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Clinical paper

The effect of dispatcher-assisted cardiopulmonary resuscitation on early defibrillation and return of spontaneous circulation with survival

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Abstract

Background: Dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) programs are implemented to augment bystander CPR and improve outcomes of patients with out-of-hospital cardiac arrest (OHCA). To understand the pathway of how DA-CPR improves outcomes of OHCA, we aimed to evaluate the effect of DA-CPR on defibrillation and return of spontaneous circulation (ROSC) with survival to hospital discharge within 90 min.

Methods: We conducted a population-based observational study of all adults with OHCA with presumed cardiac aetiology treated by emergency medical services (EMS) between 2013 and 2016, using a national OHCA registry. We excluded cases without a witness, those that occurred in hospital, were witnessed by an EMS provider, or defibrillated by a layperson. The exposure was bystander CPR status: no bystander CPR (No BCPR), bystander CPR without dispatcher assistance (NDA-BCPR), and bystander CPR with dispatcher assistance (DA-BCPR). The observation time was set to a maximum of 90 min for survival analysis. The primary outcome was ROSC within 90 min leading to being discharged alive (ROSC with survival). The secondary outcomes were ROSC within 90 min leading to being discharged with cerebral performance category I or II (ROSC with good CPC) and first defibrillation within 90 min (defibrillation). Multivariable Cox proportional hazards analysis was performed to calculate adjusted hazard ratios (AHRs), according to bystander CPR status adjusted for potential confounders.

Results: Of 25,450 eligible OHCAs, NDA-BCPR was provided for 3193 cases (12.5%) and DA-BCPR was provided for 12,154 cases (47.8%). ROSC with survival was observed in 13.2% of cases with NDA-BCPR and 12.0% with DA-BCPR. Compared with No BCPR, both type of bystander CPR were associated with 44% and 55% increases in ROSC with survival to discharge (AHR, 95% confidence interval (CI): 1.44, 1.27–1.63 for NDA-BCPR and 1.55, 1.41–1.69 for DA-BCPR). DA-BCPR was also associated with defibrillation compared with No-BCPR, accounting for ROSC as a competing risk (AHR 1.16, 95% CI 1.12–1.21).

Conclusions: Compared with no bystander CPR provided, both bystander CPR with or without dispatcher assistance were associated with defibrillation and ROSC leading to survival to discharge in patients with witnessed OHCA.

Keywords: Dispatcher, Defibrillation, Cardiac arrest, Bystander cardiopulmonary resuscitation

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https://doi.org/10.1016/j.resuscitation.2019.01.004

Received 10 September 2018; Received in revised form 20 November 2018; Accepted 3 January 2019

Available online xxx

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health burden in developed countries.[1] As the aging population increases, cardiac arrests are expected to increase. However, the survival rate of patients with OHCA remains low.[1,2] Bystander cardiopulmonary resuscitation (CPR) is a key factor in the survival of patients with cardiac arrest, so dispatcher-assisted cardiopulmonary resuscitation (DA-CPR) programs have been implemented.[3–5] Because a DA-CPR program enables people who are not trained to perform CPR, many countries where DA-CPR programs have been implemented report that these programs have increased the bystander CPR rate in their communities.[6,7] Several observational studies have also reported that DA-CPR is also associated with favourable neurological outcome of patients with OHCA.[8–10] An overall increase in the bystander CPR rate may induce improved neurological outcome; however, it is unclear how bystander CPR with dispatcher assistance (DA-BCPR) improves favourable neurological outcome, as does bystander CPR without dispatcher assistance (NDA-BCPR).

According to studies on the factors related to prognosis of patients with cardiac arrest, the initial shockable rhythm is an important prognostic factor of successful resuscitation.[11–13] If patients with cardiac arrest do not receive bystander CPR, the shockable rhythm decreases over time and the survival rate decreases rapidly.[14] If bystander CPR is provided, however, the minimum necessary circulation is maintained and the duration of the shockable rhythm is longer.[14,15] Despite much research on the effect of NDA-BCPR on shockable rhythm in patients with OHCA, no definite conclusion has been reached regarding whether DA-BCPR has the similar effect as NDA-BCPR.[14,16,17]

As resuscitation technology has advanced, the importance of early return of spontaneous circulation (ROSC) has been emphasized.[18,19] According to a study on the predictors of good neurological outcome in patients with ROSC, short time interval from receipt of the call to ROSC was the only independent factor for favourable neurological outcome in patients with postcardiac arrest syndrome.[20] Duration of CPR is also important in deciding to apply advanced resuscitation technology, such as targeted temperature management (TTM) or extracorporeal membrane oxygenation (ECMO). Despite the importance, few studies have been conducted on early ROSC.[11,19] Because of the difficulty of accurate time monitoring in a resuscitation situation, it is also unclear that whether bystander CPR with or without dispatcher assistance is associated with early ROSC, as well as ROSC itself.

In this study, we aimed to evaluate the effect of DA-CPR on faster defibrillation and ROSC leading to being discharged alive as well as to understand the pathway of how DA-CPR improves neurological outcomes of patients with OHCA. We hypothesize that both bystander CPR with or without dispatcher assistance leads to faster defibrillation and results in ROSC with improved survival in bystander-witnessed OHCA.

Methods

Study setting and data collection

This was a cross-sectional observational study using the nationwide OHCA registry database of Korea. In Korea, emergency medical technicians are intermediate level and the emergency medical services (EMS) system is fire-based. All ambulances are equipped with defibrillators to provide basic life support. Because only physicians can pronounce death, all EMS-assessed patients with OHCA are transferred to the nearest hospital and provided with CPR in the ambulance, according to the 2015 American Heart Association (AHA) guideline. In Korea, a dispatcher-assisted CPR program was initiated in 2011 and implemented nationwide in 2013.[4,21] In accordance to the 2010 AHA guidelines, the dispatcher asks two key questions to detect OHCA (altered mental status and abnormal breathing); if answers to both questions are yes, the dispatcher provides standard instruction in high-quality bystander CPR.[9,22]

The nationwide OHCA registry was constructed in 2006 and includes all EMS-assessed OHCAs. The registry includes the following four sources: an EMS run report with ambulance operation information, an EMS cardiac arrest registry with Utstein factors, a dispatcher registry, and a hospital medical record review of hospital care and outcomes. Korea Centers for Disease Control and Prevention (CDC) and quality management committees, consisting of emergency physicians and statistical experts, perform a quality control process every month. Detailed information of this registry has been reported previously.[23,24]

Study population

In this study, we included all EMS-treated adult patients (18 years or older) with OHCA of presumed cardiac aetiology between January 2013 and December 2016. We excluded patients who did not receive resuscitation attempts, those who were witnessed by EMS personnel, experienced an arrest at a primary care clinic or long-term care facility, and patients who received defibrillation performed by a layperson before EMS arrival. Layperson-unwitnessed cases and patients with missing information on time of ROSC and defibrillation were excluded so that we could calculate the exact duration of CPR.

Main outcomes

Considering that the 95th percentile of pre-hospital time was 52 min in our study population, and advanced cardiovascular life support time in the emergency room (ER) was usually 30 min in the absence of ROSC, the maximal observation time from the call received at dispatch was set to 90 min. ROSC and defibrillation after the maximum observation time were not included in the study outcome because they were unlikely to be an effect of DA-CPR.

The primary outcome was ROSC within 90 min leading to being discharged alive from the hospital (ROSC with survival). This was defined as cases where the patients achieve ROSC within 90 min from the call and finally survived to hospital discharge. The secondary outcome was ROSC within 90 min leading to being discharged with good neurological outcome (ROSC with good CPC) and first defibrillation within 90 min (defibrillation). Good neurological outcome was defined as cerebral performance category I or II. Defibrillation included both during transport and done in the ER.

Variables and measurements

The main exposure of interest was bystander CPR status categorized into three groups: no bystander CPR (No BCPR), bystander CPR without dispatcher assistance (NDA-BCPR), and bystander CPR with dispatcher assistance (DA-BCPR). We collected patient demographic factors including age, sex, comorbidity (diabetes mellitus, hypertension, heart disease, and stroke), and community-EMS factors including urbanization level (metropolitan area or not), location of arrest (public or private),

primary recorded cardiac rhythm at the scene (ventricular fibrillation/pulseless ventricular tachycardia, pulseless electrical activity, and asystole), and prehospital defibrillation by an EMS provider. We also collected information on defibrillation in the ER, independent of defibrillation by an EMS provider. We collected time variables including date and time of emergency call, EMS response time interval (time interval from call received at dispatch to EMS arrival at the scene), EMS scene time interval (time interval from EMS arrival at the scene to departure from the scene), and EMS transport time interval (time interval between departure from the scene and arrival in the ER). We also collected ROSC at arrival in the ER (prehospital ROSC), survival to discharge, and good neurological outcome at discharge, for patient outcomes.

Statistical analysis

Descriptive analysis was conducted to examine the distribution of categorical variables (count and proportion) and continuous variables (median and interquartile range). Exposure groups were compared and tested using the chi-square test for categorical variables and Kruskal–Wallis test for continuous variables. *p* values were based on a two-sided significance level of 0.05.

Before the main analysis, multivariable logistic regression analysis was conducted to calculate the adjusted odds ratios (AORs) and 95% confidence intervals (CIs) for the study outcomes, with adjustment for potential confounders: age, sex, metropolitan area, location of arrest, comorbidity (diabetes mellitus, hypertension, heart disease, stroke), and response time interval.

As a main analysis, multivariable Cox proportional hazard regression analysis was performed to assess time-to-event data with censored observation. The Kaplan–Meier method was used to compare the time-to-event distribution as a cumulative incidence curve. Adjusted hazard ratios (AHRs) were calculated according to bystander CPR status, adjusting for potential confounders (same with logistic regression). To conduct a survival analysis, the maximum observation time was set to 90 min from the emergency call. Study outcome was defined as ROSC with survival, ROSC with good CPC, and defibrillation, which are all occurred within 90 min of resuscitation. If ROSC or defibrillation were not achieved within 90 min, the case was considered censored. Censoring could occur for death or a prolonged resuscitation attempt without ROSC or defibrillation. Proportional hazards assumptions of the models were verified using a graphical method. Because patients with ROSC cannot be defibrillated, the cause-specific hazard ratio (HR) was calculated by accounting for the competing risk of ROSC when analyzing defibrillation as a secondary outcome.[25,26]

For the sensitivity analysis, Cox regression analyses were conducted for different maximum observation times. The maximum observation times were changed to 30, 60, and 120 min. The primary outcome was changed to ROSC with survival within 30, 60, and 120 min. The secondary outcome was also changed to ROSC with good CPC within 30, 60, and 120 min and first defibrillation within 30, 60, and 120 min.

All statistical analyses were conducted using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA) and graphs were drawn with R version 3.4.1 (https://www.r-project.org. accessed on Feb. 25, 2018).

Ethics statements

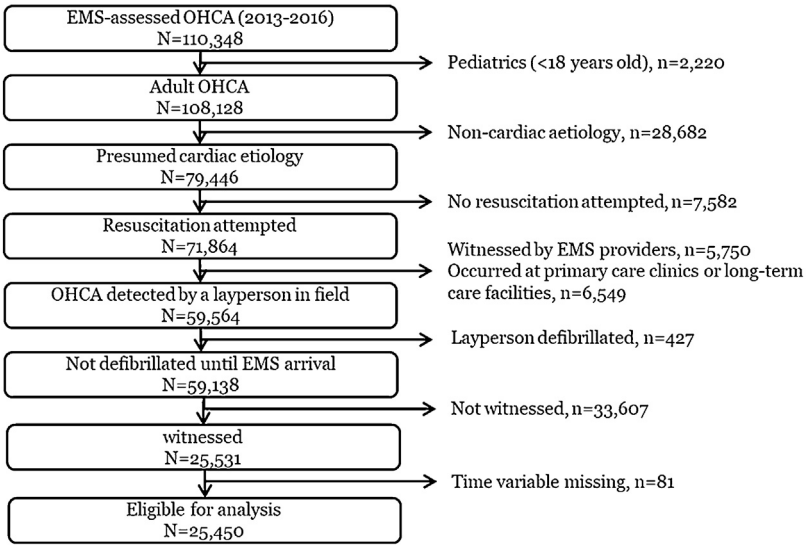
The study was approved by the Institutional Review Boards of Seoul National University Hospital (IRB No. 1401-090-550) and the Korea Centers for Disease Control and Prevention (IRB No. 2012-07CON-01-2C).

Results

Demographic findings

Among 110,348 EMS-assessed OHCAs during the study period, 25,450 patients were included in the analysis after excluding pediatric cases (n = 2220), noncardiac aetiology (n = 28,682), as well as cases that did not receive resuscitative attempts (n = 7582), were witnessed by EMS personnel (n = 5750), occurred at primary care clinics or long-term care facilities (n = 6549), were defibrillated by a layperson (n = 427), were not witnessed by a layperson (n = 33,607), and cases with missing time variables (n = 81) (Fig. 1).

Of the 25,450 eligible patients, bystander CPR without dispatcher assistance (NDA-BCPR) was provided to 3193 (12.5%) patients, and



EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest.

Fig. 1 – Patient flow.

bystander CPR with dispatcher assistance (DA-BCPR) was provided to 12,154 patients (47.8%). ROSC within 90 min with survival to hospital discharge was observed more frequently in the both type of bystander CPR groups than in the no bystander CPR (No BCPR) group (No BCPR 7.2%, NDA-BCPR 13.2%, and DA-BCPR 12.0%) ($p < 0.01$). ROSC with good CPC and first defibrillation within 90 min were also observed more frequently in the both type of bystander CPR groups (No BCPR 4.1%, NDA-BCPR 9.6% and DA-BCPR 8.5% for ROSC with good CPC and No BCPR 37.6%, NDA-BCPR 47.2%, and DA-BCPR 43.4% for defibrillation) (all $p < 0.01$) (Table 1).

Table 1 – Demographics of all out-of-hospital cardiac arrests, by bystander CPR status.

	Total		No BCPR		NDA-BCPR		DA-BCPR		*p value*
	N	%	N	%	N	%	N	%	
All	25,450	100.0	10,103	100.0	3193	100.0	12,154	100.0	
Female	16,966	66.7	6777	67.1	2240	70.2	7949	65.4	<0.01
Age group									<0.01
19–39	1155	4.5	362	3.6	174	5.4	619	5.1	
40–49	2218	8.7	770	7.6	343	10.7	1105	9.1	
50–59	4186	16.4	1457	14.4	644	20.2	2085	17.2	
60–69	4571	18.0	1774	17.6	602	18.9	2195	18.1	
70–79	7150	28.1	3072	30.4	850	26.6	3228	26.6	
80–	6170	24.2	2668	26.4	580	18.2	2922	24.0	
Age, Median (Q1–Q3)	71 (57-80)		73 (60-80)		67 (55-77)		70 (57-80)		<0.01
Characteristics									
Metropolis	11,580	45.5	4569	45.2	1040	32.6	5971	49.1	<0.01
Public place	5638	22.2	1875	18.6	1198	37.5	2565	21.1	<0.01
Comorbidity									
Diabetes	5221	20.5	2143	21.2	607	19.0	2471	20.3	0.02
Hypertension	8281	32.5	3302	32.7	1030	32.3	3949	32.5	0.89
Heart disease	4210	16.5	1683	16.7	537	16.8	1990	16.4	0.77
Stroke	2152	8.5	875	8.7	234	7.3	1043	8.6	0.05
ECG									<0.01
VF/pulseless VT	6261	24.6	1962	19.4	998	31.3	3301	27.2	
PEA	3842	15.1	1745	17.3	494	15.5	1603	13.2	
Asystole	15,347	60.3	6396	63.3	1701	53.3	7250	59.7	
Defibrillation									
EMS	8204	32.2	2756	27.3	1214	38.0	4234	34.8	<0.01
ER	5724	22.5	2298	22.7	815	25.5	2611	21.5	<0.01
Response time interval, min									<0.01
0–3	880	3.5	399	3.9	94	2.9	387	3.2	
4–7	7694	30.2	3141	31.1	848	26.6	3705	30.5	
7–11	3997	15.7	1631	16.1	592	18.5	1774	14.6	
12+	12,879	50.6	4932	48.8	1659	52.0	6288	51.7	
Median (Q1–Q3)	7 (5-10)		7 (5-9)		8 (6-11)		7 (5-9)		
Scene time interval, min									<0.01
0–3	837	3.3	430	4.3	133	4.2	274	2.3	
4–7	3530	13.9	1523	15.1	538	16.8	1469	12.1	
7–11	4500	17.7	1757	17.4	630	19.7	2113	17.4	
12+	16,583	65.2	6393	63.3	1892	59.3	8298	68.3	
Median (Q1–Q3)	10 (7-15)		10 (6-14)		9 (6-13)		11 (7-15)		
Transport time interval, min									<0.01
0–3	3700	14.5	1523	15.1	417	13.1	1760	14.5	
4–7	10,804	42.5	4345	43.0	1292	40.5	5167	42.5	
7–11	5413	21.3	2176	21.5	688	21.5	2549	21.0	
12+	5533	21.7	2059	20.4	796	24.9	2678	22.0	
Median (Q1–Q3)	7 (4-11)		7 (4-10)		7 (5-11)		7 (4-11)		
Final outcomes									
Prehospital ROSC	2938	11.5	735	7.3	491	15.4	1712	14.1	<0.01
Survival to discharge	2706	10.6	756	7.5	446	14.0	1504	12.4	<0.01
Good CPC	1815	7.1	424	4.2	324	10.1	1067	8.8	<0.01
Study outcomes (within 90 min)									
ROSC with survival	2601	10.2	726	7.2	422	13.2	1453	12.0	<0.01
ROSC with good CPC	1753	6.9	411	4.1	307	9.6	1035	8.5	<0.01
Defibrillation	10,587	41.6	3800	37.6	1508	47.2	5279	43.4	<0.01

CPR, cardiopulmonary resuscitation; No BCPR, No bystander CPR; NDA-BCPR, bystander CPR without dispatcher assistance; DA-BCPR, bystander CPR with dispatcher assistance; ECG, electrocardiogram; VF, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity; EMS, emergency medical service; ER, emergency room; ROSC, return of spontaneous circulation; Good CPC, cerebral performance scale 1 or 2.

Multivariable logistic regression analysis of outcomes and bystander CPR status

Compared with the No BCPR group, AORs (95% CIs) for ROSC with survival were 1.51 (1.32–1.74) in the NDA-BCPR group and 1.63 (1.47–1.80) in the DA-BCPR group. For ROSC with good CPC, AORs (95% CIs) were 1.87 (1.59–2.21) in the NDA-BCPR group and 2.03 (1.79–2.29) in the DA-BCPR group (Table 2). For faster defibrillation, AORs (95% CIs) were 1.17 (1.07–1.28) in the NDA-BCPR group and 1.21 (1.14–1.28) in the DA-BCPR group (Table 2).

Cox regression analysis of outcomes and bystander CPR status

Compared with the No BCPR group, both type of bystander CPR group were associated with 44% and 55% increases in ROSC with survival (AHRs, 95% CIs: 1.44, 1.27–1.63 for NDA-BCPR and 1.55, 1.41–1.69 for DA-BCPR). The cumulative incidence of ROSC with survival according to bystander CPR status is shown in Fig. 2. Both type of bystander CPR group were also associated with increases in ROSC with good CPC (AHRs, 95% CIs: 1.75, 1.51–2.04 for NDA-BCPR and 1.90, 1.69–2.13 for DA-BCPR). DA-BCPR was also associated with faster defibrillation compared with No BCPR, after accounting for ROSC as a competing risk (AHR 1.16, 95% CI 1.12–1.21) (Table 3).

Sensitivity analysis

When we performed sensitivity analysis for different maximum observation times, the three different sensitivity analyses showed that the both type of bystander CPR groups were associated with increases in ROSC with survival, ROSC with good CPC and defibrillation, compared with the No BCPR group (Table 4).

Discussion

In this study, we investigated the effect of dispatcher-assisted bystander CPR on ROSC with survival, ROSC with good CPC, and defibrillation in patients with bystander-witnessed OHCA using a survival analysis method. Both bystander CPR with and without dispatcher assistance were associated with increases in faster ROSC with survival compared with no bystander CPR. Accounting for the competing risk of ROSC, bystander CPR with dispatcher assistance was associated with increases in faster defibrillation, as was bystander CPR without dispatcher assistance. These results were maintained in the sensitivity analysis performed by changing the maximum observation time to 30, 60, and 120 min.

Several observational studies have reported that DA-CPR is associated with favourable neurological outcome of patients with OHCA.[4,22] Before DA-CPR programs were popularized, bystander CPR without dispatcher assistance was known to improve neurologic outcome by shortening the no-flow time from collapse to resuscitation initiation.[15,22] After implementation of a DA-CPR program, the bystander CPR rate nearly doubles.[4,27] However, it has been unclear whether bystander CPR performed with dispatcher assistance would have the same effect as bystander CPR without dispatcher assistance.[17] The result of this study showed that DA-BCPR significantly increased defibrillation compared with No BCPR, as did NDA-BCPR. Defibrillation is a surrogate index of shockable rhythm in this study. The initial shockable rhythm changes to non-shockable rhythm over times without bystander effort. If bystander CPR is appropriately provided, the shockable rhythm is lasting longer or initial non-shockable rhythm can be converted to shockable rhythm.[11,14,15] We chose the defibrillation as the study outcome to include all these effects of bystander CPR. Our study demonstrated that DA-BCPR associated with more defibrillation, as did NDA-BCPR. Because early defibrillation is a reliable predictor of survival in patients with cardiac

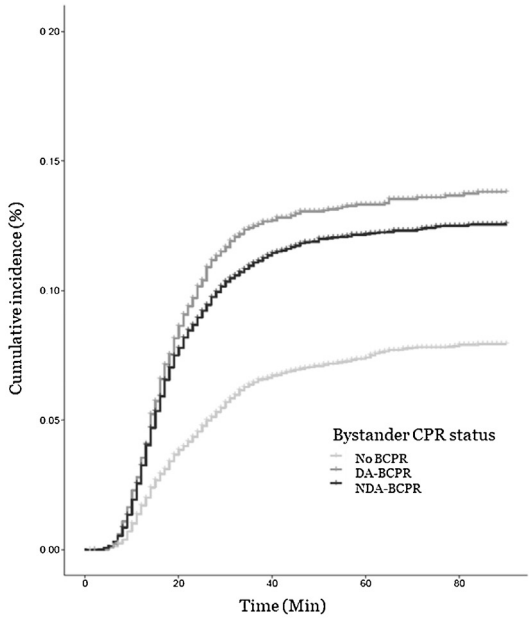
Table 2 – Multivariable logistic regression analysis on outcomes, by bystander CPR status.

		Total	Outcome		Unadjusted			Adjusted[a]		
			N	%	OR	95% CI		AOR	95% CI	
ROSC with survival										
Total		25,450	2601	10.2						
bystander CPR	No	10,103	726	7.2	1.00			1.00		
	without DA	3193	422	13.2	1.97	1.73	2.23	1.51	1.32	1.74
	with DA	12,154	1453	12.0	1.75	1.60	1.93	1.63	1.47	1.80
ROSC with good CPC										
Total		25,450	1753	6.9						
bystander CPR	No	10,103	411	4.1	1.00			1.00		
	without DA	3193	307	9.6	2.51	2.15	2.93	1.87	1.59	2.21
	with DA	12,154	1035	8.5	2.20	1.95	2.47	2.03	1.79	2.29
Defibrillation										
Total		25,450	10,587	41.6						
bystander CPR	No	10,103	3800	37.6	1.00			1.00		
	without DA	3193	1508	47.2	1.48	1.37	1.61	1.17	1.07	1.28
	with DA	12,154	5279	43.4	1.27	1.21	1.34	1.21	1.14	1.28

CPR, cardiopulmonary resuscitation; OR, odds ratio; AOR, adjusted odds ratio; ROSC, return of spontaneous circulation; DA, dispatcher assistance; Good CPC, cerebral performance scale 1 or 2.

Note: All study outcomes are measured within 90 min of call received at dispatch.

[a] Adjusted for age, sex, metropolitan area, location of arrest, comorbidity (diabetes mellitus, hypertension, heart disease, and stroke), and response time interval.



ROSC, return of spontaneous circulation; CPR, cardiopulmonary resuscitation; No BCPR, no bystander CPR provided; DA-BCPR, bystander CPR with dispatcher assistance; NDA-BCPR, bystander CPR without dispatcher assistance.

Fig. 2 – Cumulative incidence of ROSC (within 90 min) with survival to hospital discharge, by bystander CPR status.

Table 3 – Cox regression analysis of study outcomes, by bystander CPR status.

		Total	Outcome		Unadjusted			Adjusted[a]		
			N	%	HR	95% CI		AHR	95% CI	
ROSC with survival										
Total		25,450	2601	10.2						
bystander CPR	No	10,103	726	7.2	1.00			1.00		
	without DA	3193	422	13.2	1.88	1.67	2.12	1.44	1.27	1.63
	with DA	12,154	1453	12.0	1.69	1.55	1.85	1.55	1.41	1.69
ROSC with good CPC										
Total		25,450	1753	6.9						
bystander CPR	No	10,103	411	4.1	1.00			1.00		
	without DA	3193	307	9.6	2.42	2.09	2.80	1.75	1.51	2.04
	with DA	12,154	1035	8.5	2.13	1.90	2.39	1.90	1.69	2.13
Defibrillation[b]										
Total		25,450	10,587	41.6						
bystander CPR	No	10,103	3800	37.6	1.00			1.00		
	without DA	3193	1508	47.2	1.35	1.27	1.43	1.14	1.07	1.21
	with DA	12,154	5279	43.4	1.21	1.16	1.27	1.16	1.12	1.21

CPR, cardiopulmonary resuscitation; HR, hazard ratio; AHR, adjusted hazard ratio; CI, confidence intervals; ROSC, return of spontaneous circulation; DA, dispatcher assistance; Good CPC, cerebral performance scale 1 or 2.

Note: All study outcomes are measured within 90 min of call received at dispatch.

[a] Adjusted for age, sex, metropolitan area, location of arrest, comorbidity (diabetes mellitus, hypertension, heart disease, and stroke), and response time interval.

[b] In analysis of defibrillation, the cause-specific hazard ratio was calculated by accounting for ROSC as a competing risk.

arrest, faster defibrillation is also likely to lead to faster ROSC.[28,29] As DA-CPR programs become more widespread, DA-BCPR may be performed more than NDA-BCPR in some regions.[10,21] In this study, DA-BCPR was performed about four times more than NDA-BCPR (NDA-BCPR 12.5% and DA-BCPR 47.8%). The fact that DA-BCPR could increase faster defibrillation and early ROSC, as did NDA-BCPR, is important evidence for the expansion of DA-CPR programs.

The strength of this study is that we measured not only the occurrence of outcomes but also the timing of outcomes using survival analysis. To date, the duration from call to ROSC, a proxy of duration of resuscitation, has been considered a predominant key element of the rule of resuscitation termination.[30] However, as resuscitation technology advances, the importance of early ROSC is emphasized, as well as ROSC itself.[11,31] "Downtime", or time from collapse to

Table 4 – Sensitivity analysis with Cox regression analysis of study outcomes, by bystander CPR status.

		Total	30 min					60 min					120 min				
			Outcome		Adjusted[a]			Outcome		Adjusted[a]			Outcome		Adjusted		
			N	%	AHR	95% CI		N	%	AHR	95% CI		N	%	AHR	95% CI	
ROSC with survival																	
Total		25,450	2175	8.5				2541	10.0				2601	10.2			
bystander CPR	No	10,103	564	5.6	1.00			700	6.9	1.00			728	7.2	1.00		
	without DA	3193	369	11.6	1.58	1.39	1.81	414	13.0	1.46	1.29	1.66	419	13.1	1.43	1.26	1.61
	with DA	12,154	1242	10.2	1.70	1.53	1.87	1427	11.7	1.58	1.44	1.73	1454	12.0	1.54	1.41	1.69
ROSC with good CPC																	
Total		25,450	1639	6.4				1737	6.8				1753	6.9			
bystander CPR	No	10,103	374	3.7	1.00			408	4.0	1.00			412	4.1	1.00		
	without DA	3193	288	9.0	1.80	1.54	2.10	304	9.5	1.75	1.50	2.03	305	9.6	1.74	1.49	2.02
	with DA	12,154	977	8.0	1.97	1.74	2.22	1025	8.4	1.89	1.69	2.12	1036	8.5	1.89	1.69	2.12
Defibrillation[b]																	
Total		25,450	8553	33.6				10379	40.8				10629	41.8			
bystander CPR	No	10,103	2963	29.3	1.00			3717	36.8	1.00			3817	37.8	1.00		
	without DA	3193	1240	38.8	1.16	1.08	1.24	1478	46.3	1.13	1.07	1.21	1511	47.3	1.13	1.07	1.20
	with DA	12,154	4350	35.8	1.23	1.17	1.29	5184	42.7	1.17	1.12	1.22	5301	43.6	1.16	1.12	1.21

CPR, cardiopulmonary resuscitation; AHR, adjusted hazards ratio; CI, confidence intervals; ROSC, return of spontaneous circulation; DA, dispatcher assistance; Good CPC, cerebral performance scale 1 or 2.

Note: All study outcomes are measured within 90 min of call received at dispatch.

[a] Adjusted for age, sex, metropolitan area, location of arrest, comorbidity (diabetes mellitus, hypertension, heart disease, and stroke), and response time interval.

[b] In analysis of defibrillation, the cause-specific hazard ratio was calculated by accounting for ROSC as a competing risk.

ROSC, is an important criteria to determine whether to apply advanced interventions such as TTM or maintain aggressive resuscitation.[18,32] Especially in the era of extracorporeal cardiopulmonary resuscitation (E-CPR), which can be considered an alternative to prolonged traditional CPR, early ROSC is of even greater importance.[19,33] However, because measurement of downtime is complex and sometimes inaccurate during resuscitation, few studies have been conducted concerning the time interval from call to ROSC.[19,20,33] The Korean nationwide OHCA registry used in this study was constructed in 2006 and since then, the Korea CDC and quality management committee have continued quality control efforts through monthly meetings and education programs for paramedics and medical record reviewers covering baseline data sources.[24,34] Thanks to these measures, not only logistic regression analysis but also survival analysis can be conducted, considering the timing of ROSC and timing of defibrillation based on reliable minute-level data. Time intervals from call to study outcomes were calculated using the following six time variables: emergency call time, defibrillation time by an EMS provider, ROSC time during transport, defibrillation time in the ER, ROSC time in the ER, and time of death. From this analysis, we can conclude that DA-BCPR is associated not only with increased ROSC but also faster ROSC.

Another noteworthy point of improvement suggested by our findings is regarding faster defibrillation. Early defibrillation is a reliable predictor of good neurological outcome.[13] This study showed that compared with the No BCPR group, both type of bystander CPR increased the probability of faster defibrillation, which can lead to early ROSC. To evaluate the effect of DA-CPR on faster defibrillation, we excluded cases with layperson defibrillation because the layperson defibrillation time was unknown in our database. Because it is the earliest defibrillation case, this would underestimate the effect of the DA-CPR on faster defibrillation and ROSC. Given this, the next challenge in resuscitation is to increase the use of public access defibrillators (PADs) by laypeople, to shorten the interval from collapse to first defibrillation. Although many countries have expanded their PAD programs to increase layperson defibrillation, many barriers remain to the use of PADs by laypeople and the rate of layperson defibrillation remains low.[35–37] In parallel with implementation of DA-CPR programs, expansion of PAD programs to enable early defibrillation by laypeople will be an important breakthrough to achieving better outcomes in patients with OHCA.

Limitations

This study has several limitations. First, we defined the secondary outcome as defibrillation rather than shockable rhythm itself. Shockable rhythm but no defibrillation provided was not checked as an outcome of this study. We assumed that it is less likely that defibrillation is not provided to patients with shockable rhythm during resuscitation. In addition, we did not distinguish whether defibrillation was performed with initial shockable rhythm or in cases where initial non-shockable rhythm converted to shockable rhythm; these two situations could result in different effects on the final neurologic outcome. Second, we adjusted possible confounders in logistic regression and the Cox regression model. However, there may be additional unidentified confounding factors. As a limitation of an observational study, this study showed an association of DA-CPR and early ROSC with survival, but we could not confirm causality.

Conclusions

Compared with no bystander CPR provided, both bystander CPR with or without dispatcher assistance were associated with ROSC with

survival to discharge in patients with bystander-witnessed OHCA. Bystander CPR with dispatcher assistance increased faster defibrillation in the same way as bystander CPR without dispatcher assistance.

Conflict of interest statement

This study had no conflict of interest. And this study was approved by the Korea Centers for Disease Control and Prevention (IRB No. 2012-07CON-01-2C).

REFERENCES

1. Berdowski J, Berg RA, Tijssen JG, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation 2010;81:1479–87.
2. Girotra S, van Diepen S, Nallamothu BK, et al. Regional variation in out-of-hospital cardiac arrest survival in the United States. Circulation 2016;133:2159–68.
3. Swor RA, Jackson RE, Walters BL, Rivera EJ, Chu KH. Impact of lay responder actions on out-of-hospital cardiac arrest outcome. Prehosp Emerg Care 2000;4:38–42.
4. Song KJ, Shin SD, Park CB, et al. Dispatcher-assisted bystander cardiopulmonary resuscitation in a metropolitan city: a before-after population-based study. Resuscitation 2014;85:34–41.
5. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. Jama 2013;310:1377–84.
6. Lee SY, Ro YS, Shin SD, et al. Interaction effects between highly-educated neighborhoods and dispatcher-provided instructions on provision of bystander cardiopulmonary resuscitation. Resuscitation 2016;99:84–91.
7. Beard M, Swain A, Dunning A, Baine J, Burrowes C. How effectively can young people perform dispatcher-instructed cardiopulmonary resuscitation without training? Resuscitation 2015;90:138–42.
8. Bobrow BJ, Spaite DW, Vadeboncoeur TF, et al. Implementation of a regional telephone cardiopulmonary resuscitation program and outcomes after out-of-hospital cardiac arrest. JAMA Cardiol 2016;1:294–302.
9. Ro YS, Shin SD, Lee YJ, et al. Effect of dispatcher-assisted cardiopulmonary resuscitation program and location of out-of-hospital cardiac arrest on survival and neurologic outcome. Ann Emerg Med 2017;69:52–61 e1.
10. Wu Z, Panczyk M, Spaite DW, et al. Telephone cardiopulmonary resuscitation is independently associated with improved survival and improved functional outcome after out-of-hospital cardiac arrest. Resuscitation 2018;122:135–40.
11. Hara M, Hayashi K, Kitamura T. Outcomes differ by first documented rhythm after witnessed out-of-hospital cardiac arrest in children: an observational study with prospective nationwide population-based cohort database in Japan. Eur Heart J Qual Care Clin Outcomes 2017;3:83–92.
12. Wibrandt I, Norsted K, Schmidt H, Schierbeck J. Predictors for outcome among cardiac arrest patients: the importance of initial cardiac arrest rhythm versus time to return of spontaneous circulation, a retrospective cohort study. BMC Emerg Med 2015;15:3.
13. Nagao K, Nonogi H, Yonemoto N, et al. Duration of prehospital resuscitation efforts after out-of-hospital cardiac arrest. Circulation 2016;133:1386–96.
14. Tanguay-Rioux X, Grunau B, Neumar R, Tallon J, Boone R, Christenson J. Is initial rhythm in OHCA a predictor of preceding no flow time? Implications for bystander response and ECPR candidacy evaluation. Resuscitation 2018;128:88–92.
15. Swor RA, Jackson RE, Cynar M, et al. Bystander CPR, ventricular fibrillation, and survival in witnessed, unmonitored out-of-hospital cardiac arrest. Ann Emerg Med 1995;25:780–4.
16. Vaillancourt C, Verma A, Trickett J, et al. Evaluating the effectiveness of dispatch-assisted cardiopulmonary resuscitation instructions. Acad Emerg Med 2007;14:877–83.
17. Takahashi H, Sagisaka R, Natsume Y, Tanaka S, Takyu H, Tanaka H. Does dispatcher-assisted CPR generate the same outcomes as spontaneously delivered bystander CPR in Japan? Am J Emerg Med 2018;36:384–91.
18. Camp-Rogers TR, Sawyer KN, McNicol DR, Kurz MC. An observational study of patient selection criteria for post-cardiac arrest therapeutic hypothermia. Resuscitation. 2013;84:1536–9.
19. Reynolds JC, Frisch A, Rittenberger JC, Callaway CW. Duration of resuscitation efforts and functional outcome after out-of-hospital cardiac arrest: when should we change to novel therapies? Circulation 2013;128:2488–94.
20. Komatsu T, Kinoshita K, Sakurai A, et al. Shorter time until return of spontaneous circulation is the only independent factor for a good neurological outcome in patients with postcardiac arrest syndrome. Emerg Med J 2014;31:549–55.
21. Lee SY, Ro YS, Shin SD, et al. Recognition of out-of-hospital cardiac arrest during emergency calls and public awareness of cardiopulmonary resuscitation in communities: a multilevel analysis. Resuscitation 2018;128:106–11.
22. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. Circulation 2001;104:2513–6.
23. Ahn KO, Do Shin S, Suh GJ, et al. Epidemiology and outcomes from non-traumatic out-of-hospital cardiac arrest in Korea: a nationwide observational study. Resuscitation 2010;81:974–81.
24. Lee SY, Lee SC, Shin SD, et al. Epidemiology and outcomes of anaphylaxis-associated out-of-hospital cardiac arrest. PLoS One 2018;13:e0194921.
25. Austin PC, Lee DS, Fine JP. Introduction to the analysis of survival data in the presence of competing risks. Circulation 2016;133:601–9.
26. Lau B, Cole SR, Gange SJ. Competing risk regression models for epidemiologic data. Am J Epidemiol 2009;170:244–56.
27. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation: time to identify cardiac arrest and deliver chest compression instructions. Circulation 2013;128:1522–30.
28. Blom MT, Beesems SG, Homma PC, et al. Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. Circulation 2014;130:1868–75.
29. Valenzuela TD, Roe DJ, Nichol G, Clark LL, Spaite DW, Hardman RG. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. N Engl J Med. 2000;343:1206–9.
30. Reynolds JC, Grunau BE, Rittenberger JC, Sawyer KN, Kurz MC, Callaway CW. Association between duration of resuscitation and favorable outcome after out-of-hospital cardiac arrest: implications for prolonging or terminating resuscitation. Circulation 2016;134:2084–94.
31. Goto Y, Maeda T, Nakatsu-Goto Y. Prognostic implications of conversion from nonshockable to shockable rhythms in out-of-hospital cardiac arrest. Crit Care 2014;18:528.
32. Sawyer KN, Kurz MC. Caution when defining prolonged downtime in out of hospital cardiac arrest as extracorporeal cardiopulmonary resuscitation becomes accessible and feasible. Resuscitation 2014;85:979–80.
33. Grunau B, Reynolds J, Scheuermeyer F, et al. Relationship between time-to-ROSC and survival in out-of-hospital cardiac arrest ECPR candidates: when is the best time to consider transport to hospital? Prehosp Emerg Care 2016;20:615–22.
34. Ro YS, Shin SD, Song KJ, et al. A trend in epidemiology and outcomes of out-of-hospital cardiac arrest by urbanization level: a nationwide observational study from 2006 to 2010 in South Korea. Resuscitation 2013;84:547–57.

35. Lee SY, Do YK, Shin SD, et al. Community socioeconomic status and public access defibrillators: a multilevel analysis. Resuscitation 2017;120:1–7.
36. Sidebottom DB, Potter R, Newitt LK, Hodgetts GA, Deakin CD. Saving lives with public access defibrillation: a deadly game of hide and seek. Resuscitation 2018;128:93–6.
37. Ringh M, Jonsson M, Nordberg P, et al. Survival after public access defibrillation in Stockholm, Sweden—a striking success. Resuscitation 2015;91:1–7.