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Clinical paper

Effect of team-based cardiopulmonary resuscitation training for emergency medical service providers on pre-hospital return of spontaneous circulation in out-of-hospital cardiac arrest patients



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Abstract

Objective: This study aimed to assess whether team-based cardiopulmonary resuscitation (CPR) training for emergency medical service (EMS) providers improved the pre-hospital return of spontaneous circulation (ROSC) rates of non-traumatic adult out-of-hospital cardiac arrest (OHCA) patients.

Methods: This was a before-and-after study evaluating educational intervention for community EMS providers, which was conducted in Gyeonggi province, South Korea. Team-based CPR training was conducted from January to March 2016 for every level 1 and level 2 EMS provider in the study area. Non-traumatic EMS treated OHCA patients from July to December 2015 and from July to December 2016 were enrolled and used for the analysis. The primary outcome was pre-hospital ROSC rates before and after the training period. A multivariable logistic regression model with an interaction term (period × dispatch type) was used to determine the adjusted odds ratios (aORs) according to the dispatch type (single vs. multi-tiered).

Results: Of the 2125 OHCA cases included, 1072 (50.4%) and 1053 (49.6%) were categorized in the before- and after-training groups, respectively, and the pre-hospital ROSC rates were 6.6% and 12.6%, respectively. In the multivariable logistic regression analysis, the aOR for pre-hospital ROSC was 2.07 (95% CI, 1.32–3.25) in the after-training period. In the interaction model (period × type of dispatch), the aORs for pre-hospital ROSC were 2.00 (95% CI, 1.01–3.98) and 2.13 (95% CI, 1.20–3.79) in the single- and multi-tiered dispatch groups, respectively, during the after-training period.

Conclusion: Team-based CPR training for EMS providers in a large community EMS system improved the pre-hospital ROSC rates of OHCA patients.

Keywords: Cardiac arrest, Cardiopulmonary resuscitation, Prehospital, Emergency medical service

Introduction

Out-of-hospital cardiac arrest (OHCA), with its high incidence and low survival rate, is a major public health concern.^{1–3} Despite various

efforts to improve the survival of OHCA patients, overall outcomes remain suboptimal.

A large body of evidence has emphasized that high-quality cardiopulmonary resuscitation (CPR) provided at the scene and during transport by emergency medical service (EMS) providers was

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associated with favorable outcomes.^{4,5} One of the strategies for performing high-quality CPR at the scene is team-based CPR. To maximize the effects of CPR at the scene, a highly organized team is required to coordinate resuscitative efforts. Recent studies have reported that team-based CPR was associated with improved outcomes of OHCA patients, and thus, the active implementation of team-based CPR has been encouraged both in the field and at hospitals.^{6–8}

In Korea, the EMS system, which provides basic-to-intermediate level of emergency services, is operated by the National Fire Agency. Since 2015, mandatory multi-tiered dispatch for OHCA has been implemented. A previous study revealed no difference in pre-hospital return of spontaneous circulation (ROSC) rates between single- and multi-tiered dispatch in a large community (Gyeonggi province, population of approximately 12 million) in South Korea.⁹ This was likely because no team-based training program preceded the change to a multi-tiered dispatch approach, and thus, the skill needed to deliver high-quality CPR by the resuscitation teams was lacking.

Recently, the EMS of the public fire agency of Gyeonggi province performed focused team-based CPR training in the circumstance of multi-tiered dispatch for OHCA. This study aimed to evaluate the effect of team-based CPR training on the pre-hospital ROSC rates of OHCA patients.

Methods

Study design and participants

This before-and-after study was conducted in Gyeonggi province, South Korea and compared the pre-hospital ROSC rates of OHCA patients. From July to December 2015 and from July to December 2016, non-traumatic OHCA patients who were treated by EMS providers in Gyeonggi province were enrolled. Patients aged <18 years, those who were presumed to have non-cardiac etiologies, whose OHCA was initially witnessed by EMS providers during hospital transport, and those with do-not-resuscitate orders were excluded.

Setting

Gyeonggi province is an area of 10,170 km² with mixed urban and rural areas and a population of approximately 12,549,000 individuals.^{10,11} There are 34 fire stations and 222 ambulances with 1184 emergency medical technicians (EMTs) on active duty, including 799 level 1 EMTs and nurses. In addition, 229 fire engines are equipped with automated external defibrillators. A typical responding ambulance crew consists of 2–3 persons, including one level-1 EMT, and one level-2 EMT. Under the regional standard protocol, they are encouraged to stay and provide CPR for at least 5 min at the scene. Advanced cardiac life support, including advanced airway managements and medications at the scene, are allowed only for level-1 EMTs under direct medical direction by telephone communication with the EMS medical director.

In 2015, the Gyeonggi province fire service recorded 382,217 cases of ambulance transport, and all causes of EMS-assessed cardiac arrests accounted for 6379 cases. The length of time between a call for help and the arrival of EMS was about 7 min and 30 s.¹² Until 2014, the Gyeonggi province fire services employed a single-tiered dispatch system that deployed a single ambulance to respond to EMS calls. However, in 2015, according to the updated

national guidelines, the Gyeonggi province fire services implemented a multi-tiered system that deploys either two ambulances or one ambulance and one fire engine or more when possible for cases of cardiac arrest or suspected severe trauma.

Team-based CPR training

Team-based CPR is a systematic, team-focused approach to cardiac arrest resuscitation where the providers know and practice their individual roles according to their order of arrival at the scene in order to optimize CPR performance. Under this concept and based on the regional standard standing protocol, the first arriving providers initiate high-quality chest compression and apply an automated external defibrillator. Passive oxygen insufflation or back-valve-mask ventilation was recommended, rather than advanced airway insertion, for the first arriving providers. Providers who arrived afterward would then use a manual defibrillator, secure an advanced airway, and attempt intravenous (IV) access for administering medication. The providers were instructed to continue resuscitative efforts for 20 min at the scene or until ROSC was achieved. The whole CPR process was organized and conducted under the direction of the EMT CPR team leader.

The team-based CPR training course focused on the knowledge and skills in team approaches necessary to performing the high-quality CPR, rather than technical skills. The contents of the training were based on the 2015 American Heart Association CPR guidelines.¹³ The training included high-quality chest compression, minimally interrupted CPR, individualized roles according to the order of arrival at the scene, and team leadership behavior. The training course was 4–5 h long, depending on the number of participants in the course. The participants were assessed by the instructor through the participation in role-playing in three types of cases, which were cardiac arrest scenarios.

Selected level 1 EMS providers from each fire station participated in the team-based CPR training course (trainer-training course), which was designed to train participants as instructors for subsequent courses. In each trainer-training course, 24 to 26 EMS providers participated as trainees, and 4 to 6 regional medical directors participated as main instructors. The first 100 EMS providers who were trained through this trainer-training course became team-based CPR instructors. These instructors and two administrative medical directors of fire stations trained the other EMS providers in the province from January to March 2016.

Data collection and variables

The EMS OHCA database (EMS run sheets and EMS cardiac arrest registry) was used to extract data on demographics and pre-hospital Utstein elements. Information at the scene and during transport was recorded on electronic forms on computer tablets by EMS providers, as is the norm in South Korea, with recorded data automatically uploaded to the main server of the fire department. Administrative medical directors who are assigned regional fire stations evaluate all EMS-assessed OHCA records and provide feedbacks to the EMTs. However, a feedback system for the team-based CPR performance was not in operation during the study period. The following variables were extracted from the database and used in the analysis: date, age, sex, location of arrest, witnessed arrest, bystander CPR by laypersons, type of dispatch (single vs. multi-tiered), initial rhythm on EMS arrival, defibrillation by EMTs, advanced airway insertion, IV access, use of epinephrine, and pre-hospital ROSC.

Analysis

The primary outcome was pre-hospital ROSC and was defined as the restoration of palpable pulse after resuscitation, which was maintained until arrival at the hospital. To evaluate the effectiveness of team-based CPR training, we categorized July to December 2015 as the before-training period and July to December 2016 as the after-training period. January to June 2016 was considered a period of training and “settling-in” and the data from this period were, therefore, excluded from the analysis.

The continuous variables are presented as means and standard deviations. The categorical variables are reported as frequencies with percentages. Descriptive analyses of the general characteristics of the patients were conducted. To determine the association between team-based CPR training and study outcomes, adjusted odds ratios (aORs) with 95% confidence intervals (CI) were calculated using multivariable logistic regression analysis, with the before-training group as the reference. We adjusted for age, sex, location of arrest (private vs. public place), witnessed arrest, initial rhythm on EMS arrival, and use of epinephrine as potential confounders (likelihood ratio p-value for variables included in the model <0.25 or judged a significant confounder) in the model. Furthermore, to calculate aORs according to the dispatch types (single vs. multi-tiered), we used a multivariable logistic regression model with an interaction term (period \times type of dispatch) for the outcome. The Hosmer-Lemeshow goodness-of-fit test was performed to evaluate the fit of the logistic regression model. All statistical tests were 2-tailed, with p-values <0.05 considered statistically significant. Statistical analyses were performed using Stata/SE 14.0 (StataCorp, College Station, TX, USA).

Ethical statement

The Institutional Review Board for Clinical Research at Korea University Ansan Hospital approved the use of the EMS OHCA records for this study (2018AS0279). The requirement for informed consent was waived by the board.

Results

In total, 3107 OHCA patients were treated by EMS providers during the study period. After exclusion, the remaining 2125 patients who underwent resuscitation and transportation to a hospital by EMS were included (Fig. 1). Of the included OHCA cases, 1072 (50.4%) and 1053 (49.6%) OHCA occurred before (July–December 2015) and after training (July–December 2016), respectively.

Characteristics of the study participants

The patient characteristics are presented in Table 1. The mean age of the patients was 69.1 ± 15.6 years and 1012 (47.6%) patients were females. The two groups did not differ significantly with respect to age, sex, location of arrest, presence of a witness, and initial presenting rhythm. There were 417 (38.9%) and 884 (84.0%) multi-tiered dispatches in the before- and after-training periods, respectively. EMTs more frequently performed advanced procedures, such as advanced airway insertion, IV access, and epinephrine administration, during the after-training period. The pre-hospital ROSC rates were higher in the after-training period than in the before-training period (6.6% vs. 12.6%) (Fig. 2).

Main outcomes

Logistic regression analyses were performed to identify the factors associated with pre-hospital ROSC (Table 2). The adjusted odds ratio (aOR) of the after-training period for pre-hospital ROSC was 2.07 (95% CI, 1.32–3.25). The aOR of multi-tiered dispatch was 1.03 (95% CI, 0.65–1.62). An additional multivariable logistic regression analysis was performed by considering the interaction of the training periods with dispatch types (Table 3). According to the dispatch types, 17 (10.1%) and 116 (13.1%) patients in the single- and multi-tiered dispatch groups, respectively, had pre-hospital ROSC during the after-training period. After adjusting for other covariables in the interaction model, the aORs for pre-hospital ROSC were 2.00 (95% CI, 1.01–3.98)

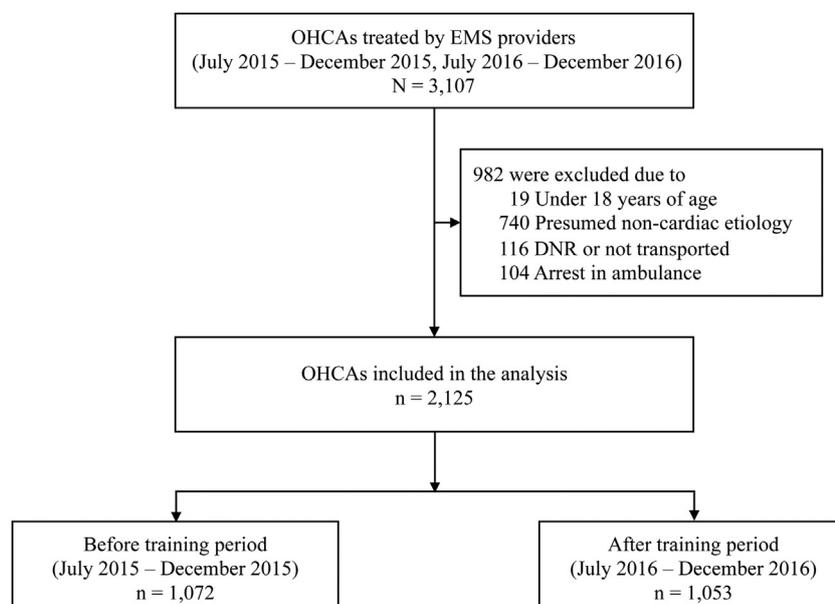


Fig. 1 – Flow diagram of patient enrolment in the analysis OHCA, out-of-hospital cardiac arrest; DNR, do-not-resuscitate; EMS, emergency medical service.

Table 1 – Demographics and outcomes of study participants before and after training.

Variables	Overall (n = 2125)	Before team-based CPR training (n = 1072)	After team-based CPR training (n = 1053)	p value
Age, years, mean ± SD	69.1 ± 15.6	68.9 ± 15.8	69.2 ± 15.4	0.665
Male, n (%)	1113 (62.3)	606 (62.7)	507 (63.3)	0.786
Event at home, n (%)	1306 (61.5)	678 (63.3)	628 (59.6)	0.088
Witnessed arrest, n (%)	1015 (47.8)	505 (47.1)	510 (48.4)	0.541
Provision of bystander CPR, n (%)	1368 (65.9)	659 (63.0)	709 (68.8)	0.005
Shockable rhythm at EMS arrival, n (%)	354 (16.7)	169 (15.8)	185 (17.6)	0.264
Type of dispatch				
Multi-tiered dispatch	1,301 (61.2)	417 (38.9)	884 (84.0)	<0.001
Single-tiered dispatch	824 (38.8)	655 (61.1)	169 (16.1)	
Advanced airway insertion, n (%)	1171 (55.1)	429 (40.0)	742 (70.5)	<0.001
Intravenous access, n (%)	259 (12.2)	85 (7.9)	174 (16.5)	<0.001
Use of epinephrine, n (%)	78 (3.7)	9 (0.84)	69 (6.6)	<0.001
Defibrillation by EMTs, n (%)	497 (23.4)	235 (21.9)	262 (24.9)	0.107
Pre-hospital ROSC, n (%)	204 (9.6)	71 (6.6)	133 (12.6)	<0.001

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; EMT, emergency medical technician; ROSC, return of spontaneous circulation.

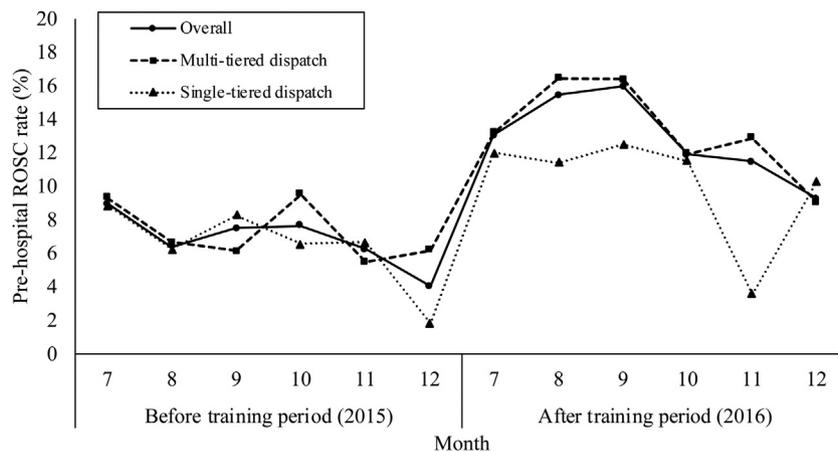


Fig. 2 – Monthly trends of pre-hospital return of spontaneous circulation rates with respect to dispatch type ROSC, return of spontaneous circulation.

and 2.13 (95% CI, 1.20–3.79) in the single- and multi-tiered dispatch groups, respectively, during the after-training period.

Discussion

This study assessed a community-led effort to improve the quality of EMS and showed that team-based CPR training for EMS providers improved pre-hospital ROSC rates of OHCA patients within a provincial community. The authors expected that the effects of team-based CPR training would be greater in a multi-tiered dispatch system because the protocol was optimized for a multi-tiered dispatch system. However, the effects on pre-hospital ROSC by the team-based CPR training according to the dispatch type were not significantly different.

Current resuscitation guidelines emphasize the importance of providing high-quality CPR.¹³ To improve CPR quality, the Gyeonggi province EMS has implemented various measures, including

evaluation of each EMS-assessed OHCA case by medical directors, dispatch center integration for OHCA recognition and telephone-guided CPR instruction, multi-tiered dispatch system implementation, and various types of educational programs.^{9,14,15} Despite such efforts, the pre-hospital ROSC for OHCA in Korea was 4.2% for and the survival discharge rate in 2014 was 4.8%, which were not satisfactory.¹⁶ In particular, the pre-hospital ROSC rate was lower than the survival discharge rate. That was thought to be due to EMS providers in Korea generally performing substandard CPR. Therefore, effective interventions at the pre-hospital level are needed to improve the quality of CPR.

Until 2014, the Gyeonggi province EMS generally dispatched one ambulance for cardiac arrest, however, the smaller number of EMS providers at the scene was considered a major barrier to providing high-quality CPR. A previous preliminary study assessed the effect of implementing a multi-tiered dispatch system in Gyeonggi province and reported that there was no significant difference in pre-hospital ROSC rates between single- and multi-tiered dispatches.⁹ One

Table 2 – Results of the multivariable logistic regression analysis for pre-hospital ROSC.

Variables	Absolute difference, % (95% CI)	Associated OR	
		Crude OR (95% CI)	Adjusted ^a OR (95% CI)
Study period			
Before training	6.0 (3.5–8.5)	1 (reference)	1 (reference)
After training		2.04 (1.51–2.76)	2.07 (1.32–3.25)
Type of dispatch			
Single-tiered dispatch	4.0 (1.5–6.4)	1 (reference)	1 (reference)
Multi-tiered dispatch		1.63 (1.19–2.23)	1.03 (0.65–1.62)
Age	0.3 ^b (–1.1 to 1.8)	0.96 (0.95–0.97)	0.97 (0.96–0.98)
Sex			
Female	4.6 (1.9–7.2)	1 (reference)	
Male		1.80 (1.25–2.59)	0.96 (0.62–1.51)
Location of arrest			
Others	6.2 (9.0–3.5)	1 (reference)	
Home		0.45 (0.37–0.67)	0.83 (0.56–1.22)
Witnessed arrest			
No		1 (reference)	1 (reference)
Yes	10.7 (8.1–13.2)	3.79 (2.72–5.28)	3.49 (2.27–5.37)
Provision of bystander CPR			
No	4.6 (2.1–7.1)	1 (reference)	1 (reference)
Yes		1.76 (1.25–2.46)	1.12 (0.72–1.72)
Shockable rhythm at EMS arrival			
No	33.2 (28.1–38.3)	1 (reference)	1 (reference)
Yes		14.03 (10.19–19.3)	9.35 (6.27–13.94)
Advanced airway insertion			
No	4.5 (2.0–6.9)	1 (reference)	1 (reference)
Yes		1.71 (1.26–2.32)	1.07 (0.69–1.65)
Use of epinephrine			
No	8.7 (0.1–17.3)	1 (reference)	
Yes		2.14 (1.18–3.89)	1.61 (0.77–3.37)

ROSC, return of spontaneous circulation; OR, odds ratio; CI, confidence interval; CPR, cardiopulmonary resuscitation; EMS, emergency medical service. The goodness of fit of the model was tested using the Hosmer-Lemeshow test with chi-square analysis (p = 0.996).

^a Adjusted covariables in the model: age, sex, location of arrest, witness status, bystander CPR, shockable rhythm, type of dispatch, advanced airway insertion, and use of epinephrine.

^b year.

Table 3 – Results of the multivariable logistic regression analysis^a using the interaction term for pre-hospital ROSC.

Type of dispatch	Total, n	Pre-hospital ROSC	
		Pre-hospital ROSC, n (%)	Adjusted OR (95% CI)
Single-tiered dispatch	824		
Before-training period	655	42 (6.4)	1 (reference)
After-training period	169	17 (10.1)	2.00 (1.01–3.98)
Multi-tiered dispatch	1301		
Before-training period	417	29 (7.0)	1 (reference)
After-training period	884	116 (13.1)	2.13 (1.20–3.79)

ROSC, return of spontaneous circulation; OR, odds ratio; CI, confidence interval.

^a Adjusted for age, sex, location of arrest, witnessed status, bystander CPR, shockable rhythm, type of dispatch, advanced airway insertion, use of epinephrine, and interaction term (study period × type of dispatch).

reason for the result is that it is likely that there were no training programs suitable for such a change prior to deployment. For high-quality CPR, it is necessary that each member of the team must perform a specific role, in conjunction with their teammates' efforts.

Although the individual performance and skill of each EMT are important, the coordination and integration of resuscitative efforts of the participating members as an effective team are essential for providing high-quality CPR in the pre-hospital phase. Such team-based approaches are of paramount importance during the often chaotic environment encountered by EMS providers when responding

to OHCA. In the early days of EMS and pre-hospital care, the primary objective when treating OHCA patients was to initiate CPR and quickly transport the patient to the nearest hospital. Although there remains some variability among local protocols, team-based CPR focuses on resuscitative efforts that occur at the scene. In particular, there is an emphasis on basic, fundamental skills such as effective chest compression, rather than on advanced technical skills such as endotracheal intubation.¹⁷

Bobrow et al. reported improved CPR quality and outcomes after implementing scenario-based CPR training and emphasized a team

approach to resuscitation and the importance of CPR quality metrics.⁶ Resuscitation efforts were considered a systematic, team-focused approach where each provider has a predetermined role and responsibility according to their order of arrival at the scene.

Our findings revealed that team-based CPR training for EMS providers improved the pre-hospital ROSC rates of non-traumatic adult OHCA patients. In addition, EMS providers more frequently performed advanced procedures, such as advanced airway insertion, IV access, and epinephrine administration, during the after-training period. This might be due to the higher rate of multi-tiered dispatch in the after-training period. However, advanced procedures did not significantly affect the pre-hospital ROSC.

This study had some limitations. First, the primary outcome was pre-hospital ROSC, and we did not consider the final outcomes of the enrolled patients after in-hospital care. However, pre-hospital ROSC is closely associated with survival to discharge and good neurologic outcomes of OHCA patients.^{5,18–20} Furthermore, survival and neurologic outcomes are affected by many factors such as differences in post-resuscitation care and severity of the underlying cause. In this context, pre-hospital ROSC may better reflect the effect of team-based CPR training and the improvement in EMS provider performance.²¹ Second, because of a lack of CPR feedback devices, CPR quality was not measured. Finally, due to the specific environment and EMS setting of this study, it may not be possible to generalize our findings to every community. However, this study highlights the important role of training for community EMS providers and emphasizes appropriate educational interventions for the proper implementation of new strategies in the community EMS system.

Conclusion

This study revealed that team-based CPR training for EMS providers improved the pre-hospital ROSC rates of OHCA patients. Training for EMS providers may improve CPR quality at the scene, however, further research is needed to determine the best practices in designing a team-based training protocol.

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Conflict of interest disclosure

The authors have no conflicts of interest to report.

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REFERENCES

- 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.
- McNally B, Robb R, Mehta M, et al. Out-of-hospital cardiac arrest surveillance; Cardiac Arrest Registry to Enhance Survival (CARES), United States, October 1, 2005–December 31, 2010. *MMWR Surveill Summ* 2011;60:1–19.
- Ong ME, Shin SD, De Souza NN, et al. Outcomes for out-of-hospital cardiac arrests across 7 countries in Asia: the Pan Asian Resuscitation Outcomes Study (PAROS). *Resuscitation* 2015;96:100–8.
- Bobrow BJ, Clark LL, Ewy GA, et al. Minimally interrupted cardiac resuscitation by emergency medical services for out-of-hospital cardiac arrest. *JAMA* 2008;299:1158–65.
- Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Circ Cardiovasc Qual Outcomes* 2010;3:63–81.
- Bobrow BJ, Vadeboncoeur TF, Stolz U, et al. The influence of scenario-based training and real-time audiovisual feedback on out-of-hospital cardiopulmonary resuscitation quality and survival from out-of-hospital cardiac arrest. *Ann Emerg Med* 2013;62:47–56.
- Weng TI, Huang CH, Ma MH, et al. Improving the rate of return of spontaneous circulation for out-of-hospital cardiac arrests with a formal, structured emergency resuscitation team. *Resuscitation* 2004;60:137–42.
- Stopyra JP, Courage C, Davis CA, Hiestand BC, Nelson RD, Winslow JE. Impact of a “Team-focused CPR” protocol on out-of-hospital cardiac arrest survival in a rural EMS system. *Crit Pathw Cardiol* 2016;15:98–102.
- Cho KH, Park JH, Moon SW, Yun SK, Kim JY. Effect of a multi-tiered dispatch system on out-of-hospital cardiac arrest patients: preliminary report from the Gyeonggi Province, South Korea. *Clin Exp Emerg Med* 2018;5:144–9.
- Korea Statistical Information Service. Population, households and housing units. Daejeon: Statistics Korea; 2018 (Accessed 08 July 2019, at http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_11N1502&conn_path=l2&language=en).
- Brinkhoff T. The registered population of the provinces, counties, cities and city districts in South Korea. Oldenburg: City Population; 2019 (Accessed 08 July 2019, at <https://www.citypopulation.de/php/southkorea-admin.php>).
- Ministry of Public Safety and Security. Statistical yearbook 2015 of 119 emergency services. Sejong: Ministry of Public Safety and Security; 2016.
- Neumar RW, Shuster M, Callaway CW, et al. Part 1: executive summary: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2015;132:S315–67.
- Ro YS, Shin SD, Lee SC, et al. Association between the centralization of dispatch centers and dispatcher-assisted cardiopulmonary resuscitation programs: a natural experimental study. *Resuscitation* 2018;131:29–35.
- Kim JM, Park JH, Hyeon SY, et al. Implementation of a direct medical direction system for 119 EMS providers and expansion of scope of practices under the indirect protocols—experience in Gyeonggi Province. *J Korean Soc Emerg Med* 2015;26:276–85.
- Korea Centers for Disease Control and Prevention. 2006–2017 sudden cardiac arrest survey statistics. Cheongju-si, Korea: KCDC (Korea Centers for Disease Control and Prevention); 2018 (Accessed July 2019, at http://www.cdc.go.kr/board.es?mid=a20503050000&bid=0021&act=view&list_no=142010&tag=&nPage=1).
- Bakalos G, Mamali M, Komninos C, et al. Advanced life support versus basic life support in the pre-hospital setting: a meta-analysis. *Resuscitation* 2011;82:1130–7.
- Drennan IR, Lin S, Sidalak DE, Morrison LJ. Survival rates in out-of-hospital cardiac arrest patients transported without prehospital return of spontaneous circulation: an observational cohort study. *Resuscitation* 2014;85:1488–93.

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19. Wampler DA, Collett L, Manifold CA, Velasquez C, McMullan JT. Cardiac arrest survival is rare without prehospital return of spontaneous circulation. *Prehosp Emerg Care* 2012;16:451–5.
 20. Sasson C, Hegg AJ, Macy M, et al. Prehospital termination of resuscitation in cases of refractory out-of-hospital cardiac arrest. *JAMA* 2008;300:1432–8.
 21. Bonnes JL, Brouwer MA, Navarese EP, et al. Manual cardiopulmonary resuscitation versus CPR including a mechanical chest compression device in out-of-hospital cardiac arrest: a comprehensive meta-analysis from randomized and observational studies. *Ann Emerg Med* 2016;67:349–60.