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Epidemiology and Outcomes in Out-of-hospital Cardiac Arrest: A Report from the NEDIS-Based Cardiac Arrest Registry in Korea

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Sudden cardiac death (SCD) is a significant issue affecting national health policies. The National Emergency Department Information System for Cardiac Arrest (NEDIS-CA) consortium managed a prospective registry of out-of-hospital cardiac arrest (OHCA) at the emergency department (ED) level. We analyzed the NEDIS-CA data from 29 participating hospitals from January 2008 to July 2009. The primary outcomes were incidence of OHCA and final survival outcomes at discharge. Factors influencing survival outcomes were assessed as secondary outcomes. The implementation of advanced emergency management (drugs, endotracheal intubation) and post-cardiac arrest care (therapeutic hypothermia, coronary intervention) was also investigated. A total of 4,156 resuscitation-attempted OHCAs were included, of which 401 (9.6%) patients survived to discharge and 79 (1.9%) were discharged with good neurologic outcomes. During the study period, there were 1,662,470 ED visits in participant hospitals; therefore, the estimated number of resuscitation-attempted CAs was 1 per 400 ED visits (0.25%). Factors improving survival outcomes included younger age, witnessed collapse, onset in a public place, a shockable rhythm in the pre-hospital setting, and applied advanced resuscitation care. We found that active advanced multidisciplinary resuscitation efforts influenced improvement in the survival rate. Resuscitation by public witnesses improved the short-term outcomes (return of spontaneous circulation, survival admission) but did not increase the survival to discharge rate. Strategies are required to reinforce the chain of survival and high-quality cardiopulmonary resuscitation in Korea.

Keywords: Death, Sudden, Cardiac; Resuscitation; Outcome; Cardiac Rhythms; Emergency Department

INTRODUCTION

Sudden cardiac death (SCD) is often fatal and remains a major public health issue worldwide (1). The annual incidence rate and clinical outcomes of SCD are being studied globally as significant indicators of national health. Reports on SCD vary widely, although a worldwide meta-analysis revealed that the incidence of cardiac arrest (CA) is 45-83.7 per 100,000 people (2, 3). However, the largest cumulative meta-analysis conducted to date documented a mean survival to hospital admission rate of 23.8% and a hospital discharge rate of only 7.6% (2-5).

According to The Korea Center for Disease Control and Prevention surveys (the CAVAS project), the incidence rate of sudden CA in Korea was 39.3 per 100,000 people in 2006, with a survival rate of 2.4% to 3.6% in 2007 (6, 7). The overall survival to discharge rate was 3.7% for resuscitation-attempted sudden CA from 2006 to 2010 in Korea (7), which was very poor compared with the results of the Resuscitation Outcome Consortium (ROC) studies conducted in North America (7.9%-11.4%), Europe (10.7%), and Japan (12%) during the same period (5, 8-11). However, these public ambulance-assessed, retrospective studies had some limitations: first, they did not include patients transported by private ambulance or others; second, they did not sufficiently resolve the effect of advanced cardiovascular life support used in the hospital (6).

To improve clinical outcomes, the National Emergency Department Information System for Cardiac Arrest (NEDIS-CA) consortium managed an emergency department (ED)-based, prospective registry of out-of-hospital cardiac arrest (OHCA). Therefore, we discuss herein the epidemiological features and outcomes of SCD in Korea based on prospectively collected observational data. We also report on CA-related time variables, changes in electrocardiography (ECG), advanced emergency care (e.g., endotracheal intubation and cardiopulmonary resuscitation [CPR] drugs), and post-CA care (e.g., therapeutic hypothermia and coronary intervention).

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MATERIALS AND METHODS

NEDIS database

Data were obtained from the NEDIS database, which is updated in real-time by the National Emergency Medical Center across Korea. Developed in 2004, the database information is drawn from EDs throughout Korea. During the study period, all 16 of the level I regional emergency centers and 109 of the 116 level II local emergency centers participated in the NEDIS project, which together accounted for more than 35.3% of the national overall ED census (12, 13).

The NEDIS contains patient data including sex, age, type of insurance, means of transportation, level of consciousness at presentation, emergency operative procedures, time variables (visit, discharge, and admission), critical care requirement, disposition status after the ED encounter, hospital stay after admission, and final outcomes (information regarding discharge, transfer, and death). All patient-related information is automatically transferred from each hospital to a central government server within 2 or 14 days of the patient's discharge from an ED or hospital ward, respectively. Inaccurate data are filtered by a data processing system. The health authority maintains an accuracy assessment system and annually reports the results to the Ministry of Health and Welfare. In 2010, the NEDIS records were 98.8% complete with 89.3% reliability (14).

NEDIS-CA consortium and registry implementation

To analyze the occurrence of SCD and improve the survival rate of patients with SCD in Korea, the National Emergency Medical Center and the Korean Association of Cardiopulmonary Resuscitation operate a registration system for patients who have been hospitalized in EDs because of sudden CA. This study is based on a national prospective registry entitled "Research on the actual state of OHCA in Korea," which is conducted by the NEDIS-CA consortium groups. The aim of the NEDIS-CA consortium was to establish a monitoring system and a database to identify factors related to national CA outcomes. A team composed of study co-investigators, statistical experts (Korean Association of Cardiopulmonary Resuscitation), and database managers (National Emergency Medical Center) perform quality control of the data. The NEDIS-CA project is supported by the National Emergency Medical Center in collaboration with the Korean Association of Cardiopulmonary Resuscitation, which supports the participation of the academic emergency medical community in the efforts of the National Emergency Medical Center to promote the prevention and control of CA and SCD.

NEDIS-CA was first implemented in October 2005 in 12 hospitals. Approximately 600 cases entered during the initial 12-month pilot testing period, and the system was expanded further after refinement. In 2006-2007, the Utstein template-based nationwide OHCA database was constructed from pre-hospital features, emergency medical system (EMS) records, and hospital medical data, which included ED data, hospital outcomes, and post-CA care. This registry is similar to the Cardiac Arrest Registry to Enhance Survival (CARES) system in North America (15). In 2008, the final web-based OHCA network was established. The NEDIS-CA consortium study is a prospective, multicenter, observational cohort study of OHCAs in Korea. A total of 29 emergency medical centers in 20 cities and provinces participated in the research, and the full-scale registration project started in January 2008 (sample size: 9.8% of the overall national ED census and 33% of the NEDIS database). Starting in 2010, confirmation and verification of the medical records and database from 2008-2009, the first project time point, was conducted for 2 yr; we subsequently performed the analysis. The NEDIS-CA study has been ongoing, with 7 hospitals starting a registry since 2011 and 13 hospitals participating since 2013. Therefore, to date, the consortium has participated in 49 emergency centers.

Study design and outcomes

Patients of all ages who experienced sudden OHCA were included in this study. Data were obtained from the NEDIS-CA registry database in Korea for events between January 1, 2008, and July 31, 2009.

Participants included all patients with OHCA of cardiac etiology. Patients with obvious signs of death (e.g., rigor mortis or dependent lividity) or a "do not resuscitate" order were excluded. Cases of trauma, poisoning, electrocution, primary respiratory arrest, drowning, asphyxia, hanging, and other injuries were also excluded (8, 15, 16). Previous pre-hospital researchers have defined SCD as EMS-assessed OHCAs or collapses with any attempted resuscitation (17, 18). Therefore, we analyzed resuscitation-attempted OHCA that included all patients resuscitated by a layperson, public/private EMS personnel in the pre-hospital setting, or an advanced ED provider in an ED (7). In terms of this ED-based property, sudden CA patients included resuscitation-attempted CAs transported by public or non-public EMS (e.g., private ambulance services, private vehicles, and patrol cars).

Variables were defined according to those given in the Utstein, CARES, and ROC studies (8, 16-18). The following information was extracted from the NEDIS-CA database: demographic factors, including sex, age, home address, and location of event; CPR-related characteristics such as presence of a witness, CPR by a bystander, initial ECG rhythm, and provision of CPR in the EMS or ED; CPR-related time variables such as basic life support interval (time from collapse/call to chest compression attempt at the scene), defibrillation interval (time from collapse/call to DC shock), and pre-hospital interval (time from collapse/call to arrival in an ED) (11, 16, 19); and clinical outcomes, including presence or return of spontaneous circulation (ROSC),

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ED outcomes (admitted, died, or transferred), hospital outcomes (discharged alive, died, or transferred), neurological outcomes at discharge, and whether post-CA treatment (i.e., therapeutic hypothermia or percutaneous coronary intervention) was provided. Survival to discharge was defined as final discharge to home or transfer to another facility after admission to the hospital. Neurological status was quantified by using Cerebral Performance Category (CPC) scores, which are based on a 5-point scale in which scores of 1 (good recovery) and 2 (moderate disability) are defined as favorable outcomes (15).

The primary outcomes were estimated incidence and survival outcomes on admission and at discharge. Factors influencing survival outcomes were assessed as the secondary outcome.

Statistical analysis

All OHCA events submitted to the NEDIS-CA registry from January 1, 2008, to July 31, 2009, were analyzed using IBM SPSS Statistics version 21.0 (SPSS Inc. Chicago, IL, USA) and MedCalc 12.7 version (MedCalc Software, Mariakerke, Belgium). Descriptive statistics are presented as medians with interquartile ranges (IQR; 25th and 75th percentiles). Categorical variables are presented as counts and percentages.

We characterized differences between binary survival outcome groups with respect to several potential risk factors. For descriptive variables, we calculated the number of observations in each level/outcome group combination and tested for significant differences between groups with chi-square tests. For almost non-normally distributed continuous variables, we calculated the medians with IQRs and used the nonparametric Mann-Whitney test to assess a significant difference between outcome groups.

Before multivariable analysis, we conducted co-linearity test of variables associated with OHCA events and time-related parameters. In this study, the tolerance of each variable was larger than 0.1 (range, 0.72-0.98), while the variance inflation factor (VIF) was less than 10 (range, 1.02-1.40). This demonstrates that the several variables introduced into the model basically do not exhibit multi-collinearity. We used logistic regression for the multivariate analyses, and the outcome of interest was survival to hospital discharge. To determine logistic model calibration, we calculated the Hosmer-Lemeshow goodness of fit. Odds ratio (OR) greater than 1 were indicative of a beneficial effect on survival. The ORs and 95% confidence intervals (CIs) were derived for all covariates. The characteristics of the adjusted OR are described according to the Forest plot. $P < 0.05$ was considered statistically significant.

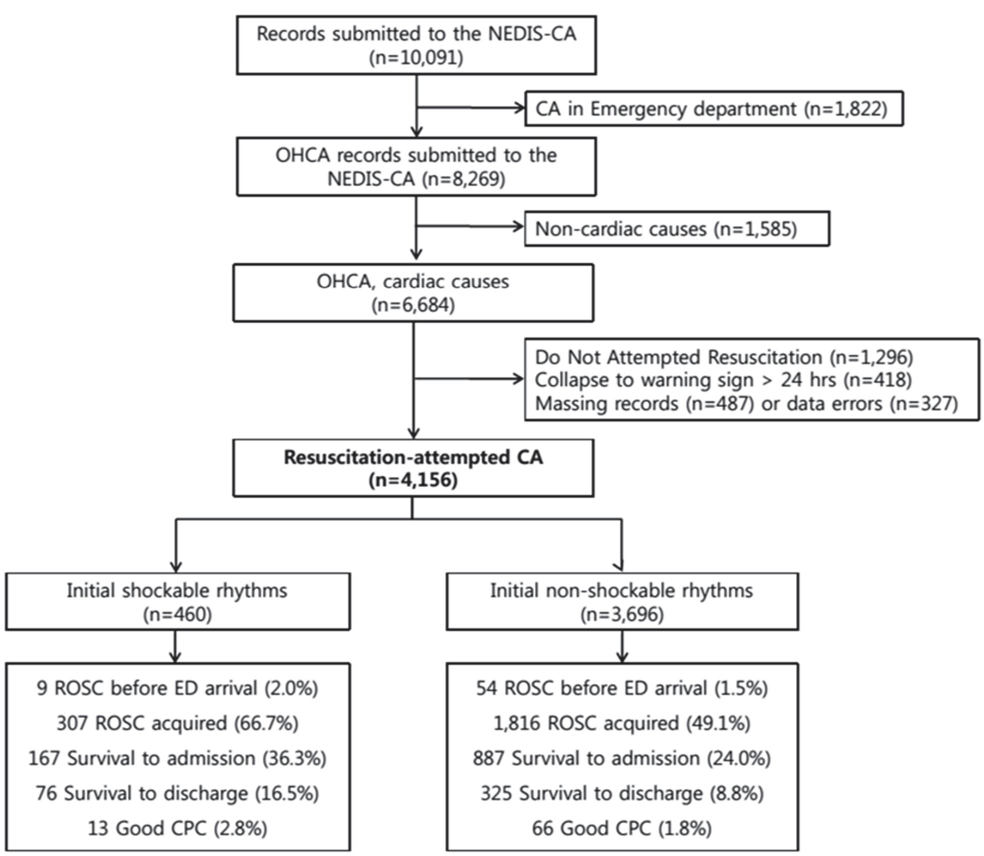

Fig. 1. Patient flow according to NEDIS-CA determined on the basis of sudden cardiac death. CA, cardiac arrest; CPC, Cerebral Performance Category; ED, emergency department; NEDIS-CA, National Emergency Department Information System for Cardiac Arrest; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.

Ethics statement

The study was reviewed and approved by the institutional review board of Kyungpook National University Hospital (14-061). Informed consent was waived by the IRB.

RESULTS

Characteristics of the entire patient group

A total of 10,091 records were submitted to the NEDIS-CA registry over a 19-month period. After omitting CAs classified as in-hospital arrest in the ED (n = 1,822), non-cardiac causes (n = 1,585), and any exclusion criteria (n = 2,528), 4,156 resuscitation-attempted CAs were analyzed (Fig. 1). Compared with the previous the US national sample, we evaluated the ED census in participating hospitals (16). During the study period, there were 1,662,470 ED visits in 29 participant hospitals; therefore, the predicted proportion of resuscitation-attempted CA was 1 per 400 ED visits (0.25%).

Epidemiology and clinical characteristics

In resuscitation-attempted OHCA, 58.5% of the patients were men. The median age at the onset of SCD was 69 yr, and 55.9% of these events occurred at a home/residence. Public ambulance services were used in 62.6% of the ED cases, and private EMS was used in 24.4% (Table 1). In witnessed CAs, a total of 64.9% (1,641/2,530) collapses were witnessed by family members or other bystanders, and 13.2% (334/2,530) OHCAs received bystander CPR. In unwitnessed CAs, only 10.9% (174/1,591) events received bystander CPR.

In the ECG rhythm analysis, most of the 3,255 (78.3%) patients had a non-shockable rhythm in both the pre-hospital and in-hospital stages, 460 (11.1%) patients had a rhythm for which the initial ECG required defibrillation, and 441 (10.6%) patients had a non-shockable rhythm on the initial ECG at the pre-hospital stage but converted to ventricular fibrillation in emergency centers. A total of 3.0% resuscitation-attempted OHCAs were treated with automated external defibrillation (AED) by emergency medical technicians.

In terms of advanced cardiac treatments used in the ED, 47.3% of the patients were treated with CPR drugs and 1.3% of events were treated with vasopressin. Cardiac circulation was restored before arriving in the ED in 63 patients (1.5%) and was restored

Table 1. Pre-hospital event-related characteristics and hospital management by primary outcome

Characteristics	Resuscitation-attempted OHCA (n = 4,156)	Survival to discharge (n = 401)	Death before discharge (n = 3,755)	*P* value
Age groups* (yr)	69.0 [53-79]			< 0.001
Pediatric (0-14)	128 (3.2)	22 (5.8)	106 (3.0)	
Adult (15-64)	1,533 (38.8)	197 (51.7)	1,336 (37.5)	
Elderly (≥ 65)	2,286 (57.9)	162 (42.5)	2,124 (59.6)	
Male sex	2,432 (58.5)	237 (59.1)	2,195 (58.5)	0.969
Location of OHCA*				< 0.001
Home/residency	2,301 (55.9)	149 (37.3)	2,152 (57.9)	
Healthcare/nursing home	787 (19.1)	105 (26.3)	682 (18.4)	
Public	352 (8.6)	59 (14.8)	293 (7.9)	
Other	674 (16.4)	86 (21.6)	588 (15.8)	
Event area, higher than 6th floor	573 (13.8)	31 (7.7)	542 (14.4)	< 0.001
Event area, moved by elevator	861 (20.7)	57 (14.2)	804 (21.4)	0.001
Event time status				
Weekend	1,229 (29.6)	106 (26.4)	1,123 (29.9)	0.147
Night (10 PM to 6 AM)	1,152 (27.7)	103 (25.7)	1,049 (27.9)	0.339
Witnessed event*	2,530 (61.4)	277 (69.6)	2,253 (60.5)	< 0.001
Bystander CPR	509 (12.2)	49 (12.2)	460 (12.3)	0.986
Pre-hospital AED use	125 (3.0)	6 (1.5)	119 (3.2)	0.062
Transport by 119 public EMS	2,600 (62.6)	262 (65.3)	2,338 (62.3)	0.227
EMS (BLS) treated	3,747 (90.2)	323 (80.5)	3,424 (91.2)	< 0.001
ED (ACLS) treated	3,014 (72.5)	379 (94.5)	2,635 (70.2)	< 0.001
Pre-hospital shockable rhythms	460 (11.1)	76 (19.0)	384 (10.2)	< 0.001
Final shockable rhythms	901 (21.7)	128 (31.9)	773 (20.6)	< 0.001
ROSC before ED arrival	63 (1.5)	11 (2.7)	52 (1.4)	0.034
Resuscitation in ED				
Epinephrine	1,965 (47.3)	263 (65.6)	1,702(45.3)	< 0.001
Vasopressin	56 (1.3)	2 (0.5)	54 (1.4)	0.121
Percutaneous coronary intervention	50 (1.2)	21 (5.2)	29 (0.8)	< 0.001
Extracorporeal membrane oxygenation	17 (0.4)	8 (2.0)	9 (0.2)	< 0.001
Therapeutic hypothermia	51 (1.2)	19 (4.7)	32 (0.9)	< 0.001

Data are median [interquartile range] or number (percent). *Unknown or not determined data: age (n = 209), location of OHCA (n = 42), witnessed events (n = 35). ACLS, advanced cardiac life support; AED, automated external defibrillation; BLS, basic life support; CPR, cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical system; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.

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Table 2. Resuscitation-related time variables by primary outcome

Time variables	Resuscitation-attempted OHCA* (n = 3,901)	Survival to discharge (n = 367)	Death before discharge (n = 3,534)	*P* value
Witnessed CA (zero time: collapse time)				
EMS response time	3 [0-14]	3 [0-11]	3 [0-15]	0.279
Time to CPR	10 [1-22]	8 [0-18]	11 [1-23]	0.001
Time to first shock	17 [8-31]	13 [5-20]	19 [10-31]	0.002
Time to administration of drugs	21 [10-31]	18 [6-27]	22 [10-32]	< 0.001
Pre-hospital time	26 [18-42]	20 [13-28]	28 [19-44]	< 0.001
Time to ROSC	33 [18-50]	29 [14-44]	36 [20-52]	0.001
Unwitnessed CA (zero time: call time)				
Time to CPR	8 [2-19]	7 [2-18]	8 [3-19]	0.276
Time to first shock	14 [7-28]	12 [5-20]	16 [8-29]	0.024
Time to administration of drugs	20 [8-28]	18 [6-25]	21 [9-28]	0.009
Pre-hospital time	23 [17-32]	19 [13-27]	24 [18-32]	< 0.001
Time to ROSC	34 [22-48]	30 [19-41]	37 [24-51]	< 0.001
In-hospital variables				
ED arrival to manual defibrillation	2 [1-5]	1 [1-4]	2 [1-5]	0.225
ED arrival to first drug administration	2 [1-3]	1 [0-3]	1 [1-3]	0.397
ED arrival to ROSC	2 [1-5]	3 [1-5]	2 [1-5]	0.032

Data are median [interquartile range] minutes. *Data extracted for time-missing values (n = 255). In some of the literature, the terms of EMS response time (as collapse to EMS call), time to CPR (as to basic life support), or pre-hospital time (as to ED/hospital arrival) were represented. CA, cardiac arrest; CPR, cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical system; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.

in the ED in 2,123 patients (51.1%). Among the 1,054 patients who survived to admission, percutaneous coronary intervention and therapeutic hypothermia was performed in 52 and 53 patients, respectively.

CPR-related time variables

For witnessed events, patients with SCD had a median interval from collapse to CPR of 10 min (IQR, 1-22), from collapse to ED arrival of 26 min (IQR, 18-42), and from collapse to defibrillation of 17 min (IQR, 8-31). For unwitnessed CAs, the patients had a median interval from call to CPR of 8 min (IQR, 2-19), from call to ED arrival of 23 min (IQR, 17-32), and from call to defibrillation of 14 min (IQR, 7-28). Other time values of in-hospital variables are presented in Table 2.

Survival outcomes

The ROSC rate was 1.5% (n = 63) before ED arrival and 51.1% (n = 2,123) in the ED. The survival to hospital admission rate was 25.4% (n = 1,054), the survival to discharge rate was 9.6% (n = 401), and the rate of a favorable neurological outcome was 1.9% (n = 79).

The shockable group had higher rates of ROSC, survival to admission, and survival to discharge (all $P < 0.001$) and a more favorable neurological outcome ($P = 0.123$). The survival outcomes of the initial ECG subgroups are summarized in Fig. 1.

Predictors influencing the outcome of survival to discharge

In the univariate analysis of the patients who survived to discharge, the rate of favorable outcomes significantly increased depending on the patient's age, whether the CA occurred in a public place or while the patient was on a floor lower than 6th level, whether the onset of CA was witnessed or not, whether there was a rhythm for which defibrillation was required, and when the time of arrival at the hospital and the administration of medications for resuscitation was earlier. In the in-hospital stage, outcomes improved in patients treated with percutaneous coronary intervention and therapeutic hypothermia. The other demographic findings, collapse events, and CPR-related variables are summarized in Tables 1 and 2 by subgroup.

Based on these results, a logistic regression was performed and showed that survival outcomes were related to an age younger than 65 yr, sudden onset of CA in a public place, witnessed event, pre-hospital shockable rhythms, and whether advanced resuscitation was applied (Table 3). Bystander CPR and final shockable rhythms did not significantly improve survival outcome ($P = 0.835$ and 0.638, respectively). In the additional multivariate analysis, the patients were assigned to either a group discharged alive or a group restored a spontaneous circulation. The characteristics of the two groups are described in Fig. 2 using a Forest plot.

DISCUSSION

The NEDIS-CA registry differs from other registries in several important respects: 1) it is a multicenter, prospective, ED-based database; 2) the incidence of SCD is estimated as a fraction of the ED census number; 3) it provides factor analysis of clinical outcomes, thus illustrating weak points in the survival chain at a glance; and 4) it includes the national status of post-CA care before the 2010 guidelines were implemented.

The NEDIS-CA is the first prospective study of a web-based registry of OHCA and integrates the NEDIS with the Utstein tem-

Table 3. Independently predictive factors for survival to discharge on univariate and multivariate analysis

	Resuscitation-attempted OHCA			
	Unadjusted OR	*P* value	Adjusted OR*	*P* value
Sex (male)	1.03 (0.83-1.29)	0.804	1.25 (0.98-1.57)	0.065
Age < 65 yr	1.99 (1.61-2.47)	< 0.001	1.74 (1.38-2.18)	< 0.001
Location, home/residency	0.43 (0.35-0.54)	< 0.001	0.61 (0.48-0.77)	< 0.001
Event area, higher than 6th floor	0.49 (0.34-0.73)	< 0.001	0.68 (0.41-1.12)	0.130
Event area, moved by elevator	0.61 (0.45-0.81)	0.001	0.87 (0.59-1.28)	0.472
Witnessed event	1.49 (1.20-1.87)	< 0.001	1.39 (1.09-1.77)	0.008
Bystander CPR	0.07 (0.78-1.47)	0.986	1.04 (0.73-1.47)	0.835
Pre-hospital AED use	0.50 (0.22-1.15)	0.069	0.25 (0.11-0.64)	0.004
Electrocardiographic findings				
Pre-hospital shockable rhythms	2.05 (1.57-2.69)	< 0.001	1.59 (1.06-2.40)	0.026
Final shockable rhythms	1.81 (1.45-2.26)	< 0.001	1.09 (0.77-1.53)	0.638
ROSC before ED arrival	2.01 (1.04-3.88)	0.038	1.59 (0.77-3.27)	0.209
CPR-related time variables				
Time to CPR (per min)	0.98 (0.98-0.99)	0.001	1.01 (0.96-1.07)	0.742
Time to first shock (per min)	0.98 (0.96-0.99)	0.022	1.01 (0.97-1.05)	0.914
Pre-hospital time (per min)	0.97 (0.96-0.98)	< 0.001	1.00 (0.97-1.04)	0.999
Time to ROSC (per min)	0.99 (0.98-0.99)	0.002	0.98 (0.95-1.00)	0.050
Advanced cardiac care in the ED				
Epinephrine	2.30 (1.85-2.85)	< 0.001	1.88 (1.48-2.38)	< 0.001
Coronary intervention	7.10 (4.01-12.57)	< 0.001	4.74 (2.44-9.20)	< 0.001
Therapeutic hypothermia	5.79 (3.25-10.31)	< 0.001	3.97 (2.07-7.65)	< 0.001

Data are odds ratio (95% confidence interval). *Statistical analysis was performed using the entered method of logistic regression model. Nagelkerke R square 0.440, Hosmer and Lemeshow Test: chi-square 3.566, df 8, significant = 0.894. AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; ED, emergency department; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; ROSC, return of spontaneous circulation.

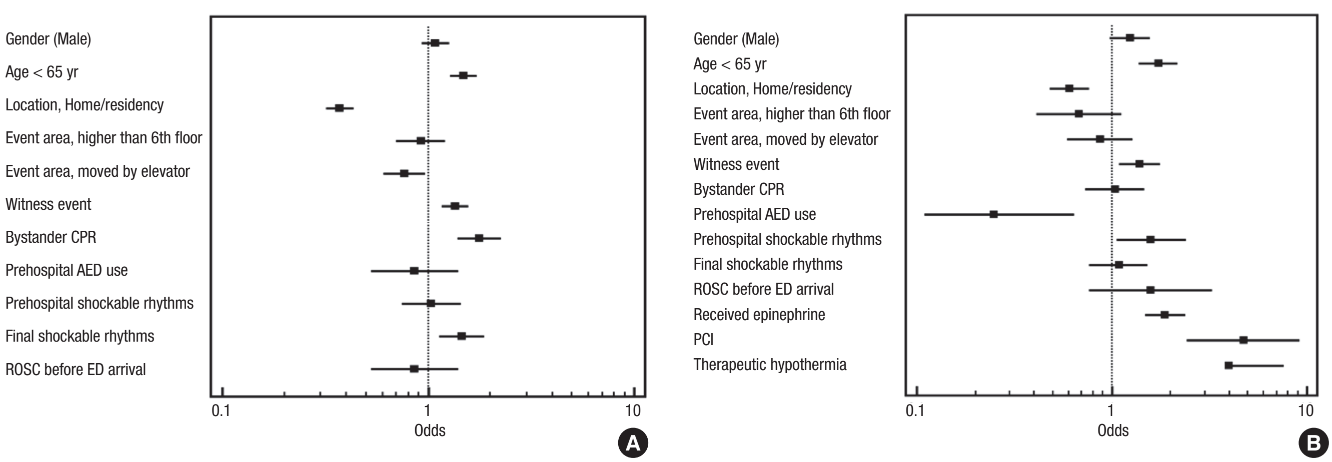

Fig. 2. Forest plots associated with clinical outcomes in the resuscitation-attempted OHCA group. (**A**) ROSC (pre-hospital factors), (**B**) survival to hospital discharge (pre-hospital and in-hospital factors). The odds ratios for survival are significant in age, bystander witnessed, received epinephrine, and initial shockable rhythms. The bystander CPR improved the short-term outcomes (return of spontaneous circulation), but, it did not increase the survival to discharge rate. AED, automated external defibrillation; CPR, cardiopulmonary resuscitation; ED, emergency department; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; ROSC, return of spontaneous circulation.

plate in Korea. Unlike EMS-based epidemiological analysis, an ED-based approach encourages proper management of data quality and intervention studies. This study is limited in that only 29 hospitals participated (i.e., only 8.3% of the emergency medical centers in Korea) but differs from previous research in that it is a prospective, multi-institutional study and reports on the advanced cardiac care used in hospitals. Moreover, according to the results, only 62.6% of OHCAs used the public ambulance services in Korea. The public EMS was not used in one-third of the ED cases. This can be characterized as a supplementary nationwide survey of patients with CA hospitalized through means of admission other than the 119 public ambulance services (6).

In the present study of resuscitation-attempted OHCA, the proportions of patients who were hospitalized alive, discharged alive, and hospitalized with a favorable neurological outcome were 25.4%, 9.6%, and 1.9%, respectively; these rates were twice those reported in the study that only described public EMS-as-

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sessed data in Korea (the CAVAS project, which reported rates of 10.1%, 3.5%, and 1.0%, respectively) (7). However, the survival-to-discharge rate was similar to that reported by ROC studies conducted in North America (7.9-11.4%), Europe (10.7%), and Japan (12%) (5, 8-11). Considering the Korean medical environment in which all cases of sudden collapse were pronounced dead in the hospital by a physician, the data on the patients registered with ED-based sudden CA could be similar to the actual status in Korea.

In 2008-2009, we estimated that 1 of every 400 ED visits (0.25%) experienced resuscitation-attempted OHCA as sudden collapse. Previously, using a sample from the US National Hospital Ambulatory Medical Care Survey (NHAMCS), Valderrama et al. reported that the number of patients receiving primary diagnoses of CA in EDs from 2001 to 2007 represented 1 in every 600 visits (0.17%) (16). This higher figure indicates that the severity of the cases reported herein is greater because emergency centers categorized as higher than level II were included in the present study.

In the multivariate logistic analysis, the pre-hospital factors influencing patient survival were age younger than 65 yr, onset of sudden CA in a public place, witnessed onset of CA, and an initial ECG rhythm that needed defibrillation. These findings are similar to those of previous research studies (6, 17, 18). What is unusual is that the implementation of CPR by a witness did not significantly affect patient survival. This is in contrast to numerous previous research studies that reported bystander CPR as a major factor in the improvement in the survival rate (20, 21). Considering that the present study was prospective research that used verified data, thus minimizing selection bias and input error fallibility, it is possible that the CPR performed by the witnesses was not of high quality in Korea. This indicates that the quality of the resuscitation effort, not the attempt itself, may play a significant role. The authors of a recent report also pointed out the possibility that there is a wide gap between willingness to perform CPR and the ability to perform qualified CPR in a real situation (21).

In the factor analysis, pre-hospital AED use did not improve the survival outcomes as expected, which was the opposite of our prediction. Pre-hospital AED use did not improve short-term outcomes (ROSC and survival admission); furthermore, it interfered with a favorable outcome. These diametric results can be explained that lower proportion of AED use caused a masking effect on early defibrillation. Few AED cases were not sufficient to verify its efficacy, contributing to a selection bias. In the US nationwide data, approximately 23% of EMS-treated OHCAs have initial shockable rhythms or shockable by AED; 31% receive bystander CPR (4). In Korean EMS-based studies, however, Na et al. reported that the proportion of pre-hospital AED use was 4.3% of adult EMS-assessed OHCA in 2008-2010 (22). In addition, Shin et al. (23) reported that 2.8% of resuscitation-attempted OHCA received pre-hospital defibrillation by EMS in 2007. Compared to these data, we similarly reported that a total of 3.0% resuscitation-attempted OHCAs were treated with AED by emergency medical technicians.

In cases with an initial/final shockable rhythm in the pre-hospital or ED setting, the overall survival outcomes showed a significant amelioration. Furthermore, upon multivariate analysis, only the initial rhythm that needed defibrillation improved survival rate. Currently, the management of converted and initial shockable rhythms does not differ. On the basis of these results, in case of later ventricular defibrillation converted at the emergency center, correction and reconsideration of the treatment strategy regarding the early application of defibrillation are deemed necessary. Mader et al. (24) also showed that the survival rate for patients with converted shockable OHCAs was significantly lower than that for earlier shockable victims. They suggested that later and initial converted shockable rhythms are different entities and that alternatives to the existing resuscitation strategy adapted to the converted shockable patients should be investigated.

Through multivariate analysis, we identified factors improving the survival rate not only in the pre-hospital setting, but also in the in-hospital setting, and thereby established an early mediation strategy. At the in-hospital stage, there was a significant possibility of survival in patients treated with advanced emergency drugs, therapeutic hypothermia, or active cardiac care such as percutaneous coronary intervention, bypass surgery, or extracorporeal membrane oxygenation (18, 25, 26). The odds of the factors indicate that the influence was greater than pre-hospital factors, that is, the application of active ED-based advanced resuscitation greatly contributed to the improvement in patient survival. However, during the present study period, the rate of improvement of survival in the patients treated with therapeutic hypothermia and percutaneous coronary intervention was only 4.8%, and the proportion of patients hospitalized alive who had a rhythm requiring defibrillation was only 8.6%. The reason for these low rates is because this was before implementation of the resuscitation guidelines in 2010. Moreover, in the cases in which the outcomes of therapeutic hypothermia were expected to be desirable, there was selection bias from actively applying the treatment option. Thus, randomly controlled research studies are necessary in the future. In addition, all the time variables were significant with univariate analysis but were not significant with multivariate analysis. Accordingly, a subgroup analysis or other approaches will be necessary in the future.

This study has several limitations. First, although this study was based on data collection through universal web-based protocols, there could be errors as the data collection was conducted at 29 hospitals. To address this, we conducted error feedbacks every 3 months and a 2-yr-long data confirmation procedure after the first survey project. Second, because we defined sudden CA as OHCA occurring within 24 hr after symptom onset, patients transferred from other facilities after resuscitation and those with CA that occurred more than 24 hr after symptom onset were excluded. At the time of this study, data concerning the actual number of cases of SCD in Korea were not available; therefore, we were unable to establish the standardized death rate. Third, considering the characteristics of the hospitals that participated in this multi-institutional research, the participating emergency centers were categorized as higher than level II and thus could not reveal the characteristics of the entire CA patient population in EDs in Korea; thus, the incidence of CA and survival outcomes might have been overestimated. Finally, because indexes that can be applied in EDs were used, various factors and underlying diseases potentially influencing the treatment approach or physiological mechanism were not considered. Thus, along with large-scale multi-institutional studies, in-depth researches that consider all factors should be conducted in the future.

In conclusion, NEDIS-based prospective multi-center research in Korea indicates that 1 of every 400 patients who visited the ED (0.25%) experienced sudden CA and the proportion of the patients discharged alive was 9.6%. Age, witnessed onset of CA, onset of CA in a public place, a rhythm requiring defibrillation in the pre-hospital stage, and use of advanced cardiac care were identified as factors influencing improvement in the survival rate; thus, we found that active advanced multidisciplinary resuscitation efforts influenced improvement in the survival rate. Unlike previous research studies, however, resuscitation by witnesses did not influence the survival rate in Korea. This indicates that the quality of the resuscitation effort, not the attempt itself, may play a significant role.

DISCLOSURE

The authors have no conflict of interest to declare.

AUTHOR'S CONTRIBUTION

Conception and coordination of the study: MJ Lee. Design of the study and ethical issues: HJ Yang, HD Yoon, H Kim, TH Rho, MJ Lee. Acquisition of data: JS Cho, GW Kim. Data review: HJ Yang, MJ Lee. Statistical analysis: JS Cho, MJ Lee. Manuscript preparation: TH Rho, HJ Yang, JS Cho, HD Yoon, MJ Lee. Manuscript approval: all authors.

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