Effect of transported hospital resources on neurologic outcome after out-of-hospital cardiac arrest

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ABSTRACT

Objective. Appropriate regional transport protocol for out-of-hospital cardiac arrest (OHCA) patients is important for achieving favorable outcomes in a certain community. This study aimed to investigate the effect of transported hospital resources on the neurologic outcome after OHCA.
Methods. We categorized cardiac receiving centers (CRC) in our community into two levels (primary [P-CRC] and definite CRC [D-CRC]) according to the hospital resources that were identified by the Hospital Assessment Survey in 2015. OHCA patients with presumed cardiac etiology resuscitated by emergency medical service providers between 2012 and 2014, were enrolled in the study. The main exposure was the level of CRC. The primary endpoint was discharge with good neurologic outcomes. We compared outcomes between CRCs after adjusting for potential confounders.
Results. Among the 9,912 patients, 5,876 were transported to P-CRC and 4,036 to D-CRC from 2012 to 2014. Patients admitted to D-CRC showed better neurologic outcome than those admitted to P-CRC (6.2% vs 1.5%, p<0.001). With regard to patients who survived to admission, the neurologic outcome of patients in D-CRC was better than those in P-CRC (11.3% vs 3.3%, p<0.001). In the multivariable logistic model, the adjusted odds ratio for all OHCA patients was 2.10 (95% confidence interval, 1.51–2.95).
Conclusion. Transportation of OHCA patients to the D-CRC resulted in significantly good neurologic outcome than those transported to P-CRC. Further research is needed to establish a regional OHCA transport protocol.

Key words: cardiac arrest, outcome, regionalization

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is the leading cause of morbidity and mortality. (1) Although much effort has been devoted, the outcome is still poor in Korea, with an 8.0% survival rate and only 5.8% with good neurologic outcomes. (2)
In 2006, integrated post-arrest care was added to the chain of survival, emphasizing the importance of comprehensive multidisciplinary post-arrest care. Currently, an increasing number of publications have reported on the beneficial effects of targeted temperature management and other forms of post-resuscitation care on neurologic outcomes. (3-5)
However, not all cardiac arrest receiving facilities have the capacity to provide comprehensive post-arrest care. To overcome this issue, the concept of 'cardiac resuscitation center' or 'regionalization strategy of OHCA care' has emerged. In 2010, the American Heart Association (AHA) proposed two levels of cardiac resuscitation centers and suggested the criteria for each level of CRC. (6) The main recommended strategy is to transfer patients with spontaneous circulation after OHCA to specialized CRCs for comprehensive care. (6) Locally, in Los Angeles, OHCA patients with initial shockable rhythm were sent to ST-elevation myocardial infarction (STEMI) receiving centers, which resulted in higher rates of neurologically intact survival. (7) In Arizona, the implementation of a statewide system of cardiac receiving centers resulted in the improvement of survival in patients with intact neurologic status. (8)
The appropriate transport strategy for cardiac arrest patients in a certain community could be designed and implemented after the assessment of hospital resources and performances. In this study, we aimed to categorize CRCs according to the hospital resources and identified outcome differences among facilities in our community.

MATERIALS AND METHODS

Study design and setting

This retrospective observational study was conducted using data from the Hospital Assessment Survey and national OHCA database. A survey on the availability of resources, number of personnel, and physical infrastructures of each emergency medical center in the Gyeonggi province was conducted in 2015 by the Gyeonggi Emergency Support Center. The Gyeonggi Emergency Support Center is a regional center under

the National Emergency Medical Center, which serves as the central emergency medical service (EMS) control tower. The survey was conducted primarily via the National Emergency Department Information System (NEDIS) and additively by email to all emergency departments (EDs) that provided care to at least one OHCA patient who was transported to the said unit between 2013 and 2014.

Gyeonggi province has an area of 10,175 km2, which is seventeen times larger than the Seoul Metropolitan Area and nine times larger than Hong Kong. It occupies 10.1% of the national territory and is the 5th largest province in Korea. The population in Gyeonggi almost reached a total of 12.5 million, which is almost a quarter of the total Korean population.

The Korean EMS system is managed by the fire department and provided by the government. It offers single-tiered basic-to-intermediate ambulance services. The ambulance crew can perform cardiopulmonary resuscitation (CPR) at the scene and during transport, with performances comparable to the intermediate emergency medical technician (EMT) level in the United States, including intravenous catheterization and advanced airway under direct medical oversight. Advanced circulatory life support, including administration of drugs such as epinephrine, is not legally authorized in the field in most areas, and EMTs cannot declare death or stop CPR without direct medical oversight. They call for medical directions if OHCA victims show definite signs of death such as decapitation, rigor mortis, decomposition, or dependent lividity and withdraw resuscitation. All OHCA patients with resuscitation attempts are transported to the nearest ED according to the EMS standard procedure protocol. There are 218 ambulances operating in Gyeonggi province, and usually, two or three EMTs ride in each ambulance.

Study population

EMS-treated OHCA patients with a presumed cardiac etiology transported by Gyeonggi EMS to hospitals located in Gyeonggi province were included in this study. Among them, OHCA patients, whose final outcomes are available on medical records during 2012–2014, were finally enrolled in the analysis. Patients with presumed cardiac etiology were defined if they had no definite evidence of non-cardiac causes. (9) EMS-treated OHCA patients were defined if they received at least one of the following resuscitation efforts: chest compression, rescue breathing, and defibrillation.

Main exposure and variables

The main exposure was the classification of CRCs, which was attained using the results of the Gyeonggi Hospital Assessment Survey. Facilities were classified as definite CRC (D-CRC) if they had a standardized resuscitation protocol in the ED, admitted OHCA patients who achieved return of spontaneous circulation (ROSC), had a standardized therapeutic temperature management (TTM) protocol, if they offered percutaneous coronary intervention (PCI) 24 hours a day and 7 days a week, if they had a cardiac arrest registry for quality assurance, could confirm brain death, had rehabilitation programs for OHCA survivors, and offered community-based resuscitation training programs. Other facilities were defined as primary CRC (P-CRC). Classification of CRC was based on the internationally accepted criteria (10,11) and consensus from expert meetings.

Data of potential confounders such as age; gender; pre-arrest medical conditions such as cardiac disease, hypertension and diabetes mellitus; initial ECG rhythm at scene; the presence of witnesses; provision of bystander CPR; EMS response interval; EMS scene resuscitation interval; patient transport interval; and pre-hospital ROSC were obtained from the national OHCA database.

Data setting

Pre-hospital and hospital data of OHCA patients transported to hospitals were collected using the national OHCA database in Korea. The national OHCA database captures all incident cases of OHCA in the country using the EMS run sheet for basic ambulance operation information and the national OHCA registry for hospital care and survival outcomes via hospital medical record review. The EMS run sheet and EMS cardiac arrest registry are abstracted from the EMS database of the National Emergency Management Agency (NEMA), and a subsequent medical record review is conducted by reviewing the medical records of each OHCA patient transferred to a hospital by trained medical record reviewers from the Korea Centers for Disease Control and Prevention (CDC). Monthly quality assurance meetings are held by the Korea CDC Data Quality Control team, which consists of emergency physicians, epidemiologists, statistical experts, representatives from NEMA, and medical record reviewers.

Outcome Measures

The primary outcome was good neurologic recovery classified according to cerebral performance category (CPC) and defined as favorable if the CPC was 1 or 2. The secondary outcome was survival to discharge. All outcome measures were based on a review of medical records.

Statistical Analysis

Descriptive statistics between CRCs for categorical variables are presented as frequency distributions and percentages. Continuous variables are reported as medians and interquartile ranges (IQRs). Univariate comparisons of the distributions of demographic and clinical factors were analyzed using the chi-square test for discrete variables and the Wilcoxon rank-sum test for continuous variables. We compared the outcomes between CRCs using crude and adjusted odds ratios (aORs) and 95% confidence intervals (CIs). Multivariable logistic regression was performed after adjusting for potential confounders including Utstein co-variables (age, sex, witness status, location of arrest [public vs private], bystander CPR, EMS response time, EMS transport time and pre-hospital electrocardiogram pattern [shockable vs non-shockable]), pre-existing comorbidities (hypertension, diabetes, and cardiac disease), and result of pre-hospital ROSC.

We also analyzed for collinearity and tested if variables had conditional index >30 and variance decomposition proportion >0.5. No multicollinearity was detected in our models and all terms were retained. All data were analyzed using SAS 9.4 (SAS Institute Inc., NC, USA).

The study protocol was approved by the Korea University Ansan Hospital Institutional Review Board to be conducted with a waiver of informed consent (IRB number: K2018-0500-001).

RESULTS

Among a total of 14,951 EMS-treated OHCA patients, 4,126 were definitely of non-cardiac etiology, 329 were transported to hospitals in other regions, and the final outcomes of 584 were unavailable. A total of 9,912 cases were enrolled in the study (Figure 1).

Of the 90 cardiac arrest receiving facilities, 77 facilities responded to the survey. All 13 (13.1%) facilities that did not respond to the survey were non-ED facilities. Of the 77 cardiac arrest receiving facilities, 50

facilities (64.9%) admitted post-ROSC (return of spontaneous circulation) patients and 22 facilities (28.6%) were available to provide therapeutic hypothermia. A total of 29 (37.7%) facilities offered 24/7 PCI, and 27 (35.1%) provided a quality management program on OHCA resuscitation and treatment. The facility was classified as D-CRC if they had a standard resuscitation protocol at the ED; had the device, manpower, and standard protocol for TTM; if PCI was available 24/7; if they had an OHCA registry system; if they could confirm brain death, had an available rehabilitation program for post-resuscitated patients, and provided community-based CPR programs (Table 1).

Among 9,912 OHCA, 4,036 patients (40.7%) were initially transported to D-CRC. The proportion of pre-existing comorbidities was higher among OHCA patients transported to D-CRC. OHCA patients transported to D-CRC showed better neurologic outcome (6.2% vs 1.5%, p<0.001) and better survival to discharge rate (11.3% vs 3.3%, p<0.001) than those transported P-CRC (Table 2).

Of the 1,681 patients who survived to admission, 1,025 (56.1%) were admitted to D-CRC. D-CRC provided higher proportions of post-resuscitation treatments, such as PCI (15.2% vs 7.5%, p<0.001), TTM (29.9% vs 7.6%, p<0.001), and extracorporeal membrane oxygenation (5.5% vs 1.4%, p<0.001) compared to P-CRC. Patients admitted to D-CRC showed better neurologic recovery (24.3% vs 13.1%, p<0.001) and survival to discharge (44.0% vs 29.7%, p<0.001) than those admitted to P-CRC (Table 3).

Table 1. Result of Hospital Assessment Survey and classification of CRCs by result

Hospital Assessment Survey		**n**	**%**
Questionnaire		77	100.0
1. Level of your emergency department at your medical facility?	Regional EMC	4	4.4
	Local EMC	26	26.3
	Local ED	33	33.4
	Non-ED facility	14	14.2
	NA	13	13.1
2. Does your medical facility usually admit or transfer post-ROSC patients?	Admit	50	64.9
	Transfer	27	35.1
3.Does your medical facility have a standard resuscitation protocol for OHCA at ED?	Yes	67	87.0
	No	10	13.0
4. Does your medical facility have a standard inter-hospital transfer protocol for post-ROSC patients?	Yes	48	62.3
	No	29	37.7
5. Does your medical facility have any device and manpower to provide therapeutic hypothermia to post-ROSC patients?	Yes	22	28.6
	No	55	71.4
6. Does your medical facility have a standard protocol for providing therapeutic hypothermia?	Yes	18	23.4
	No	59	76.6
7. Is PCI available 24/7 at your medical facility?	Yes	29	37.7
	No	48	62.3
8. Does your medical facility have a specialized registration system for OHCA resuscitation and treatment?	Yes	23	29.9
	No	54	70.1
9. Does your medical facility perform quality management of OHCA resuscitation and treatment?	Yes	27	35.1
	No	50	64.9
10. Does your medical facility have a standard termination of resuscitation rule (or protocol)?	Yes	36	46.8
	No	41	53.3
11. Is EEG available to post-resuscitation patients at your medical facility?	Yes	35	45.5
	No	42	54.6
12. Is confirmation of brain death possible at your medical facility?	Yes	32	41.6
	No	45	58.4
13. Is rehabilitation program available to post-resuscitation patients at your medical facility?	Yes	38	49.4
	No	39	50.7
14. Does your medical facility provide CPR education to the community?	Yes	54	70.1
	No	23	29.9
Cardiac Resuscitation Center Classification	Medical facilities	OHCA (2012–2014)	
Total number of hospitals that participated in the survey	77	9,912 (100%)	
D-CRC	15	4,036 (40.7%)	
P-CRC	62	5,876 (59.3%)	

CPR, cardiopulmonary resuscitation; CRC, cardiac resuscitation center; D-CRC, definite cardiac resuscitation center; ED, emergency department; EEG, electroencephalography; EMC, emergency medical center; NA, no answer; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; P-CRC, primary cardiac resuscitation center; ROSC, return of spontaneous circulation.

Table 2. Demographics and outcomes of all OHCA patients transported to CRCs

Risk factors	All OHCA		P-CRC		D-CRC		P*
	n	%	n	%	n	%	
All	9,912	100.0	5,876	100.0	4,036	100.0	
Male	6,286	63.4	3,654	62.2	2,632	65.2	0.002
Age							
Median (IQR)	71	55–80	72	57–81	68	54–79	<0.001
<15 years	179	1.8	62	1.1	117	2.9	<0.001
15–64 years	3,684	37.2	2,058	35.0	1,626	40.3	
Older than 65 years	6,049	61.0	3,756	63.9	2,293	56.8	
Pre-arrest comorbidities							
Cardiac disease	1,338	13.5	718	12.2	620	15.4	<0.001
Hypertension	3,250	32.8	1,759	29.9	1,491	36.9	<0.001
Diabetes mellitus	2,191	22.1	1,209	20.6	982	24.3	<0.001
Cardiac arrest location							<0.001
Public	1,579	15.9	875	14.9	704	17.4	
Private	1,644	16.6	1,064	18.1	580	14.4	
Unknown	6,689	67.5	3,937	67.0	2,752	68.2	
Witness	4,827	48.7	2,684	45.7	2,143	53.1	<0.001
Who witnessed or found							<0.001
EMT	1,139	11.5	598	10.2	541	13.4	
Layperson	6,764	68.2	3,977	67.7	2,787	69.1	
Unknown	2,009	20.3	1,301	22.1	708	17.5	
Bystander CPR	4,743	47.9	2,703	46.0	2,040	50.6	<0.001
Initial EMS ECG							<0.001
Shockable	1,321	13.3	639	10.9	682	16.9	
Non-shockable	8,222	83.0	5,019	85.4	3,203	79.4	
Unknown	369	3.7	218	3.7	151	3.7	
EMS response intv.							
Median (IQR)	8	6–10.5	8	6–11	7	6–10	<0.001
<4 minutes	426	4.3	241	4.1	185	4.6	<0.001
4–8 minutes	4,262	43.0	2,379	40.5	1,883	46.7	
Over 8 minutes	5,224	52.7	3,256	55.4	1,968	48.8	
Scene resuscitation intv.							
Median (IQR)	8	5–12	8	5–11	9	6–12	<0.001
<5 minutes	1,608	16.2	978	16.6	630	15.6	<0.001
5–15 minutes	6,973	70.4	4,209	71.6	2,764	68.5	
Over 15 minutes	1,331	13.4	689	11.7	642	15.9	
Patient transport intv.							
Median (IQR)	7	5–10	6	4–10	7	5–10	<0.001
<15 minutes	8,702	87.8	5,214	88.7	3,488	86.4	<0.001
15–30 minutes	1,047	10.6	617	10.5	430	10.7	
Over 30 minutes	163	1.6	45	0.8	118	2.9	
Pre-hospital ROSC	569	5.7	163	2.8	406	10.1	<0.001
Survival to admission	1,681	17.0	656	11.2	1,025	25.4	<0.001
Survival to discharge	651	6.6	196	3.3	455	11.3	<0.001
Good neurology	338	3.4	87	1.5	251	6.2	<0.001

CPR, cardiopulmonary resuscitation; CRC, cardiac resuscitation center; D-CRC, definite cardiac resuscitation center; ECG, electrocardiography; ED, emergency department; EEG, electroencephalography; EMC, emergency medical center; EMS, emergency medical service; EMT, emergency medical technician; IQR, interquartile range; NA, no answer; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; P-CRC, primary cardiac resuscitation center; ROSC, return of spontaneous circulation.
* P-values were calculated using the Wilcoxon-rank sum test and chi-square test, as appropriate.

Table 3. Demographics and outcomes of admitted OHCA patients transported to CRCs

Risk factors	All OHCA		P-CRC		D-CRC		P*
	n	%	n	%	n	%	
All	1,681	100.0	656	100.0	1,025	100.0	
Male	1,149	68.4	432	65.9	717	70.0	0.078
Age							
Median (IQR)	61	50–74	64	51–77	60	49–73	<0.001
<15 years	32	1.9	4	0.6	28	2.7	<0.001
15–64 years	905	53.8	327	49.9	578	56.4	
Older than 65 years	744	44.3	325	49.5	419	40.9	
Pre-arrest comorbidities							
Cardiac disease	302	18.0	107	16.3	195	19.0	0.157
Hypertension	672	40.0	247	37.7	425	41.5	0.119
Diabetes mellitus	443	26.4	182	27.7	261	25.5	0.301
Location of cardiac arrest							<0.001
Public	384	22.8	124	18.9	260	25.4	
Private	363	21.6	174	26.5	189	18.4	
Unknown	934	55.6	358	54.6	576	56.2	
Witness	1,134	67.5	432	65.9	702	68.5	0.127
Who witnessed or found							
EMT	347	20.6	137	20.9	210	20.5	0.069
Layperson	1,036	61.6	386	58.8	650	63.4	
Unknown	298	17.7	133	20.3	165	16.1	
Bystander CPR	937	55.7	358	54.6	579	56.5	0.665
Initial EMS ECG							0.014
Shockable	509	30.3	175	26.7	334	32.6	
Non-shockable	1,100	65.4	457	69.7	643	62.7	
Unknown	72	4.3	24	3.7	48	4.7	
EMS response intv.							0.991
Median (IQR)	7	5–9	7	5–9.5	7	5–9	0.546
<4 minutes	90	5.4	39	6.0	51	5.0	
4–8 minutes	850	50.6	323	49.2	527	51.4	
Over 8 minutes	741	44.1	294	44.8	447	43.6	
Patient transport intv.							<0.001
Median (IQR)	6	4–10	5	4–8	6	4–10	<0.001
<15 minutes	1,465	87.2	613	93.5	852	83.1	
15–30 minutes	145	8.6	40	6.1	105	10.2	
Over 30 minutes	71	4.2	3	0.5	68	6.6	
Post-resuscitation care							
PCI	205	12.2	49	7.5	156	15.2	<0.001
TTM	356	21.2	50	7.6	306	29.9	<0.001
ECMO	65	3.9	9	1.4	56	5.5	<0.001
Pre-hospital ROSC	453	27.0	114	17.4	339	33.1	<0.001
Survival to discharge	646	38.4	195	29.7	451	44.0	<0.001
Good neurology	335	19.9	86	13.1	249	24.3	<0.001

CPR, cardiopulmonary resuscitation; CRC, cardiac resuscitation center; D-CRC, definite cardiac resuscitation center; ECG, electrocardiography; ECMO, extracorporeal membrane oxygenation circulation, ED, emergency department; EEG, electroencephalography; EMC, emergency medical center; EMS, emergency medical service; EMT, emergency medical technician; IQR, interquartile range; NA, no answer; OHCA, out-of-hospital cardiac arrest; PCI, percutaneous coronary intervention; P-CRC, primary cardiac resuscitation center; ROSC, return of spontaneous; TTM, target temperature management.
*P-values were calculated using the Wilcoxon-rank sum test and chi-square test, as appropriate.

Table 4. Effect of CRC on the neurologic outcomes and survival to discharge

	Total n	Outcome n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
All OHCA		Good neurology outcome		
Total	9,912	338 (3.4%)		
P-CRC	5,876	87 (1.5%)	Reference	Reference
D-CRC	4,036	251(6.2%)	4.41 (3.45–5.65)	2.10 (1.51–2.92)
		Survival to discharge		
Total	9,912	651 (6.6%)		
P-CRC	5,876	196 (3.3%)	Reference	Reference
D-CRC	4,036	455 (11.3%)	3.68 (3.10–4.38)	2.41 (1.95–2.98)
Survival to admitted OHCA		Good neurology outcome		
Total	1,681	335 (19.9%)		
P-CRC	656	86 (13.1%)	Reference	Reference
D-CRC	1,025	249 (24.3%)	2.13 (1.63–2.78)	1.48 (1.02–2.14)
		Survival to discharge		
Total	1,681	646 (38.4%)		
P-CRC	656	195 (29.7%)	Reference	Reference
D-CRC	1,025	451 (44.0%)	1.86 (1.51–2.29)	1.57 (1.22–2.03)

CI, confidential interval; CRC, cardiac resuscitation center; D-CRC, definite cardiac resuscitation center, OHCA, out-of-hospital cardiac arrest; OR, odds ratio; P-CRC, primary cardiac resuscitation center.
a Adjusted for age, gender, medical conditions, initial ECG rhythm at scene, the presence of witness, provision of bystander CPR, EMS response interval, EMS scene resuscitation interval, patient transport interval, pre-hospital return of circulation

Among all OHCA patients, after adjusting for potential confounders, transportation to D-CRC was significantly associated with good neurologic recovery (aOR, 2.10; 95% CI, 1.51–2.93) and survival to discharge (aOR, 4.41; 95% CI, 3.45–5.65). For patients who survived to admission, D-CRC was significantly associated with better neurologic recovery than P-CRC (aOR, 1.48; 95% CI, 1.02–2.14) (Table 4).

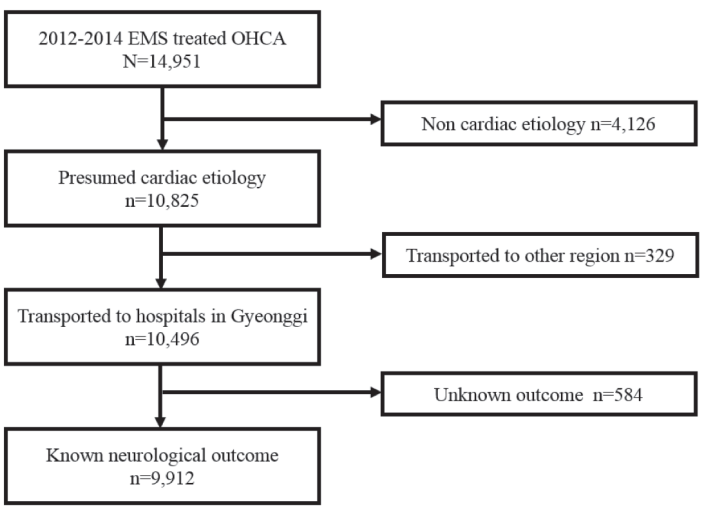

Figure 1. Flow chart of study population

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

DISCUSSION

This is the first regional attempt to categorize cardiac arrest receiving hospitals based on their practices and resources and compare the outcomes between the two levels of cardiac arrest receiving hospitals. This population-based study demonstrated that OHCA patients transported to D-CRC had better neurologic outcome than those transported to P-CRC (Table 2). Patients who survived and were admitted to D-CRC showed better neurologic outcome than those admitted to P-CRC (Table 3). This result supports the hypothesis that comprehensive post-resuscitation care applied to successfully resuscitated patients results in a better neurologic outcome. Our result coincided with those of recent studies, which suggested that transferring OHCA patients to specialized cardiac arrest centers resulted in good neurologic recovery. (8,10,12) From this study, we were able to assess the distribution of hospital resources and OHCA results based on the distribution of our community. This result will be helpful in establishing the transport protocol of EMS and inter-hospital transfer strategy after OHCA.

The result of this study suggests that it is desirable for the prognosis of OHCA patients to be transported to D-CRC. However, in a large district like Gyeonggi province, direct transfer of OHCA patients to D-CRC may result in long-distance transportation with resuscitation performed at the back of the moving ambulance. Many studies have demonstrated that the quality of CPR is suboptimal during ambulance transportation. Korean EMTs are legally restricted from performing advanced skills such as endotracheal intubation or intravenous drug infusion. The ambulance crew is composed of not more than three members. Therefore, to overcome

these legal and resource barriers, instead of transporting OHCA patients to D-CRC regardless of transport interval, it is important to provide high-quality resuscitation at P-CRC and transfer patients safely to D-CRC as soon as they achieve ROSC. The American Heart Association proposed 2 levels of CRCs and provided the criteria for each center. Arizona established a statewide network of hospitals classified by the government as 'cardiac receiving centers' or 'cardiac referral centers'. (8,10) Although the criteria should be re-evaluated periodically, the basic concept of a regional system of care is focused on providing specialized post-resuscitation care in selected hospitals and transferring post-ROSC patients to these hospitals as appropriate. (6)

A safe inter-hospital transfer protocol between P-CRC and D-CRC is also essential to the regionalization of OHCA care. A previous study reported that therapeutic hypothermia had a less beneficial effect on the neurologic recovery of patients who arrived via inter-hospital transfer than those who were directly transported to the hospital. (13) Other literature reported that good neurologic recovery was less frequently observed among patients who experienced any events during the transfer. (14) To date, a successful inter-hospital transfer protocol for post-resuscitation care has been integrated into an existing regional system of care for STEMI. (15) No study was able to define the role of secondary transfer to a regional center after initial care at primary care hospitals. Nevertheless, inter-hospital transfer is an inevitable procedure in operating a regionalization strategy especially with the EMS system at an intermediate level. Considering that this is the first study that attempts to suggest a regionalization model in Korea, developing a safe inter-hospital transfer protocol based on the current resources would be necessary.

Lastly, optimization of a regionalization strategy in communities must be implemented. The interval between EMS arrival on the scene and transport to a D-CRC is unduly long in rural and suburban areas of the Gyeonggi province. Although observational studies suggested that the duration of transport to the hospital was not associated with patient outcomes, this negative association was only observed among OHCA patients successfully resuscitated on-scene. (16,17) To date, no study has been able to provide a safe transport interval for OHCA patients who failed to achieve ROSC in the field. A priori categorization, verification, and designation of CRCs based on their actual practice performances should be done within the community. High-quality resuscitation at P-CRCs followed by a safe transfer to D-CRCs to provide multidisciplinary post-resuscitation care would enhance the survival of OHCA patients.

LIMITATIONS

This study had several limitations. First, all patients with unknown final outcome were excluded from the study. Second, the year of survey (2015) and OHCA occurrence (2012–2014) differed. However, the list of facilities for the survey was selected if they received an OHCA patient during 2013–2014; thus, it would not have affected the result. Third, post-resuscitation care, such as PCI timing or TTM protocol, was not standardized among the CRCs. Although patient care policy may differ between CRCs, this would increase the generalizability of our study findings. Fourth, similar to other observational studies, the unmeasured bias would have influenced the study. Lastly, the result of this study can only be implemented in an EMS system where field termination of OHCA is legally not allowed.

CONCLUSION

Through this study, we were able to categorize CRCs according to hospital resources in our region. After adjusting for potential confounders, D-CRC was independently associated with better neurologic outcome compared to P-CRC. This finding highlights an important opportunity to implement the regionalization strategy for OHCA in Gyeonggi province.

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