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Impact of seasonal temperature environment on the neurologic prognosis of out-of-hospital cardiac arrest: A nationwide, population-based cohort study☆,☆☆,★

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ABSTRACT

Objective: The relationship between environmental factors, such as winter or cold environments, and the onset of out-of-hospital cardiac arrest (OHCA) is well known. However, the association between environmental factors and the neurologic outcome of OHCA is poorly understood. This study aimed to assess the impact of the ambient temperature on the neurologic outcome of adult OHCA.

Methods: In a nationwide, population-based, observational study, we enrolled 121 081 adults 18 years or older who experienced an OHCA from January 1, 2010, to December 31, 2010. We used the All-Japan Utstein Registry database coupled with climate statistics data from the Japan Meteorological Agency. The primary end point was favorable neurologic outcome 1 month after OHCA.

Results: Of the eligible 120 721 adult patients with OHCA, 7747 cases of OHCA (6.4%) occurred during the cold season, 80 739 (66.9%) occurred during the midseason, and 32 235 (26.7%) occurred during the warm season. The adults who experienced an OHCA during the cold season exhibited a significantly lower rate of a favorable neurologic outcome than did those who experienced an OHCA during the warm season (2.4% vs 3.3%; odds ratio, 0.73; 95% confidence interval, 0.62-0.85; $P < .0001$). The adjusted odds ratio for favorable neurologic outcome per 1°C increase in the monthly ambient temperature was 1.006 (95% confidence interval, 1.002-1.010; $P = .0080$).

Conclusions: The seasonal ambient temperature is likely to affect favorable neurologic outcome. A lower seasonal ambient temperature may exacerbate the neurologic outcome of OHCA.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) has one of the worst prognoses and is experienced by 125 000, 275 000, and 375 000 individuals annually in Japan, Europe, and the United States, respectively [1–3]. The occurrence of OHCA is associated with patient characteristics including age, sex, medical history, and family history [4,5]. Environmental factors are also suggested to be associated with OHCA; in particular, winter and cold environments are associated with the onset of OHCA [6–8]. However, the effects of low ambient temperature on the neurologic outcome of OHCA are poorly understood.

One study reports that body temperature after OHCA can more easily decrease during the winter than during the summer but that the seasonal alteration in body temperature has no effect on the neurologic outcome of OHCA [9]. Another study reports that spontaneous hypothermia after OHCA, the extent of which is associated with seasonal changes in ambient temperature, is associated with in-hospital mortality [10]. Although very little is known concerning the relationship between the neurologic outcome of OHCA, body temperature, and ambient temperature, it is generally believed that vital organs can be protected and that a favorable neurologic outcome is anticipated under low-body-temperature conditions. [11,12] Therefore, longer-than-usual cardiopulmonary resuscitation (CPR) is typically required [11], and advanced critical care medicine, particularly extracorporeal CPR, is sometimes performed on patients with OHCA experiencing hypothermia [13,14]. In addition, therapeutic hypothermia, a targeted temperature management protocol, is an established method for the treatment of postcardiac arrest syndrome [15–17], and it is sometimes reported

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that the initiation of therapeutic hypothermia as soon as possible after OHCA may be desirable [18,19].

Based on these viewpoints, although the body temperature may not always follow the same trend as the ambient temperature, it is presumed that an OHCA occurring at a lower ambient temperature would result in survival with a more favorable neurologic outcome. The purpose of this study was to examine the impact of ambient temperature on the neurologic outcome of OHCA.

2. Methods

2.1. Study design and participants

The All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA) is a prospective, nationwide, population-based database of all patients with OHCA that uses Utstein-style data collection [20]. This study was a population-based cohort study using data from the All-Japan Utstein Registry coupled with climate statistics data from the Japan Meteorological Agency. The analysis of this study was conducted retrospectively using prospectively collected data.

This study enrolled all adults 18 years or older who had an OHCA and for whom resuscitation was attempted by emergency medical service (EMS) personnel with subsequent transport to medical institutions from January 1, 2010, to December 31, 2010. Patients were excluded from the analysis if the data and information regarding the onset date, the call receipt time, the hospital arrival time, the airway management status, or the use of a public access automated external defibrillator (AED) were missing or unknown.

The FDMA and the institutional review board at The University of Tokyo approved the study with a waiver of informed consent because of the anonymous nature of the data.

2.2. Study setting

Japan is an island nation that lies between longitudes 122° and 153° and latitudes 20° and 45° and that has an area of approximately 378 000 km^2 [21]. It comprises 8 regions of 47 prefectures, including subarctic and subtropical regions. Most regions have a temperate humid climate and 4 distinct seasons [22]. The population of Japan was approximately 128 million people in 2010, including approximately 107 million people 18 years or older [21].

The EMS system in Japan has been described previously [23–28]. In Japan, municipal governments provided EMS via 802 fire stations with dispatch centers [1,23]. All EMS personnel performed CPR in conformity with the Japanese CPR guidelines, which are based on the American Heart Association and the International Liaison Committee on Resuscitation [29–31]. In most cases, an ambulance crew consisted of 3 EMS personnel, including at least 1 emergency lifesaving technician who had completed extensive training [23–25]. Some of these emergency lifesaving technicians were authorized to secure an infusion line, administer epinephrine, perform endotracheal intubation, perform defibrillation, and lead CPR [23–25]. Advance directives, living wills, or do-not-attempt-resuscitation orders are not generally accepted in Japan [24–29]. Emergency medical service providers in Japan were not allowed to terminate resuscitation outside the hospital, except for specific situations such as decapitation, rigor mortis, livor mortis, or decomposition. Therefore, most patients who experienced an OHCA and were treated by EMS personnel were transported to an emergency hospital [24–27].

2.3. Data collection and quality control

The data related to OHCA were collected using an Utstein-style data record that included sex, age, etiology of arrest, bystander witness status, bystander CPR status, initial cardiac rhythm, use of a public access AED, presence of an emergency lifesaving technician or physician in the ambulance, administration of epinephrine by EMS personnel, and the airway management technique.

Cardiac arrest was defined as the end of mechanical cardiac activity determined based on the absence of signs of circulation [20,32]. *Bystander CPR* was defined as CPR performed by a person who was not responding as part of an organized emergency medical system approach to an OHCA [1,20,29]. The etiology of arrest was presumed to be cardiac, unless evidence suggested cerebrovascular disease, respiratory disease, a malignant tumor, an external cause (such as trauma, drowning, burn, asphyxia, or intoxication), or any other noncardiac cause. Designation of cardiac or noncardiac etiology was made by attending physicians in the emergency department in collaboration with EMS personnel.

The time series of EMS call receipt, vehicle arrival at the scene, contact with the patient, initiation of CPR, and hospital arrival were recorded based on the clock used by each EMS system.

The outcome measures included return of spontaneous circulation (ROSC) before hospital arrival, 1-month survival, and neurologic status 1 month after the event.

To collect the 1-month follow-up data, the EMS personnel in charge of each patient experiencing OHCA queried the medical control director at the hospital. The neurologic status of each patient was determined by the attending physician. The EMS personnel received a written response. At this time, the etiology of the arrest was reconfirmed. If the patient was not at the hospital, the EMS personnel performed a follow-up search.

The data records were completed by the EMS personnel who cared for the patients, and the data were integrated into the Utstein registry system on the FDMA database server. The records were logically checked by the computer system and were confirmed by the FDMA. If the data form was incomplete, the FDMA returned it to the respective fire station, and the data were reconfirmed.

The data regarding the ambient temperature (ie, the monthly mean ambient temperature and monthly mean daily maximum and minimum ambient temperatures) were obtained from the 2010 climate statistics of the Japan Meteorological Agency [22] because the All-Japan Utstein Registry data did not include information about the ambient temperature (Appendix 1). A total of 564 data components (12 months × 47 prefectures) on the monthly ambient temperature in the 47 prefectural capitals were applied as approximate values according to the date and the location of the OHCA. According to the geographical characteristics of Japan, because the climate differs from place to place even in the same month, those with a monthly mean daily minimum ambient temperature lower than 0°C were defined as the *cold season*, whereas those with a monthly mean daily maximum ambient temperature of 25°C or higher were defined as the *warm season*[22]. These definitions not were based on an astronomical classification, but rather the climatic classification of the Japan Meteorological Agency in which a day with minimum ambient temperature lower than 0°C was defined as a *frost day* and that of a maximum ambient temperature of 25°C or higher was defined as a *summer day*.

2.4. Study end points

The primary end point was favorable neurologic outcome 1 month after cardiac arrest, defined a priori as Glasgow-Pittsburgh cerebral performance category 1 (good performance) or 2 (moderate disability) [20]. Cerebral performance categories 3 (severe cerebral disability), 4 (vegetative state), and 5 (death) were regarded as unfavorable neurologic outcomes [20]. The secondary outcome measures were ROSC before hospital arrival and 1-month survival.

2.5. Statistical analysis

We defined 3 seasonal categories (cold season, midseason, and warm season) based on the Japan Meteorological Agency (monthly