

Available online at www.sciencedirect.com

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

The effects of route of admission to a percutaneous coronary intervention centre among patients with out-of-hospital cardiac arrest



Joohyun Suh^a, Ki Ok Ahn^{a,*}, Sang Do Shin^{b,c}

^a Department of Emergency Medicine, Myongji Hospital, Hanyang University College of Medicine, Goyang-si, Republic of Korea

^b Department of Emergency Medicine, Seoul National University College of Medicine, Seoul, Republic of Korea

^c Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul, Republic of Korea

Abstract

Aim: Patients with OHCA who are not transported directly to a percutaneous coronary intervention (PCI)-capable hospital may eventually undergo an inter-hospital transfer (IHT). The aim of the present study was to investigate the effects of route of admission to a PCI centre among patients with OHCA.

Methods: We included patients with OHCA of presumed cardiac aetiology that were admitted to a PCI centre between January 2015 and December 2016. The exposure variable was route of admission: direct versus indirect. The 'direct' group was defined as patients who were transferred directly from the field to a PCI centre by emergency medical service (EMS) providers. The 'indirect' group was defined as patients who underwent IHT from a non-PCI centre to a PCI centre. The primary outcome was neurological recovery. We evaluated the effects of route of admission using multivariable logistic regression analysis after adjusting for potential confounders.

Results: There were total of 4363 eligible patients: 3488 (78.2%) in the direct group and 975 (21.8%) in the indirect group. Neurologic recovery was better in the direct group (38.0%) than in the indirect group (29.0%). After adjusting for potential confounders, indirect admission was negatively associated with outcomes (adjusted odds ratio [aOR] 0.70; 95% confidence interval [CI] 0.58–0.85).

Conclusions: The route of admission to a PCI centre is associated with neurological recovery among resuscitated patients with OHCA of presumed cardiac aetiology. This has implications for regionalized EMS transport and IHT protocols for patients with OHCA.

Keywords: Out-of-hospital cardiac arrest, Patient transfer, Coronary intervention, Percutaneous

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major health problem because of its increasing incidence and high fatality rate.¹ A recent meta-analysis reported that the annual incidence of OHCA per 100,000 people was 54.6 in North America, 35.0 in Europe, and 28.3 in Asia.² Survival and neurological outcomes remain notoriously dismal (6%–9%) and are subject to regional variation.^{3,4}

Regionalization of care is recommended to improve outcomes for patients with OHCA, as well as patients with ST-segment elevation

myocardial infarction (STEMI) and trauma.⁵ The 2015 American Heart Association guidelines recommend direct transport to a specialized cardiac resuscitation centre (CRC) for patients with OHCA.⁶ The capability to deliver emergency percutaneous coronary intervention (PCI) is crucial for CRCs. Recently, several studies have reported that direct transport to PCI-capable hospitals is associated with better outcomes, not only for STEMI patients, but among OHCA patients in general.^{7–9}

Although the international consensus is that direct transport to a PCI-capable hospital is desirable, in some regions emergency medical service (EMS) providers transport OHCA patients to the

* Corresponding author at: 679-24 Hwajung-dong, Deokyang-gu, Goyang-si, Gyeonggi-do 412-270, Republic of Korea.

E-mail addresses: joohyun.suh@mjh.or.kr (J. Suh), arendt75@hanyang.ac.kr (K.O. Ahn), sdshin@snu.ac.kr (S.D. Shin).

<https://doi.org/10.1016/j.resuscitation.2019.09.032>

Received 28 June 2019; Received in revised form 27 August 2019; Accepted 29 September 2019

0300-9572/© 2019 Elsevier B.V. All rights reserved.

nearest hospital because of non-regionalized protocols.^{7,10} Patients with OHCA who are not transported directly to a PCI-capable hospital may eventually undergo an inter-hospital transfer (IHT). Several previous studies have reported adverse outcomes among transferred patients with OHCA.^{7,11} However, these studies were conducted in single centres or within a single geographic region. Here, we report our findings based on analysis of a national OHCA database, which encompasses multiple regions.

The objective of this study was to compare outcomes between patients who were directly transported to PCI-capable hospitals and those who underwent IHT. We hypothesized that there would be no significant differences in outcomes according to the route of admission among patients with OHCA.

Methods

Study setting

The Korean EMS is a multi-tiered system for patients with OHCA and is operated by fire departments.¹² According to the national pre-hospital protocol; EMS providers should transport patients with OHCA to the nearest emergency department (ED), regardless of the PCI capacity of the receiving hospital. However, there are no regional CRCs in Korea. The majority of community hospitals do not have protocols for IHT of OHCA patients. Mobile intensive units (MICUs) for IHT have been adopted in only one metropolitan region (Seoul) in Korea since 2016.¹³

Study design and participants

This was a cross-sectional observational study that analysed data from a national Korean EMS-assessed OHCA registry. The pre-hospital data were probabilistically linked to information from medical records held at the hospitals to which patients were transported. Data held by hospitals that patients were transferred to were similarly linked based on patient demographics, time of arrival at the hospital, and the names of the hospitals. Trained medical reviewers extracted data information on outcomes using an Utstein template.¹⁴ Detailed information regarding the data quality management processes of the national EMS-assessed OHCA registry have been described previously.¹⁵

We enrolled adult EMS-treated patients with OHCA of presumed cardiac aetiology who were admitted to PCI-capable hospitals from January 2015 to December 2016. We determined PCI capability whether the hospitals were designated as regional cardiovascular centres or accredited by the Korean Society of Interventional Cardiology (KSIC). As of 2015, 11 regional cardiovascular centres were designated as such by the Korean Ministry of Health and Welfare,¹⁶ and 97 hospitals were KSIC-accredited for PCI.¹⁷ These institutions offer 24/7 PCI availability and operated educational and quality assurance programs pertaining to treatment of cardiovascular disease. To verify performance, these hospitals should carry out at least 100 or more interventional procedures a year.¹⁷

We excluded patients who were transferred from PCI-capable or unknown referring hospitals. We also excluded patients who had unknown ED disposition or outcomes.

The study was approved by the Institutional Review Board of Seoul National University Hospital, and the need for informed consent was waived (IRB number: H-1401-090-550).

Outcomes and variables

The primary outcome in this study was neurological recovery, defined as a Cerebral Performance Category (CPC) score of 1 or 2 at discharge.¹⁸ A score of 1 indicates mild or no neurologic deficit; 2 indicates moderate cerebral disability, 3 severe cerebral disability, 4 coma or vegetative state, and 5 brain death. The secondary outcome was survival to discharge.

The main exposure variable was route of admission to the PCI-capable hospital. We categorized patients into direct and indirect (transferred) groups. The direct group was defined as patients who were directly transported from the field to a PCI-capable hospital by EMS. The indirect group was defined as patients transferred from non-PCI-capable hospitals to PCI-capable hospitals.

Patient demographic and socioeconomic status (SES) data were collected; type of medical insurance was used as a proxy of SES (non-medical aid vs. medical aid).¹⁹ Information regarding community urbanization level (rural, urban, or metropolitan) was collected.²⁰ We also collected data about the circumstances of OHCA, such as witness status, location (public vs. non-public location) and initial echocardiography (ECG) rhythm (shockable vs. non-shockable). Prehospital care information was collected, such as bystander cardiopulmonary resuscitation (CPR), elapsed time before arrival of the EMS provider. Response time interval was defined as the interval between the EMS call to arrival at the scene. Transport time interval (TTI) was defined as the interval between scene departure and arrival at the hospital. We also collected information on the transfer distance (TD) between the referring and receiving hospital. The TD was measured based on the shortest driving distance between the referring and receiving hospitals using an electronic map.

Statistical analysis

Demographic characteristics were analysed according to route of admission. Categorical variables are reported as counts and percentages and were compared via cross-tabulation analysis using the chi-square method. Differences in the distribution of EMS time intervals were examined using Wilcoxon rank-sum tests for continuous variables. Two-sided tests were conducted, and a p value <0.05 was considered statistically significant.

We evaluated the effects of indirect admission on outcomes using multivariable logistic regression analysis. The adjusted odds ratios (aOR) were calculated (95% confidence interval [CI]) for the exposure variable after adjustment for potential confounding factors, such as Utstein variables.

We performed sensitivity analysis of the OHCA patients who achieved ROSC on scene using the same multivariable logistic regression model. These patients are likely candidates for the bypass protocol, which bypasses hospitals with insufficient PCI capacity. The distances between hospitals were calculated in intervals of 10 km, and the proportion of patients within each interval was determined.

Results

Of the 36,259 EMS-assessed adults with presumed cardiac-origin OHCA during the study period, 44.7% were directly transported to PCI-capable hospitals. Among these patients, 3488 (21.5%) were admitted to a hospital. Among patients who were initially

transported to non-PCI-capable hospitals, 975 (6.4%) were transferred to a PCI-capable hospital. A total of 4463 eligible patients were thus admitted to PCI-capable hospitals, excluding patients who were transferred from PCI-capable hospitals or from unknown referring hospitals (Fig. 1).

The baseline characteristics among study groups are compared in Table 1. Among 4363 eligible patients, the direct group included 3488 (78.2%) and the indirect group included 975 (21.8%). The direct group had a higher proportion of males, younger individuals, and cases with shockable rhythm and prehospital ROSC compared with the indirect group. Survival (55.2% vs. 45.8%; $p=0.001$) and neurological recovery (38.0% vs. 29.0%; $p=0.001$) rates were higher in the direct group compared with the indirect group. After adjusting for potential confounders, indirect admission was negatively associated with outcomes (aOR: 0.67; 95% CI: 0.53–0.84 for neurological recovery, and aOR: 0.70; 95% CI: 0.58–0.85 for survival) (Table 2).

The sensitivity analysis for patients who achieved ROSC on scene showed similar results. Among patients admitted to PCI-capable hospitals with OHCA, 1436 (32.2%) achieved ROSC on scene. Table 3 shows the demographic characteristics of the patients in this subgroup according to route of admission. The direct group had higher proportions of males and cases with initial shockable rhythm. Rates of survival (86.3% vs. 73.5%, respectively; $p=0.001$) and neurological recovery (71.8% vs. 62.9%, respectively; $p=0.001$) were higher in the direct group compared with the indirect group. After adjusting for potential confounders, the indirect group showed poorer outcomes (aOR: 0.64; 95% CI: 0.46–0.89 for neurological recovery and aOR: 0.41; 95% CI: 0.28–0.59 for survival) (Table 4).

Fig. 2 shows the distribution of TD in 10 km intervals. The proportion of patients within each interval decreased with distance from the hospital. Within the indirect group, 27.6% patients were transferred to PCI-capable hospitals within 10 km. Interestingly, among patients who achieved ROSC on scene, a small peak in TD was observed around 40–50 km.

Discussion

This nationwide study of OHCA cases with presumed cardiac origin found that direct EMS transport to a PCI-capable hospital was associated with improved neurological recovery and survival to discharge compared with transfer via non-PCI-capable hospitals. This association remained significant across the subgroup of patients who achieved ROSC on scene.

The indirect group had poorer outcomes compared with the direct group, even after adjustment for potential cofounders. There are several possible explanations for these results. Firstly, it is possible that transferred patients experienced insults such as hypotension or hypoxia during IHT. In the previous study, 6% of patients experienced a re-arrest, and 23% of patients with OHCA experienced critical events during IHT; neurologic recovery was less frequent in patients who experienced such critical events during IHT.²¹ Secondly, delayed post-resuscitation care in the indirect group could be associated with poor outcomes. Previous studies have reported that patients who received PCI for 150 min or longer after arrest were less likely to show neurological recovery compared with those who received an early intervention.²² In the indirect group, patients would have been delayed by the ED length of stay and the IHT time, at the minimum. Finally, the indirect group had arrest characteristics suggesting poor prognosis for the outcomes that were assessed; this is consistent with previous studies,⁸ and is considered to be due to transport decisions made for patients during the prehospital and hospital phases. In the prehospital phase, EMS providers are more likely to transport patients who have favourable prognostic factors to a PCI-capable hospital, even if it is not the nearest hospital. In the present study, TTI was longer in the indirect group than in the direct group. In the hospital phase, patients showing full neurological recovery in the ED are not likely to be transferred to PCI-capable hospitals. A previous study suggested that IHT criteria should include neurological impairment after ROSC (Glasgow Coma Scale score < 6).²³

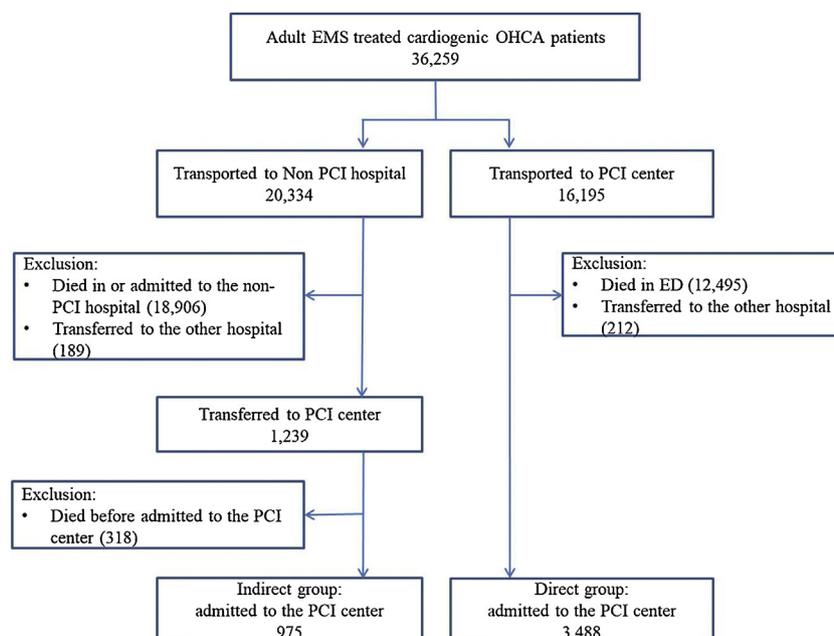


Fig. 1 – Flow of patient selection.

OHCA: out-of-hospital cardiac arrest, ED: emergency department, PCI: percutaneous coronary intervention.

Table 1 – Baseline characteristics and clinical outcomes according to the route of admission.

	Total	Indirect group		Direct group		p-Value
		(n = 975)		(n = 3488)		
		N	(%)	N	(%)	
Sex						0.0026
Male	3292	686	(70.4)	2606	(74.7)	
Age group (year)						0.0225
>65	1864	437	(44.8)	1427	(40.9)	
≤65	2599	538	(55.2)	2061	(59.1)	
Medical insurance						0.55
National healthcare insurance	4162	909	(93.2)	3253	(93.3)	
Medical benefit system	301	66	(6.8)	235	(6.7)	
Community urbanization						0.0001
Metropolitan	3169	345	(35.4)	2824	(81.0)	
Rural	333	216	(22.2)	117	(3.4)	
Urban	961	414	(42.5)	547	(15.7)	
Place of arrest						0.186
Non public	3353	748	(76.7)	2605	(74.7)	
Public	1110	227	(23.3)	883	(25.3)	
Witnessed by bystander						0.332
Yes	3193	699	(71.7)	2494	(71.5)	
Bystander CPR						0.11
Yes	1250	276	(28.3)	974	(27.9)	
Initial ECG rhythm						0.012
Non-shockable	2253	519	(53.2)	1734	(49.7)	
Shockable	2210	456	(46.8)	1754	(50.3)	
Prehospital ROSC						0.007
Yes	2095	411	(42.2)	1684	(48.3)	
EMS time interval (minute median (IQR))						
Response time		7	(5–9)	6	(5–8)	0.0001
Transport time		5	(3–10)	6	(4–10)	0.0001
Clinical outcomes						
Survival to discharge	2374	447	(45.8)	1927	(55.2)	0.0001
Neurological recovery	1607	283	(29.0)	1324	(38.0)	0.0001

Abbreviations: CPR, cardiopulmonary resuscitation; ECG, electrocardiography; ROSC, return of spontaneous circulation; IQR, inter-quintile range.

Table 2 – Multivariable analysis of clinical outcomes in total cohort.

	Indirect, n/N (%)	Direct, n/N (%)	Adjusted OR	(95% CI)
Neurologic recovery	283/975 (29.0)	1324/3488 (38.0)	0.67	(0.53–0.84)
Survival	447/975 (45.8)	1927/3488 (55.2)	0.70	(0.58–0.85)

Adjusted variables: Age, sex, socioeconomic status, urbanization level of arrest, place of arrest, witness status, bystander CPR, initial rhythm, prehospital return of spontaneous circulation, and response time interval.

We performed sensitivity analysis for the OHCA patients who achieved ROSC on scene. These patients are good candidates for the bypass protocol, which bypasses non-PCI-capable hospitals. These results could be used to determine the benefits of applying regionalized transport protocols. Several regionalized protocols target OHCA patients who achieve ROSC in the field.²³ A previous study suggested that the time required for patients with OHCA to bypass the nearest hospital is about 14 min.²⁴ In Arizona, EMS providers can transport patients with OHCA to CRCs when feasible; transporting a patient to a CRC will add less than 15 min to the transport time compared with delivering the patient to a non-CRC.²³ Based on an assumed average transport speed of 50 km/h, the distance that can be covered in 15 min is about 10 km. Within the

indirect group, 27.6% of patients were transferred to PCI-capable hospitals within 10 km in this study.

Fig. 2 illustrates an interesting feature of TD, namely, a small peak around 40–50 km. Assuming that the patients were transported by ground, the most common transportation method in Korea, patients within this small peak would have been in transit for more than 1 h. Although they may have been expected to be able to withstand long transfer times because of their stable condition, this time in transit still poses a risk. This group accounts for more than 20% of all IHT patients.

This study had several limitations. Firstly, clinical and physiological characteristics in post-resuscitation states, such as mental status and haemodynamic instability, were not considered. Secondly, we did not

Table 3 – Baseline characteristics and clinical outcomes according to the route of admission in patients were achieved prehospital return of circulation on scene.

	Total	Indirect group (n = 275),		Direct group, (n = 1161)		p-Value
		N	(%)	N	(%)	
Sex						0.018
Male	1155	207	(75.3)	948	(81.7)	
Age group (year)						0.204
>65	403	86	(31.3)	317	(27.3)	
≤65	1033	189	(68.7)	844	(72.7)	
Medical insurance						0.87
National healthcare insurance	1369	263	(95.6)	1106	(95.3)	
Medical benefit system	67	12	(4.4)	55	(4.7)	
Community urbanization						0.001
Metropolitan	1028	97	(35.3)	931	(80.2)	
Rural	102	49	(17.8)	53	(4.6)	
Urban	306	129	(46.9)	177	(15.3)	
Place of arrest						0.94
Non public		181	(65.8)	767	(66.1)	
Public	488	94	(34.2)	394	(33.9)	
Witnessed by bystander						0.74
Yes	1132	219	(79.6)	913	(78.6)	
Bystander CPR						0.56
Yes	296	53	(19.3)	243	(20.9)	
Initial ECG rhythm						0.09
Non-shockable	248	57	(20.7)	191	(16.5)	
Shockable	1188	218	(79.3)	970	(83.6)	
EMS time interval (minute median (IQR))						
Response time		6	(5–9)	6	(5–8)	0.17
Transport time		5	(3–9)	7	(4–11)	0.001
Clinical outcomes						
Survival to discharge	1204	202	(73.5)	1002	(86.3)	0.001
Neurological recovery	1007	173	(62.9)	834	(71.8)	0.001

Abbreviations: CPR, cardiopulmonary resuscitation; ECG, electrocardiography; IQR, inter-qtile range.

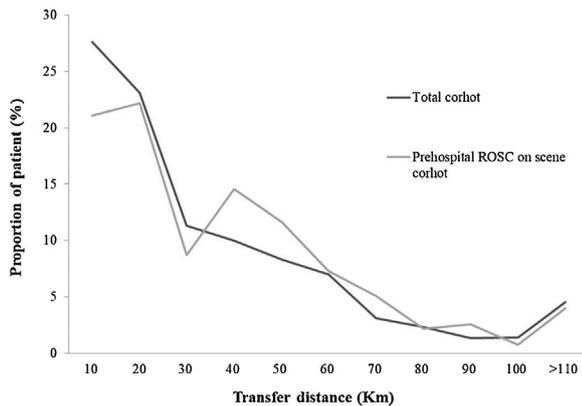


Fig. 2 – Distribution of interhospital transfer distance for all patients, and for prehospital return of the spontaneous circulation cohort.

include the IHT process, during which critical events may occur that affect outcomes; we could not directly measure the effect of critical events during IHT on outcomes. Finally, we had no information on post-resuscitation care at PCI-capable hospitals in the indirect group. There were controversies over differences in the rate of post-resuscitation care,

Table 4 – Multivariable analysis of clinical outcomes in patients were achieved prehospital return of circulation on scene.

	Indirect, n/N (%)	Direct, n/N (%)	Adjusted OR	(95% CI)
Neurologic recovery	173/275 (62.9)	834/1161 (71.8)	0.64	(0.46–0.89)
Survival	202/275 (73.5)	1002/1161 (86.3)	0.41	(0.28–0.59)

such as PCI and targeted temperature management (TTM) depending on the route of admission (direct vs. indirect). A previous study reported that indirectly transported patients received more TTM compared with directly transported patients (27.6% vs. 46.3%).²⁵ Conversely, another study reported no difference in early coronary angiograms between direct and indirect groups.⁸

Conclusions

Direct transport to a PCI-capable hospital is associated with outcome benefit for patients with OHCA. This has implications for regionalized EMS transport and IHT protocols for patients with OHCA.

Financial support

This study was financially supported by the Korea Centers for Disease Control and Prevention (CDC). Grant number [2009-E00543-00,2010-E33022-00, 2011-E33004-00, 2012-E33010-00, 2013-E33015-00, 2014-E33011-00].

Conflict of interest

All authors report no conflicts of interest.

Contributorship statement

- (1) The conception and design of the study, or analysis and interpretation of data: Dr. Suh, and Dr. Ahn.
- (2) Drafting the article or revising it critically for important intellectual content: Dr. Suh and Dr. Ahn.
- (3) Acquisition of data and Obtained funding: Dr. Shin.
- (4) Final approval of the version to be submitted: All authors.

REFERENCES

1. Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics — 2018 update: a report from the American Heart Association. *Circulation* 2018;67–492.
2. Berdowski J, Berg RA, Tijssen JGP, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. *Resuscitation* 2010;81:1479–87.
3. Sasson C, Rogers MAM, 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.
4. Nichol G, Thomas E, Callaway CW, et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. *JAMA* 2008;300:1423–31.
5. Nichol G, Aufderheide TP, Eigel B, et al. Regional systems of care for out-of-hospital cardiac arrest: a policy statement from the American heart association. *Circulation* 2010;121:709–29.
6. Kronick SL, Kurz MC, Lin S, et al. Part 4: systems of care and continuous quality improvement. *Circulation* 2015;132:S397–413.
7. Nikolaou NI, Welsford M, Beygui F, et al. Part 5: acute coronary syndromes. *Circulation* 2005;112:.
8. McKenzie N, Williams TA, Ho KM, et al. Direct transport to a PCI-capable hospital is associated with improved survival after adult out-of-hospital cardiac arrest of medical aetiology. *Resuscitation* 2018;128:76–82.
9. Kragholm K, Malta Hansen C, Dupre ME, et al. Direct transport to a percutaneous cardiac intervention center and outcomes in patients with out-of-hospital cardiac arrest. *Circ Cardiovasc Qual Outcomes* 2017;10:1–9.
10. Kim S, Ahn KO, Ro YS, Shin S Do. Factors associated with the transfer decision in resuscitated patients with out-of-hospital cardiac arrest presenting to a hospital with limited targeted temperature management capability in Korea. *Ther Hypothermia Temp Manag* 2018;00:1–7.
11. Roberts BW, Kilgannon JH, Mitchell JA, et al. Emergency Department inter-hospital transfer for post-cardiac arrest care: initial experience with implementation of a regional cardiac resuscitation center in the United States. *Resuscitation* 2013;84:596–601.
12. Park JH, Shin S Do, Ro YS, et al. Implementation of a bundle of Utstein cardiopulmonary resuscitation programs to improve survival outcomes after out-of-hospital cardiac arrest in a metropolis: a before and after study. *Resuscitation* 2018;130:124–32.
13. Kim TH, Song KJ, Shin S Do, Ro YS, Hong KJ, Ho Park J. Effect of specialized critical care transport unit on short-term mortality of critically ill patients undergoing interhospital transport. *Prehosp Emerg Care* 2019;0:1.
14. Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein resuscitation registry templates for out-of-hospital cardiac arrest: a statement for healthcare professionals from a task force of the international liaison committee. *Circulation* 2015;132:1286–300.
15. Ahn KO, Shin S Do, Suh GJ, et al. Epidemiology and outcomes from non-traumatic out-of-hospital cardiac arrest in Korea: a nationwide observational study. *Resuscitation* 2010;81:974–81.
16. Kim A, Yoon SJ, Kim YA, Kim EJ. The burden of acute myocardial infarction after a regional cardiovascular center project in Korea. *Int J Qual Heal Care* 2015;27:349–55.
17. The KPCI Certification System. http://www.kscvi.org/new_ksic2015_en/certification/info.php.
18. Edgren E, Hedstrand U, Kelsey S, Sutton-Tyrrell K, Safar P. Assessment of neurological prognosis in comatose survivors of cardiac arrest. BRCT I Study Group. *Lancet* 1994;30:1055–9.
19. Kim TH, Ro YS, Shin S Do, et al. Association of health insurance with post-resuscitation care and neurological outcomes after return of spontaneous circulation in out-of-hospital cardiac arrest patients in Korea. *Resuscitation* 2019;135:176–82.
20. Ro YS, Shin S Do, 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.
21. Hartke A, Mumma BE, Rittenberger JC, Callaway CW, Guyette FX. Incidence of re-arrest and critical events during prolonged transport of post-cardiac arrest patients. *Resuscitation* 2010;81:938–42.
22. Jeong J, Ro YS, Shin S Do, Song KJ, Hong KJ, Ahn KO. Association of time from arrest to percutaneous coronary intervention with survival outcomes after out-of-hospital cardiac arrest. *Resuscitation* 2017;115:148–54.
23. Cournoyer A, Notebaert É, de Montigny L, et al. Impact of the direct transfer to percutaneous coronary intervention-capable hospitals on survival to hospital discharge for patients with out-of-hospital cardiac arrest. *Resuscitation* 2018;125:28–33.
24. Spaite DW, Bobrow BJ, Vadeboncoeur TF, et al. The impact of prehospital transport interval on survival in out-of-hospital cardiac arrest: implications for regionalization of post-resuscitation care. *Resuscitation* 2008;79:61–6.
25. Park JH, Ahn KO, Shin S Do, et al. A multicentre observational study of inter-hospital transfer for post-resuscitation care after out-of-hospital cardiac arrest. *Resuscitation* 2016;108:34–9.