and decomposition) that are confirmed by direct medical control. If there is no return of spontaneous circulation (ROSC) after at least 5 min of CPR, EMTs transport the patients to the closest emergency department (ED), while continuing CPR during transport. Thus, almost all cases of OHCA in Korea are transported to the closest ED.

When a helicopter is dispatched, the selection of a hospital is affected by the helicopter landing facilities of the hospital.

2.2. Data sources

The cardiovascular disease surveillance database is a nationwide population based-database of EMS-assessed OHCA patients in Korea. The registry uses standardized definitions and reporting templates known as Utstein-style and comprises data collected from EMS-run sheets and hospital medical records.

Emergency medical service run sheets are completed by EMS personnel and include patient information comprising of demographic, event demographic, ambulance operation information, patient clinical information, treatment such as defibrillation or cardiopulmonary resuscitation (CPR), and transport information such as to which hospital the patient was transported. They are coded and filed electronically in each provincial EMS headquarters.

Hospital medical records were obtained from patients who transported to the ED and include patient clinical information, treatment information, hospital care information and outcomes. Medical records were collected by a trained medical record reviewer from the Korean CDC who visited all of the hospitals to evaluate medical records and document hospital outcomes electronically. A quality management committee (QMC) composed of emergency physicians, epidemiologists, statistical experts, representatives from the fire department, and medical record review experts ensured the quality of the medical record review process. The quality management committee educated all medical record reviewers (approximately 15 reviewers) prior to joining the project, provided a standard manual for data abstraction, monthly feedback to the reviewers, and consultation on equivocal cases as needed [16].

2.3. Study population

This study included the EMS-treated patients with OHCA of presumed cardiac etiology during exercise between January 2012 and December 2015. The activities at the time of cardiac arrest were based on the EMS run sheets classified as an 'exercise'. Cases were presumed to be of cardiac etiology if there was no definite evidence of non-cardiac etiology, such as evident trauma. Cases were excluded if there was missing information regarding the neurological status at hospital discharge.

2.4. Main outcomes

The primary end point was survival to discharge, and the secondary end point was survival to discharge with a good neurologic function, distinguished by scoring 1 (no neurologic disability) or 2 (moderate disability; able to perform daily activities independently) on the cerebral performance category (CPC) score, a 5-point scale used to evaluate neurologic functioning. The CPC score was measured on the basis of discharge summary abstracts or medical record documentation, written by inpatient care doctors. As there was no standard recording frame across different hospitals for coding the CPC score, the coded scores were reviewed and revised by the medical record reviewers of the Korean CDC, who were supervised by the QMC.

2.5. Variables and measurements

Our main interest in this study was location of cardiac arrest (mountainous area vs. non-mountainous area). The location of the cardiac arrest was extracted from information recorded on the EMS run sheets. We collected demographic variables and examined the effect of numerical potential confounders: age, gender, residence area (urban vs. rural), co-morbidity (diabetes, hypertension, heart disease, and strokes), a type of primary electrocardiogram (ECG) at the scene (shock-able vs.

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