Prehospital advanced cardiac life support with a smartphone-based direct medical oversight in a metropolitan city: a before–after population-based study

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This study aimed to determine whether advanced life support (ALS) under emergency physician's direct medical oversight through video call on smartphones was associated with improved out-of-hospital cardiac arrest (OHCA) outcomes on "Smart Advanced Life Support (SALS)" pilot project. This study was conducted with a "before–after" controlled trial. We divided the OHCA patients in a metropolitan city with a population of 1.5 million into two periods. The 'Before' phase was performed the basic life support (BLS group) in 2014, and the 'after' phase was performed the ALS using video calls on smartphones (SALS group) in 2015. The primary and secondary outcomes were survival to discharge and a good neurological outcome, respectively. We conducted propensity score matching to equalize potential prognostic factors in both groups. 235 OHCA patients were enrolled in the BLS group, 198 patients in the SALS group. The outcomes were better in the SALS group than in the BLS group for survival to discharge and good neurological outcome, respectively. The adjusted ORs of SALS group compared to those BLS group 1.33 (95% CI 1.00–1.77) for survival to discharge and 1.73 (95% CI 1.19–2.53) for good neurologic outcome. An emergency medical system intervention using the SALS protocol was associated with a significant increase in prehospital ROSC and an improved survival and neurologic outcome after OHCA.

Keywords: Out-of-hospital cardiac arrest; Smartphone; Advanced cardiac life support; Emergency medical system

INTRODUCTION

In 2014, there were about 30,000 cases of out-of-hospital cardiac arrest (OHCA) in Republic of Korea, and 56.7 cases per 100,000 people. This is an increase of more than 10% compared to 50.5 per 100,000 people in 2006, and is increasing every year. However, despite the efforts of many

medical policy officers, paramedics, and doctors, the survival outcomes after cardiac arrest remained at 4.8% in both 2013 and 2014, which is relatively poor compared to other countries [1–4]. Among them, it is seen that the faster the return of spontaneous circulation (ROSC) is the higher the chances of good neurological outcome and for this, it was considered to be more advantageous to make a pre-hospital

ROSC. But given the procedure in Korea for OHCA, only basic life support (BLS) is given at the site within 5 minutes and then transported to the hospital so it is difficult to expect circulation recovery before arriving at a hospital.

A number of the study support that prehospital advanced life support (ALS) was not effective for out-of-hospital cardiac arrest (OHCA) patients [5–9]. The experience of the paramedics exposed to OHCA patients affects the treatment of cardiac arrest, but the actual exposure of the paramedics is rare and declining. Prehospital emergency medical direction (EMS) – physician presence was associated with improved survival outcomes of the patient, but the characteristics of the EMS operating in each country are different, and there are places where the operation is not possible in reality [10–12].

However, recently developed video communication technologies have created opportunities to make various attempts in the medical field. A “Smart Advanced Life Support” (SALS) pilot project was introduced to some areas on a trial basis; where in the event of a cardiac arrest, the nearest two units of emergency medical services (EMS) are dispatched, and through the visual directions of an emergency physician, the paramedics will use the manual defibrillator, administer drugs, and perform advanced life support.

The objective of this study was to determine whether SALS under physician’s direct medical oversight through video call on smartphones was associated with improved OHCA outcomes in a metropolitan city.

MATERIALS AND METHODS

Design

This study was conducted with a “before–after” controlled trial. We divided the OHCA patients in the study area into two periods: before and after. The ‘before’ phase performed the same BLS for 12 months (January 2014 to December 2014), and the ‘after’ phase performed the video medical guidance for a total of 12 months (January 2015 to December 2015).

In both periods, the EMT filled out the patient’s ambulance run sheet after dispatched to the cardiac arrest scene, Ambulance run sheets are electronically stored in each provincial EMS headquarters, managed by the National Fire Agency (NFA). In after phase, the EMT additionally filled out

the ‘SALS chart’, directing physicians made the ‘Oversight physician report’. Trained reviewers visited the hospital where the patient was transferred, reviewed medical record to complete the outcomes according to the Utstein style [13]. These data are electronically stored in national emergency medical center (NEMC). Finally, the NEMC secured the sheet with the cooperation of the NFA and constructed the SALS database. Physicians responsible for database quality control in this study performed a structured, explicit data review. This study was practically impossible to obtain the informed consent of the subjects, so a written consent was waived. This study was carried after the Institutional Review Board approval from the Research Ethics Committee of the Chosun University Hospital (No. 2015–12–009).

Setting

The setting was the metropolitan city of the Republic of Korea, with a population of approximately 1.5 million people in 501 km², consisting mostly of urban area. There are 30 ambulances, 270 paramedics and 24 ambulance stations. Korean EMS has recently established a centrally based, two-tiered system for OHCA patients, two or three EMT including at least one intermediate EMT (EMT-I) or nurse per ambulance were dispatched. Ambulance crew can provide care that is comparable to the EMT-I level in the US, including intravenous fluids, endotracheal intubation or laryngeal mask airway insertion under direct medical oversight. But, they cannot use medications for ALS (e.g., epinephrine, amiodarone). This means that it is not enough time to provide ALS in the field, only BLS is being performed. One of the most important factors for ROSC is that high-quality BLS should be continuously performed for a reasonable period of time, and 10 minutes of on-site CPR is a very short time.

Selection of study participants

The study was performed on non-trauma cardiac arrest patients who were 18 years of age or older with cardiopulmonary resuscitation. Cardiac arrest patients due to trauma, poisoning, pregnancy, do not attempt resuscitation (DNAR), and patients CPRs which were put off due to definite death (for example decapitation, incineration, decomposition, rigor mortis, or dependent cyanosis) were excluded from this study. Also, even if they qualified for the pilot project, if the patients’ family did not agree on SALS pilot project

Fig. 1. Capture images during videophone-assisted advanced life support. The EMT leader takes the patient to the center of the screen and records the EMT's performance on whole screen. After 2 minutes of chest compression, EMT adjusts the angle of the camera so that the rhythm of the ECG can be monitored.

and wanted the patient transported to a hospital quickly, BLS was given as per standard procedure, and was excluded from the study.

Intervention

In the 'before' phase, EMTs dispatched to the field, perform a conventional BLS about 5 minutes and transfer to the nearest hospital. EMTs, which cannot declare death or stop CPR, can take medical directions from a physician via telephone when there is an apparent suspicion of death, such as when decapitation, rigor mortis, decomposition, and dependent lividity are observed.

In the 'after' phase, at the area implemented SALS pilot project, they were allowed to undergo further intravenous fluid, intravenous medications, advanced airway insertion (e.g., I-gel, endotracheal intubation) under physician's direct medical oversight through video call (Fig. 1).

Outcome measure

The first outcome measure is to measure the prehospital-spontaneous recovery rate of the hospital. The second outcome measure was to measure the survival rate and neurological recovery rate according to Utstein style [13]. Neurological recovery rates were measured at discharge. The recovery rate was measured using the cerebral performance category (CPC) score, and CPC 1 and 2 were defined as good neurological recovery [14].

Statistical analysis

Statistical analysis was performed using SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA). Nominal variables were expressed as counts and percentages of total numbers. Continuous variables were expressed using medi-

Fig. 2. Study flow. EMS: emergency medical service, CPR: cardiopulmonary resuscitation, SALS: smartphone video assisted advanced life support.

an and interquartile range (IQR).

Differences between BLS and SALS groups were compared using chi-square test of Fisher's exact test for nominal variables and Independent sample t-test for continuous variables. The statistical significance was judged to be the case when the p value was less than 0.05.

We matched the propensity score by using logistic regression model to compare the effects of SALS vs. BLS on the outcomes of OHCA patients. Data with missing values were excluded from the collected data. The independent variables (covariates) being potential risk factor of sex, age, witnessed, bystander CPR, public place, shockable rhythm were included. We calculated propensity scores to a maximum of 10 decimal place. Patients received SALS were matched to the closest BLS group patient whose propensity score differed by less than 1/10-4.

Adjusted multivariable logistic regression analysis was used to examine the associations between SALS and outcome except for data with missing values. Associations are presented as odds ratios (ORs) with 95% confidence intervals (CI).

RESULTS

Outcomes

Among 1,333 EMS-assessed OHCA, 235 patients in before

Table 1. Baseline characteristics of the study patients in BLS and SALS groups

Characteristics	BLS group (N=235)	SALS group (N=198)	p value
Patient & environmental factor			
Male sex – no. (%)	147 (62.5)	135 (68.2)	<0.001
Age-year – median (IQR)	70 (56–80)	71 (56–79)	0.48
Public place – no. (%)	40 (17.3)	35 (17.6)	0.55
Witnessed arrest – no. (%)	115 (48.9)	97 (49.0)	0.10
Bystander CPR – no. (%)	133 (56.6)	138 (69.7)	<0.001
Initial cardiac rhythm – no. (%)			<0.001
Ventricular fibrillation/tachycardia	39 (16.6)	40 (20.4)	
Pulseless electrical activity	43 (18.4)	33 (16.7)	
Asystole	150 (63.9)	124 (62.9)	
Unknown	3 (1.3)	1 (0.1)	
EMS factor			
Defibrillation shock – no. (%)	58 (24.7)	63 (31.8)	<0.001
EMS defibrillation success – no. (%)	30 (56.4)	25 (47.5)	0.004
Number of defibrillation attempts – no. (SD)	2.23 (1.72)	3.44 (2.49)	<0.001
Prehospital advanced airway – no. (%)		189 (95.5)	NA
Prehospital drug administered – no. (%)			
Epinephrine – no. (%)		136 (69.0)	NA
Amiodarone – no. (%)		11 (5.6)	NA
Fluid bolus – no. (%)		146 (73.7)	NA
Time interval-min			
Response time interval (Call to EMS arrival on scene) – median (IQR)	8.0 (6.0–11.0)	7.0 (6.0–9.0)	<0.001
From arrival at scene to departure – median (IQR)	9.0 (6.0–13.0)	27.0 (21.0–33.0)	<0.001
From departure to arrival at hospital – median (IQR)	6.0 (4.0–10.0)	6.0 (4.0–9.0)	0.005
Call to arrival at hospital – median (IQR)	25.0 (20.0–32.0)	42.0 (35.0–49.0)	<0.001
Call to EMS basic life support – median (IQR)	9.0 (7.0–12.0)	9.0 (7.0–12.0)	<0.001
From arrival at scene to EMS basic life support – median (IQR)	1.0 (0–2.0)	2.0 (1.0–3.0)	0.077
From arrival at scene to first ROSC – median (IQR)	29.0 (18.0–46.0)	22.0 (14.0–37.0)	<0.001
From EMS basic life support to first ROSC – median (IQR)	28.0 (16.0–47.0)	20.0 (12.0–35.0)	0.02
Call to first ROSC – median (IQR)	38.0 (26.0–55.0)	30.0 (21.0–45.0)	<0.001
From arrival at scene to first shock delivered – median (IQR)	4.0 (2.0–8.0)	3.0 (2.0–4.0)	<0.001
Post resuscitation care			
PCI – no. (%)	6 (2.6)	14 (7.0)	<0.001
Hypothermia therapy – no. (%)	12 (5.0)	12 (6.0)	0.02
ECMO therapy – no. (%)	4 (1.7)	6 (3.0)	<0.001
Outcome			
Return of spontaneous circulation	20 (8.5)	44 (22.2)	<0.001
Admission to hospital	52 (22.1)	37 (18.6)	0.008
Survival to hospital discharge	16 (6.8)	20 (10.1)	<0.001
Good neurologic recovery	10 (4.2)	13 (6.6)	<0.001

IQR: interquartile range, CPR: cardiopulmonary resuscitation, EMS: emergency medical service, SD: standard deviation, NA: not applicable, ROSC: return of spontaneous circulation, PCI: percutaneous coronary intervention, ECMO: extracorporeal membrane oxygenation.

Table 2. Survival and outcomes of patients in BLS and SALS groups

Outcome	BLS group (N=235)	SALS group (N=198)	p value	OR (95% CI)	Adjusted OR ^a (95% CI)
Prehospital ROSC – no. (%)	20 (8.5)	44 (22.2)	<0.001	3.08 (2.57–3.68)	4.04 (3.24–5.03)
ED ROSC ^b – no. (%)	63 (26.8)	16 (8.0)	<0.001	0.24 (0.20–0.29)	0.22 (0.18–0.27)
Total ROSC ^c – no. (%)	83 (35.3)	60 (30.3)	<0.001	0.79 (0.70–0.90)	0.73 (0.63–0.85)
Admission to hospital – no. (%)	52 (22.1)	37 (18.6)	0.008	0.82 (0.70–0.95)	0.70 (0.58–0.83)
Survival to discharge – no. (%)	16 (6.8)	20 (10.1)	<0.001	1.48 (1.20–1.84)	1.23 (0.96–1.68)
Good neurologic recovery – no. (%)	10 (4.2)	13 (6.6)	<0.001	1.69 (1.29–2.21)	1.39 (1.00–1.92)

OR: odds ratio, CI: confidence interval, ROSC: return of spontaneous circulation, ED: emergency department. ^aThe analysis are adjusted for sex, age, place, witness, bystander CPR, initial shockable rhythm, response time interval (call to EMS arrival on scene), ^bED ROSC is ROSC, documented initially in emergency department without prehospital ROSC, ^cTotal ROSC corresponds to obtaining prehospital ROSC or ED ROSC.

phase (BLS group), 336 patients in after phase were included in the final analysis (Fig. 2). In after phase, 198 patients were performed SALS (SALS group), and 138 patients were not performed SALS and were transported to a hospital (NoSALS group).

Table 1 provides patient characteristics, EMS factor, time interval, post resuscitation care, outcome for the overall group. In SALS group, 69.7% of the bystander provided CPR for OHCA patients, whereas 56.6% of the bystander provided CPR in BLS group. A number of patients with shockable rhythm were more frequent in SALS group than in BLS group (20.4% vs. 16.6%; $p<0.001$), whereas the success rate of the defibrillation by EMS provider were lower in SALS group than in BLS group (47.5% vs. 56.4%; $p=0.004$).

The EMS response time and transport time intervals in both groups did not show a difference. As ALS is implemented in the scene, from arrival at scene to departure time interval increased from 9.0 (median, 4.0–10.0) min to 27.0 (median, 21.0–33.0) min ($p<0.001$). On the other hand, EMS arrival to first ROSC time interval 22.0 (median, 14.0–37.0) min in SALS group were shorter than in BLS group 29.0 (median, 18.0–46.0) min ($p<0.001$). Prehospital ROSC rate in SALS group was higher than in BLS group (44/22.2% vs. 20/8.5%; $p<0.001$), respectively. In SALS group, 20 (10.1%) survived to hospital discharge, as compared to 16 (6.8%) in BLS group ($p<0.001$). Rates of survival with favorable neurologic status were 13 (6.6%) in SALS group, 10 (4.2%) in BLS group ($p<0.001$), respectively.

Logistic regression analysis

Table 2 presents the multivariable logistic regression analysis on the outcomes for SALS group compared with BLS group. Performing SALS was associated with an increased

likelihood of prehospital ROSC in analysis (22.2 vs. 8.5; adjusted odd ratio 4.04; $p<0.001$), survival to discharge (10.1 vs. 6.8; adjusted odd ratio 1.23; $p<0.001$), good neurologic recovery (6.6 vs. 4.2; adjusted odd ratio 1.39; $p<0.001$).

Propensity score matching analysis

We matched 304 patients on the propensity score for each of BLS and SALS groups. Both propensity-matched patients were well matched. Baseline characteristics comparing the propensity-matched BLS and SALS receiving patients are shown in Table 3. Patients received SALS was associated with increased odd of prehospital ROSC (odd ratio 3.60; 95% confidence interval 2.83 to 4.58; $p<0.001$), survival to discharge (odd ratio 1.33; 95% confidence interval 1.00 to 1.77; $p=0.05$), good neurologic recovery (odd ratio 1.73; 95% confidence interval 1.19 to 2.53; $p=0.004$) (Table 4).

DISCUSSION

This study is the first attempt to clarify that ACLS performed by visual direct medical direction using smartphone was effective for the ROSC and neurological recovery of OHCA patients. It is also an unusual result that showed improvement in resuscitation rate and neurological recovery rate by implementing ALS for OHCA patients. Although the effect of prehospital ALS in OHCA has been questioned recently, the Spanish OHCA registry reported the higher rate of survival with favorable neurologic outcome of physician treated OHCA patients compared to paramedic based EMS legions [15]. And this study showed that recent developments in smartphone technology may be integrated with ALS.

Recently, the development of information and communication technology has made various attempts in the field

Table 3. Selected characteristics according to SALS in propensity-matched patients

Characteristics	BLS group (N=152)	SALS group (N=152)	p value
Patient & environmental factor			
Male sex – no. (%)	103 (67.7)	103 (67.7)	0.94
Age-year – median (IQR)	59 (50–70)	60 (51–73)	0.28
Public place – no. (%)	24 (15.8)	26 (17.1)	0.35
Witnessed arrest – no. (%)	75 (49.3)	76 (50.0)	0.56
Bystander CPR – no. (%)	99 (65.1)	100 (65.8)	0.79
Initial cardiac rhythm – no. (%)			0.48
Ventricular fibrillation/tachycardia	28 (18.4)	29 (19.0)	
Pulseless electrical activity	28 (18.4)	26 (17.1)	
Asystole	96 (63.1)	96 (63.1)	
Unknown	0 (0.0)	1 (0.7)	
EMS factor			
Defibrillation shock – no. (%)	40 (26.3)	49 (32.2)	0.001
EMS Defibrillation Success – no. (%)	22 (55.0)	24 (49.0)	0.05
Mean number of Defibrillation attempts – no. (SD)	2.28 (1.74)	3.43 (2.51)	<0.001
Prehospital advanced airway – no. (%)		146 (96.1)	
Prehospital drug administered – no. (%)			
Epinephrine – no. (%)		106 (69.7)	
Amiodarone – no. (%)		8 (5.3)	
Fluid bolus – no. (%)		114 (75.0)	
Time interval – min			
Response time interval (call to EMS arrival on scene) – median (IQR)	7.0 (5.0–9.0)	7.0 (5.0–9.0)	0.94
From arrival at scene to departure – median (IQR)	11.0 (7.0–15.0)	23.0 (17.0–30.0)	<0.001
From departure to arrival at hospital – median (IQR)	6.0 (4.0–9.0)	7.0 (4.0–10.0)	0.004
Call to arrival at hospital – median (IQR)	25.0 (20.0–33.0)	38.0 (32.0–46.0)	<0.001
Call to EMS basic life support – median (IQR)	8.0 (6.0–11.0)	9.0 (7.0–11.0)	0.79
From arrival at scene to EMS basic life support – median (IQR)	1.0 (0.0–2.0)	2.0 (1.0–2.0)	0.15
From arrival at scene to first ROSC – median (IQR)	21.0 (10.0–41.0)	22.0 (13.0–38.0)	<0.001
From EMS basic life support to first ROSC – median (IQR)	19.0 (9.0–38.0)	19.0 (11.0–35.0)	0.081
Call to first ROSC – median (IQR)	28.0 (17.0–50.0)	29.0 (20.0–44.0)	<0.001
From arrival at scene to first shock delivered – median (IQR)	4.0 (2.0–6.0)	3.0 (2.0–4.0)	<0.001
Post resuscitation care			
PCI – no. (%)	4 (2.6)	5 (3.2)	0.02
Hypothermia therapy – no. (%)	8 (5.2)	9 (5.9)	0.09
ECMO therapy – no. (%)	1 (0.6)	3 (2.0)	<0.001
Outcome			
Return of spontaneous circulation	13 (8.5)	33 (21.7)	<0.001
Admission to hospital	32 (21.0)	28 (18.4)	0.02
Survival to hospital discharge	11 (7.2)	14 (9.2)	0.06
Good neurologic recovery	6 (3.9)	9 (5.9)	0.008

IQR: interquartile range, CPR: cardiopulmonary resuscitation, EMS: emergency medical service, SD: standard deviation, NA: not applicable, ROSC: return of spontaneous circulation, PCI: percutaneous coronary intervention, ECMO: extracorporeal membrane oxygenation.

of EMS. The use of smartphones for medical oversight in cardiac arrest situations is very useful. Smartphones are lightweight, portable, easy to use, and cheaper than other medical devices. These advantages make it easier for EMTs

and oversight doctors to share large amounts of information in emergency situations.

There are several reasons why this study could produce good result in a short period of time. First is the role of the

Table 4. Odd ratios between two groups among propensity-matched patients

Model	Prehospital ROSC		Survival to admission		Survival to discharge		Good neurologic recovery	
	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value	OR (95% CI)	p value
SALS (0) vs BLS (1) (n=3,042)								
Unadjusted	2.96 (2.39–3.68)	<0.001	0.81 (0.68–0.97)	0.02	1.29 (1.00–1.67)	0.05	1.54 (1.12–2.13)	0.008
Adjusted for propensity	3.08 (2.47–3.84)	<0.001	0.81 (0.67–0.97)	0.02	1.31 (1.00–1.70)	0.05	1.61 (1.15–2.25)	0.006
Adjusted for propensity and selected variables ^a	3.60 (2.83–4.58)	<0.001	0.77 (0.63–0.93)	0.007	1.33 (1.00–1.77)	0.05	1.73 (1.19–2.53)	0.004

ROSC: return of spontaneous circulation, OR: odds ratio, CI: confidence interval. ^aThe analysis is adjusted for sex, age, place, witness, bystander CPR, initial shockable rhythm, response time interval (call to EMS arrival on scene).

oversight physician to emphasize high-quality CPR. Until recently, limited studies indicate that exposure to OHCA for individual paramedics is rare, Dyson et al. reported that paramedics in Australia treat only 1.4 OHCA patients per a year [16]. Such low exposure may impact on the paramedics' ability to perform resuscitation skills according to the guidelines, which is vital to patient survival [17].

Despite many controversies, it has been reported that physicians provide benefit to the patients who have cardiac arrest before the hospital [18]. Physician are able to carry out advanced procedures, such as airway management and epinephrine use, adhere to treatment according to guidelines, and have the latest knowledge. However, in this study, the physician did not respond to the field, so the latter may have affected the outcome of the treatment. Physician's advises and instructs on-site EMT leaders on team management and detailed ECG analysis, importance of BLS, and accurate ventilation. The presence of a physician with such experience and knowledge helps to improve the quality of care of the CPR team. In addition, EMT team leaders received continuous feedback could learn oversight during resuscitation, and grow into ACLS experts. In addition to the direct instruction of the physician, the Hawthorne effect may also have worked [19].

Second, the introduction of a strategy in each director can be assumed to have influenced performance [20–22]. Each month, we held a committee with oversight physicians, university hospital emergency attending doctors, fire office education administrators, dispatcher quality managers in each area. Monthly Results were shared, problems discovered and corrected. Based on the results of the committee meeting, re-training was conducted, transfer hospitals were selected, and hospitals were cooperated to provide effective interven-

tion after cardiac arrest. This process provides an opportunity to objectively identify and rectify field weaknesses.

Lastly, it is also meaningful that each oversight doctor and EMT tried to communicate through social networking service (SNS). It is difficult for EMTs and oversight doctors to make contact with video or voice only in a cardiac arrest situation because it is much more office-friendly. Personal exchange among people increases intimacy. This affects feedback and retraining effects. Communication channels between hospitals and paramedics have indirectly positive effects for teamwork.

As a result of this intervention, pre-hospital ROSC increased in the SALS group, but survival hospitalization decreased further. On the other hand, survival rate and neurological recovery rate were found to be higher in the SALS group. Time to ROSC is a significant prognostic factor for the survival rate and neurological recovery rate of comatose OHCA patients [23,24]. The ROSC of the BLS group has been performed mostly in hospitals, but the Time to ROSC is longer. On the other hand, the ROSC of the SALS group was mostly performed in the field and the Time to ROSC was shorter. The prognosis of OHCA patients with rearrest was poor [25]. The hospital admission rate of SALS group was further reduced due to the inability to carry out critical interventions during transport, rearrest occurring after arrival at the hospital. Nonetheless, the decline in time to ROSC seems to increase survival rates and neurological recovery rates.

Limitations

This study has various limitations. First, it is a controlled before-after study, not planned RCT. In fact, the outcome of cardiac arrest in Korea is improving every year. RCT is

needed to reflect the local demographic, social and regional characteristics. In Korea, RCT for cardiac arrest patients is ethically problematic and various legal aspects are needed. Also, due to the nature of this pilot project conducted by the government, it was not possible to determine patients who would randomly perform SALS. However, according to the results of cardiac arrest in Korea, the rate of survival discharge from 2006 to 2016 increased by an average of 0.54% from 2.3% to 7.6%, and the neurological recovery rate increased by 0.36% from 0.6% to 4.2% each year. Second, approximately 40% of patients were excluded from the study due to the rejection of the family. This can lead to another selection bias, which can lead to confusion in a variety of other variables. However, we have no doubt about this result. To solve this problem, our results were statistically corrected using the propensity score matching method. Third, there were various changes like video medical direction, change to ACLS, increase of on-site time, drug administration, localization model, double tier dispatch, Hawthorne effect, Use of SNS, and training for EMTs, but we could not measure the effects of each of them. However, since pre-hospital ALS and direct medical guidance for OHCA patients are intertwined, it is difficult to measure the parameters separately. Also, the part of subjective evaluation involvement is also complex. The authors considered these changes to be the basic prerequisites for video medical direction and ALS. Of course, further study is needed to analyze the effect of each variable.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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