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Application of a Dual-Dispatch System for Out-of-Hospital Cardiac Arrest Patients: Will More Hands Save More Lives?

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ABSTRACT

Background: Recovery after out-of-hospital cardiac arrest (OHCA) is difficult, and emergency medical services (EMS) systems apply various strategies to improve outcomes. Multi-dispatch is one means of providing high-quality cardiopulmonary resuscitation (CPR), but no definitive best-operation guidelines are available. We assessed the effects of a basic life support (BLS)-based dual-dispatch system for OHCA.

Methods: This prospective observational study of 898 enrolled OHCA patients, conducted in Daegu, Korea from March 1, 2015 to June 30, 2016, involved patients > 18 years old with suspected cardiac etiology OHCA. In Daegu, EMS started a BLS-based dual-dispatch system in March 2015, for cases of cardiac arrest recognition by a dispatch center. We assessed the association between dual-dispatch and OHCA outcomes using multivariate logistic regressions. We also analyzed the effect of dual-dispatch according to the stratified on-scene time.

Results: Of 898 OHCA patients (median, 69.0 years; 65.5% men), dual-dispatch was applied in 480 (53.5%) patients. There was no difference between the single-dispatch group (SDG) and the dual-dispatch group (DDG) in survival at discharge and neurological outcomes (survival discharge, $P = 0.176$; neurological outcomes, $P = 0.345$). In the case of less than 10 minutes of on-scene time, the adjusted odds ratio was 1.749 (95% confidence interval [CI], 0.490–6.246) for survival discharge and 6.058 (95% CI, 1.346–27.277) for favorable neurological outcomes in the DDG compared with the SDG.

Conclusion: Dual-dispatch was not associated with better OHCA outcomes for the entire study population, but showed favorable neurological outcomes when the on-scene time was less than 10 minutes.

Keywords: Basic Life Support; Cardiac Arrest; Emergency Medical Services

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INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) remains a challenge worldwide.[1] In North America, approximately 134 OHCA events occur per 100,000 adults annually and the survival rate is 3%–16%.[2] To improve OHCA outcomes, many countries are applying various strategies to their emergency medical services (EMS).[1-3] Previous reports of prehospital EMS interventions, including dispatch type, airway management, and the number of emergency medical technicians (EMTs) have been reported.[4-11] Among these, multi-dispatch response to an OHCA, using more than two EMS teams of the same or different tiers, have shown some positive effects.[6,7,11-13] In Korea, to reduce response time and to increase the number of EMTs at an OHCA, a dual-dispatch system started in March 2015. We investigated the OHCA patient outcomes in Daegu Metropolitan City from March 1, 2015 to June 30, 2016, to identify the effectiveness of dual-dispatch system.

METHODS

The EMS system in Daegu metropolitan city

Daegu metropolitan city is located on the south-eastern side of the Korean peninsula, with an area of 883.56 km² and a population of 2,487,829.[14] Major hospital EMS are provided by one regional emergency medical center and four local emergency medical centers. Of 1,325 OHCA patients, approximately 90% were hospitalized at these five hospitals in 2016.[15] For the prehospital EMS, the Daegu 119 call center operates 47 ambulances at 48 safety centers through the regional fire safety central office.[16] Each prehospital EMS team comprises three EMTs, including one level-1 EMT (similar to EMT-intermediate level in U.S. EMS) as the highest-level ambulance crew, one level-2 EMT (similar to EMT-basic), and driver.[3,17] Both scopes of practice are limited to the basic life support (BLS) level and provide manual chest compressions.[18] For level-1 EMT, advanced airway and intravenous access could be attempted under direct medical direction. On March 1, 2015, the Daegu 119 started dual-dispatch, a protocol that uses two EMS teams at OHCA. In this protocol, 119 uses one EMS team generally, but if OHCA is recognized by the dispatch center, two EMS teams respond with available ambulances.

Study participants and data collection

On January 1, 2014, the Daegu Emergency Medical Cooperation Bureau began a citywide prospective population-based clinical registry for gathering information regarding OHCA patients from the prehospital phase to hospital discharge, connecting EMS and hospital data, based on the Utstein style (Daegu emergency medical services registry [DEMSRe]). This study used DEMSRe data from March 1, 2015 to June 30, 2016, during the dual-dispatch system operation period.

Of 1,476 OHCA patients, we excluded those aged < 18 years because the etiology of cardiac arrest between adults and pediatric patients is generally different. Second, patients for whom EMS resuscitations had not been attempted were excluded. Third, patients with OHCA witnessed by EMTs (the patient experienced arrest following the arrival of EMTs) were excluded, because Utstein style recommends that arrests witnessed by EMS personnel should be separated from the unwitnessed arrests or from the bystander witnessed arrests. Fourth, OHCA patients with a non-cardiac etiology were excluded. Fifth, we excluded patients for whom the in-hospital managements were not followed, because of the patient being pronounced dead on arrival (DOA) at hospital or "do not attempt to resuscitate (DNAR)" instructions. Sixth, we excluded patients with insufficient records. Lastly, patients who

experienced arrest at a nursing home were excluded because pre-existing co-morbidities could interfere. After exclusions, 898 patients were included.

For prehospital data, we identified age, gender, place of cardiac arrest, witnessed or not, bystander cardiopulmonary resuscitation (CPR) provided, first recorded electrocardiography (ECG) rhythm, recognition of cardiac arrest by a dispatcher at a 119 call center, activation of dual-dispatch, and prehospital return of spontaneous circulation (ROSC) of OHCA patients, using 119 call center records. Additionally, we identified prehospital time-related variables, such as emergency call time, scene site arrival time, first defibrillation time in patients with a shockable rhythm, departure time, and hospital arrival time. Using hospital data, we identified underlying disease, implementation of targeted temperature management (TTM) or coronary angiography (CAG), survival or not, and the cerebral performance category (CPC) score in patients who survived.

DEMSRe Works collected prehospital data from quality managers in 119 call centers on alternate weeks, and collected hospital data from researchers in each of the hospitals. The DEMSRe Works data managers linked the two datasets, and calculated the response time (time from the emergency call to EMS arrival at the scene site), on-scene time (time from EMS arrival to departure for the hospital), transport time (time from EMS departure to arrival at the hospital), and first defibrillation interval (time from EMS arrival at the scene site to first defibrillation in patients with a shockable rhythm). The data were then analyzed for quality control.

Outcome measures

The primary outcome was survival discharge, with secondary outcomes including neurological recovery. Neurological recovery was classified as "good" or "poor," based on the CPC score at the time of discharge from the final hospital. A CPC score of 1 or 2 was classified as "good", and CPC scores between 3 and 5 were classified as "poor". Data collection commenced following approval from the Institutional Review Board committee of each research institute in the five hospitals.

Statistical analysis

Patient characteristics, prehospital elements, and in-hospital processes were evaluated according to dispatch type. For continuous variables, the median and interquartile range (IQR) were calculated, and a Mann-Whitney U test was performed. For categorical variables, percentages were calculated, and a Pearson's χ^2 test was performed.

To determine the effect of each dispatch type on OHCA outcomes according to on-scene time, associations were examined after classifying each dispatch type into two groups, according to each minute of on-scene time. As a result, the direction of the association between the two groups showed the greatest difference on the basis of 10 minutes.

To identify homogeneity between the two dispatch types within the two stratified groups, Breslow and Day's tests were performed with OHCA outcomes according to the 10 minutes of on-scene time, and logistic regression analyses were performed with each element of the prehospital phase of OHCA as an independent variable in each group. Simultaneously, multiple logistic regression analysis was performed using possible confounding factors together as a covariate in each group, to determine the influence of dual-dispatch on OHCA outcomes in accordance with the stratified on-scene time.

All statistical analyses were performed using IBM SPSS version 21.0 (IBM Co., Armonk, NY, USA). A *P*-value of < 0.05 was considered statistically significant.

Ethics statement

This study was approved by the Institutional Review Board (IRB) of Kyungpook National University Hospital (IRB No.2016-03-027), and written informed consent was waived by the permission of IRB.

RESULTS

Overview

During the study period, 1,476 OHCA patients had been admitted to the study hospitals via Daegu 119 ambulances. Of these, 578 patients were excluded, comprising 44 patients aged < 18 years, 51 patients for whom EMS resuscitations had not been attempted, 82 patients whose OHCA was witnessed by EMTs, 256 patients of non-cardiac etiology, 93 patients who were DOA, DNAR, or who had insufficient records, and 52 patients who experienced arrest at a nursing home. Finally, 898 patients were included in the study population (**Fig. 1**).
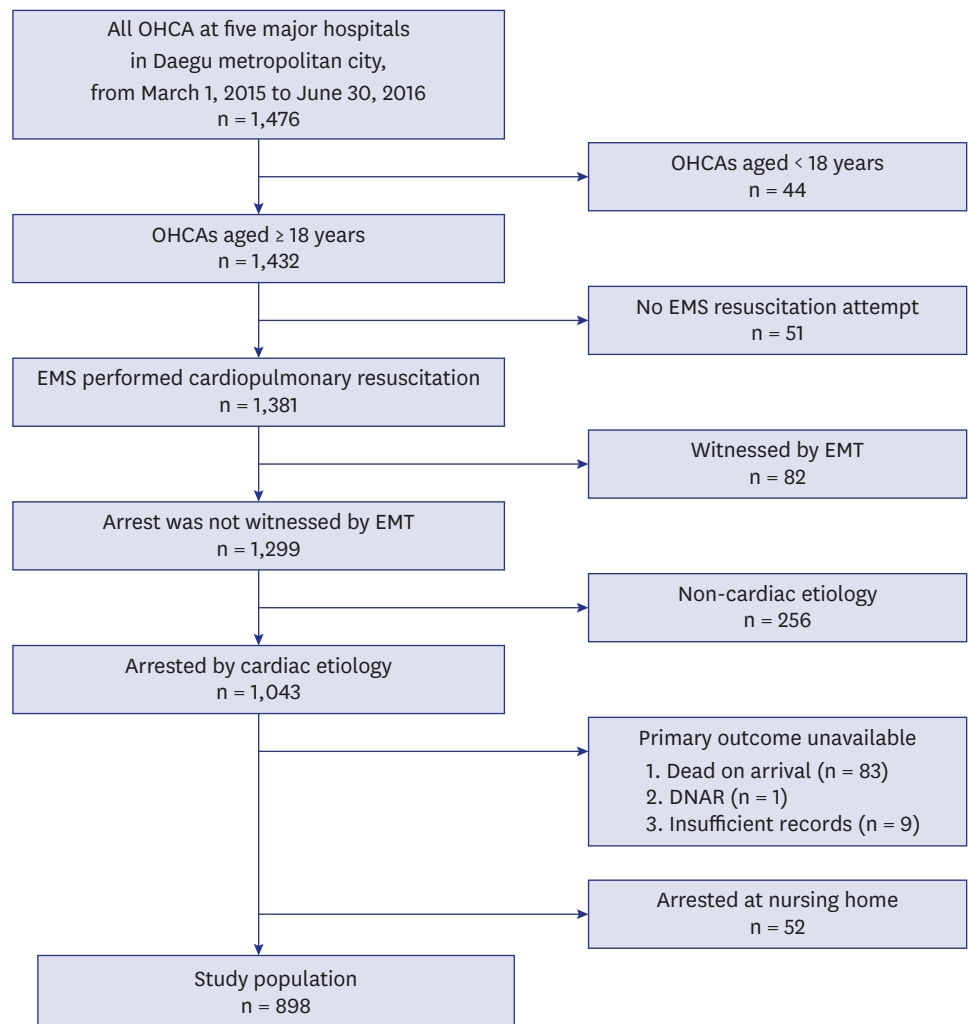

Fig. 1. Flow chart of the study population.
OHCA = out of hospital cardiac arrest, EMS = emergency medical services, EMT = emergency medical technician, DNAR = do not attempt resuscitation.

Patient characteristics

Table 1 shows the OHCA patient characteristics. The median age was 69.0 years (IQR, 56.0–78.0 years), and 65.5% were men. The most frequent OHCA site was at home (74.1%). Witnessed cases comprised 56.5% (60.5% for the single-dispatch group [SDG] and 52.9% for the dual-dispatch group [DDG], $P < 0.022$), and bystander CPR was performed in 53.7% (40.0% for the SDG and 65.6% for the DDG, $P < 0.001$). A shockable initial ECG was present in 19.3% of patients (19.9% for the SDG and 18.8% for the DDG, $P < 0.675$). Dispatchers at emergency call centers recognized 57.8% of the OHCAs (36.6% for the SDG and 76.3% for the DDG, $P < 0.001$). Prehospital ROSC was 10.7% (12.0% for the SDG and 9.6% for the DDG, $P = 0.250$), survived discharge was 7.6% (8.9% for the SDG and 6.5% for the DDG, $P = 0.176$), and good neurological survival was 5.9% (6.7% for the SDG and 5.2% for the DDG, $P = 0.345$).

Prehospital performance and hospital management

Table 2 presents prehospital EMS performance and hospital management, according to the two dispatch types. The median response time was 7.0 minutes (IQR, 5.0–9.0) for the SDG, and 6.0 minutes (IQR, 5.0–8.0) for the DDG ($P = 0.008$). The median on-scene time was 11.0 minutes (IQR, 8.0–15.0) for the SDG and 13.0 minutes (IQR, 10.0–16.8) for the

Table 1. Out of hospital cardiac arrest patient characteristics

Variables	Total (n = 898)	Single-dispatch (n = 418)	Dual-dispatch (n = 480)	P value
Age, yr	69.0 (56.0–78.0)	70.0 (56.0–79.0)	68.0 (57.0–78.0)	0.348
Gender				0.508
Men	588 (65.5)	269 (64.4)	319 (66.5)	
Women	310 (34.5)	149 (35.6)	161 (33.5)	
Place of cardiac arrest				0.152
Home	655 (74.1)	299 (71.5)	366 (76.3)	
Public area	129 (14.4)	70 (16.7)	59 (12.3)	
Others	104 (11.6)	49 (11.7)	55 (11.5)	
Underlying disease				0.650
Yes	753 (83.9)	353 (84.4)	400 (83.3)	
No	145 (16.1)	65 (15.6)	80 (16.7)	
Witnessed arrest				0.022
Yes	507 (56.5)	253 (60.5)	254 (52.9)	
No	391 (43.5)	165 (39.5)	226 (47.1)	
Bystander CPR				< 0.001
Yes	482 (53.7)	167 (40.0)	315 (65.6)	
No	416 (46.3))	251 (60.0)	165 (34.4)	
Initial ECG				0.675
Shockable	173 (19.3)	83 (19.9)	90 (18.8)	
Non-shockable	725 (80.7)	335 (80.1)	390 (81.3)	
Dispatcher recognition				< 0.001
Yes	519 (57.8)	153 (36.6)	366 (76.3)	
No	379 (42.2)	265 (63.4)	114 (23.8)	
Prehospital ROSC				0.250
Yes	96 (10.7)	50 (12.0)	46 (9.6)	
No	802 (89.3)	368 (88.0)	434 (90.4)	
Survival discharge				0.176
Yes	68 (7.6)	37 (8.9)	31 (6.5)	
No	830 (92.4)	381 (91.1)	449 (93.5)	
Neurological outcome				0.345
CPC 1–2	53 (5.9)	28 (6.7)	25 (5.2)	
CPC 3–5	845 (94.1)	390 (93.3)	455 (94.8)	

Data are presented as median (interquartile range) or number (%).
CPR = cardiopulmonary resuscitation, ECG = electrocardiography, Dispatcher recognition = recognition of cardiac arrest by dispatcher at public emergency medical services call center, ROSC = return of spontaneous circulation, CPC = cerebral performance category.

Table 2. Prehospital EMS performance and hospital management in out-of-hospital cardiac arrest

Variables	Total (n = 898)	Single-dispatch (n = 418)	Dual-dispatch (n = 480)	P value
Response time,[a] min	6.0 (5.0–8.0)	7.0 (5.0–9.0)	6.0 (5.0–8.0)	0.008
On-scene time,[b] min	12.0 (9.0–16.0)	11.0 (8.0–15.0)	13.0 (10.0–16.8)	< 0.001
Transport time,[c] min	6.0 (4.0–10.0)	6.0 (4.0–10.0)	6.0 (4.0–9.0)	0.047
First defibrillation interval,[d] min	3.0 (2.0–5.0)	3.0 (1.0–5.3)	3.0 (2.0–5.0)	0.896
Airway management				< 0.001
Advanced airway device	532 (59.2)	178 (42.6)	354 (73.8)	
Bag-valve-mask	366 (40.8)	240 (57.4)	126 (26.3)	
Intravenous access				< 0.001
Yes	126 (14.0)	21 (5.0)	105 (21.9)	
No	772 (86.0)	397 (95.0)	375 (78.1)	
TTM				0.153
Yes	21 (2.3)	13 (3.1)	8 (1.7)	
No	877 (97.7)	405 (96.9)	472 (98.3)	
Coronary angiography				0.397
Yes	68 (7.6)	35 (8.4)	33 (6.9)	
No	830 (92.4)	383 (91.6)	447 (93.1)	

Data are presented as median (interquartile range) or number (%).
IQR = interquartile range, TTM = targeted temperature management, EMS = emergency medical services.
[a]Time from the emergency call to EMS arrival at the scene site; [b]Time from EMS arrival to departure for the hospital; [c]Time from EMS departure to arrival at the hospital; [d]Time from EMS arrival at the scene site to first defibrillation in patients with shockable rhythm.

DDG ($P < 0.001$). However, the median transport time was same between the two groups, at 6.0 minutes. Additionally, the median first defibrillation interval was same between the two groups, at 3.0 minutes. An advanced airway was implemented in 42.6% and 73.8% of OHCA patients in the SDG and the DDG, respectively ($P < 0.001$), and intravenous access was implemented in 5.0% and 21.9% of OHCA patients in the SDG and the DDG, respectively ($P < 0.001$). TTM was implemented in 3.1% and 1.7% of OHCA patients in the SDG and the DDG, respectively ($P = 0.153$), and CAG was implemented in 8.4% and 6.9% of OHCA patients in the SDG and the DDG, respectively ($P = 0.397$).

Effect of dual-dispatch on OHCA patient outcomes according to on-scene time

Table 3 shows OHCA outcomes according to on-scene time. For stratification per minute of on-scene time, 10 minutes of on-scene time presented the greatest variation in homogeneity using Breslow and Day's tests in relation to survival discharge ($P = 0.238$ for an on-scene time < 10 minutes; $P = 0.027$ for an on-scene time ≥ 10 minutes; and $P = 0.005$ using Breslow and Day's test) and neurological outcome ($P = 0.060$ for an on-scene time < 10 minutes; $P = 0.028$ for an on-scene time ≥ 10 minutes; and $P = 0.027$ using Breslow and Day's test).

Table 3. Out of hospital cardiac arrest outcomes according to on-scene time and dispatch types

Variables		Total (n = 898)	Single-dispatch (n = 418)	Dual-dispatch (n = 480)	P value
On-scene time	Survival discharge, No. (%)				0.005[a]
< 10 min	Yes	21 (9.2)	10 (7.4)	11 (12.0)	0.238
	No	207 (90.8)	126 (92.6)	81 (88.0)	
≥ 10 min	Yes	47 (7.0)	27 (9.6)	20 (5.2)	0.027
	No	623 (93.0)	255 (90.4)	368 (94.8)	
On-scene time	Neurological outcome, No. (%)				0.027[a]
< 10 min	CPC 1–2	14 (6.1)	5 (3.7)	9 (9.8)	0.060
	CPC 3–5	214 (93.9)	131 (96.3)	83 (90.2)	
≥ 10 min	CPC 1–2	39 (5.8)	23 (8.2)	16 (4.1)	0.028
	CPC 3–5	631 (94.2)	259 (91.8)	372 (95.9)	

ROSC = return of spontaneous circulation, CPC = cerebral performance category.
[a]Breslow and Day's test for homogeneity.

Table 4. Multivariate logistic regression analysis of the effect of dual-dispatch in OHCA patient outcomes according to stratified on-scene time

Variables	Strata	Crude OR (95% CI)	Adjusted OR (95% CI)
Survival discharge	Total	0.711 (0.433–1.168)	0.555 (0.297–1.038)[a]
	On-scene time < 10 min	1.711 (0.695–4.212)	1.749 (0.490–6.246)[b]
	On-scene time ≥ 10 min	0.513 (0.282–0.935)	0.426 (0.203–0.893)[b]
Good neurological outcome	Total	0.765 (0.439–1.334)	0.661 (0.309–1.411)[a]
	On-scene time < 10 min	2.841 (0.920–8.771)	6.058 (1.346–27.277)[b]
	On-scene time ≥ 10 min	0.484 (0.251–0.935)	0.293 (0.121–0.709)[b]

ORs are calculated using single-dispatch as dummy variable.
OHCA = out-of-hospital cardiac arrest, OR = odds ratio, CI = confidence interval, ROSC = return of spontaneous circulation, CPR = cardiopulmonary resuscitation, ECG = electrocardiography.
[a]Adjusted for age, gender, underlying disease, witness existence, bystander CPR, initial ECG rhythm, place of cardiac arrest, airway management, intravenous access, response time, transport time, on-scene time; [b]Adjusted for age, gender, underlying disease, witness existence, bystander CPR, initial ECG rhythm, place of cardiac arrest, airway management, intravenous access, response time, transport time.

Table 4 shows multivariate logistic regression analysis of the effect of dual-dispatch in OHCA outcomes according to stratified on-scene time per 10 minutes. Dual-dispatch was not associated with better OHCA outcomes in the entire study population (adjusted odds ratio [aOR], 0.555, 0.661; 95% confidence interval [CI], 0.297–1.308, 0.309–1.411 for survival discharge and good neurological outcome, respectively). However, in situations where the on-scene time was < 10 minutes, dual-dispatch was associated with better neurological outcome (aOR, 1.749, 6.058; 95% CI, 0.490–6.246, 1.346–27.277 for survival discharge and good neurological outcome, respectively). Additionally, in situations where on-scene time was ≥ 10 minutes, dual-dispatch was associated with worse OHCA outcomes (aOR, 0.426, 0.293; 95% CI, 0.203–0.893, 0.121–0.709 for survival discharge and good neurological outcome, respectively).

DISCUSSION

In this prospective observational study, dual-dispatch did not produce better outcomes in terms of survival discharge and neurological outcome compared to single-dispatch. However, with stratified analysis according to on-scene time, we found that if the on-scene time was < 10 minutes, dual-dispatch resulted in better neurological outcome than single-dispatch, and if the on-scene time was ≥ 10 minutes, dual-dispatch resulted in worse survival discharge and neurological outcome than single-dispatch.

Early recognition, prompt EMS activation, high-quality chest compressions, and early defibrillation are key components for favorable outcomes for OHCA patients.[19] For this purpose, various strategies are operating in each EMS system, and there have been reports that a dual-dispatch could improve outcomes.[5,6,11-13] However, the effect of dual- or multi-dispatch for OHCA could differ depending on demographic characteristics, medical resources, EMT scope of practice, and type of system.[20,21] For example, multi-dispatch and multi-tier are different concepts. Multi-dispatch means an OHCA response using multiple EMS teams, and multi-tier means an OHCA response using multiple EMS teams with different scopes of practice. Therefore, a multi-tier includes the concept of multi-dispatch, but multi-dispatch may or may not be multi-tier. Additionally, there are no definite guidelines indicating the best-operation model, and effect of multi-dispatch might vary according to each EMS system.

The aim of a dual-dispatch was to reduce the response time and provide high-quality CPR through increasing the number of EMTs. For OHCA, faster response time is a positive factor;

however, optimal on-scene time remains controversial, and other factors could influence outcomes.[22,23] In this study, response time was reduced and on-scene time was increased in the DDG, but outcome improvement through dual-dispatch could not be proven. One possible reason for this is application of additional procedures and prolongation of the on-scene time. In this study, advanced airway and intravenous access were implemented more in the DDG. However, chest compression quality could be compromised when applying prehospital procedures, the effect of prehospital advanced airway in OHCA is still unclear, and the on-scene time could be extended due to these procedures.[24,25] Previous studies have reported negative effects of extended on-scene time on OHCA patients in BLS-based EMS systems. Kim et al.[26] reported that 4–7 minutes of on-scene time was associated with better neurological recovery for OHCA patients, using an intermediate level EMS. Kim et al.[27] reported that a prolonged on-scene time resulted in negative effects for OHCA patients in the "scoop-and-run" EMS model. Shin et al.[28] reported that between 8 and 16 minutes of on-scene time was associated with good neurological outcome. Our EMS system provides BLS-based intermediate level EMS, basically the "scoop-and-run" model. We thought that the on-scene time was extended as more procedures were applied in the DDG, and this may explain why the positive effect was not seen across the entire DDG. Therefore, efforts should be made to improve CPR quality and reduce the shock delivery interval using dual-dispatch.

The BLS-based EMS system is applied in various regions, including many Asian countries, but there has been little evaluation of the on-scene time according to the number of EMTs for OHCA.[26-29] In this study, the DDG showed better neurological outcome if the on-scene time was < 10 minutes. This could help determine the optimal on-scene time for OHCA in regions with BLS-based EMS systems.

Our study has several limitations. First, the proficiency of prehospital airway management was not assessed. There is no recommendation regarding a particular airway device for OHCA, but proficiency of EMT could have differed between teams and this difference might have influenced outcomes.[4,9,24] Second, we estimated in DDG that the quality of CPR would be better, but real-time quality measurements were impossible. In addition, the analysis included only the attempted rate of endotracheal intubation and IV access, but there were limitations that did not include accurate data related to more important information, endotracheal intubation, IV access success rate and time spent on processing. Third, detailed in-hospital management information, such as TTM timing, were not considered in our study. However, these cases only accounted for a very small percentage. Fourth, this study was citywide and investigated in the BLS-based system. Additionally, there was not enough study population in subgroup analysis, and it was possible that statistical significance was not obtained sufficiently. Therefore, our conclusion has limited generalizability and we cannot extrapolate our findings to advanced life support-based systems. Further studies with larger numbers or different EMS systems, such as nationwide or international investigation will be needed. Fifth, it could be possible that only cardiac arrest cases that were not recognized as such could have received single dispatch in our design. It may be that these cases that present in an atypical manner, causing the dispatcher to fail to recognize them as cardiac arrest, have a different baseline survival or neurologically intact survival rate. Therefore, further studies, such as those with a randomized design may be needed. Finally, while we considered covariates to the best of our ability, residual confounding factors may have existed.

Best practice guidelines of on-scene time for OHCA patients are still controversial. In this study, single-dispatch and dual-dispatch did not show differences in OHCA outcomes based

on BLS-based EMS system. However, dual-dispatch had a positive effect on neurological outcomes after OHCA involving an on-scene time of < 10 minutes, and had a negative effect on both survival discharge and neurological outcomes, involving an on-scene time of ≥ 10 minutes. Although this result was derived from subgroup analysis, we believe it should be considered in future EMS policies.

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