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ORIGINAL RESEARCH

Factors Associated with Return of Spontaneous Circulation following Pre-Hospital Cardiac Arrest in Daegu Metropolitan City, South Korea; a Cross-Sectional Study

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Abstract: **Introduction:** The probability of Return of Spontaneous Circulation (ROSC) in cardiac arrest cases in pre-hospital setting is still low. This study aimed to identify the factors that may improve the rate of ROSC in patients with pre-hospital cardiac arrest. **Methods:** This retrospective cross-sectional study is a secondary data analysis of cardiac arrest patients, who were managed by paramedics in the pre-hospital setting, from January 1, 2019, to December 31, 2019, in Daegu, South Korea. The association of ROSC with place of arrest occurrence, cardiac arrest being witnessed, performing cardiopulmonary resuscitation (CPR), using compression device and defibrillator, administration of epinephrine, and intubation was analyzed and independent predictive factors of ROSC were reported. **Results:** 2750 out-of-hospital cardiac arrest cases, which were managed by paramedics in the pre-hospital setting were studied. 2034 (86.9%) cases of arrest had occurred at home, 2028 (73.7%) were not witnessed, and CPR was not performed for 1721 (64.1%) cases. ROSC before arriving to emergency department (ED) was more probable if the cardiac arrest was witnessed ($p < 0.001$), if CPR was performed ($p = 0.044$), if a mechanical compression device was used ($p < 0.001$), if a first-aid defibrillator was used ($p < 0.001$), and if intravenous access was secured ($p < 0.001$). Multivariate regression analysis revealed that using mechanical compression device (OR: 0.18; 95% CI = 0.08 - 0.40; $p = 0.001$), using first-aid defibrillator (OR: 3.13; 95% CI = 1.40 - 6.99; $p = 0.005$), administration of epinephrine (OR: 6.57; 95% CI = 2.16 - 19.53; $p = 0.001$), and intubation (OR: 1.82; 95% CI = 1.04-3.19; $p = 0.001$) were independent predictive factors of ROSC before arrival to ED. **Conclusion:** It seems that chest compression by hand instead of using chest compression device, using defibrillator, epinephrine administration, and intubation my increase the probability of ROSC in pre-hospital arrest cases.

Keywords: Out-of-Hospital Cardiac Arrest; Return of Spontaneous Circulation; Patients; Korea

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1. Introduction

The rate of death due to cardiovascular system disease in South Korea was 117.4 per 100,000 people in 2019 (1). Sudden cardiac arrest (SCA) results in death due to hemodynamic failure if the heart is not restarted in minutes (2). In the United States, more than 550,000 patients suffer SCA, before and during hospitalization, each year. SCA accounts for more than half of cardiovascular mortalities and is a major national concern (3).

The probability of patients recovering from cardiac arrest that occurred before hospital arrival in Korea increased from 1.1% in 2007 to 7.6% in 2017, but this recovery rate is still very low compared to developed countries, such as the U.S. 11.4%, Sweden 14.0%, and Norway 13.0% (4, 5). To solve the practical problems associated with emergency medical treatment, the Korean government has been actively studying the prevention and management of diseases by establishing cardiovascular and cerebrovascular prevention centers in Korea (6).

Daegu Metropolitan City (DMC) in southeastern Korea has the fourth largest population (2.4 million) in the country. The rate of emergency department (ED) deaths among ED users

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in DMC was 0.418%, which was the highest in the country (7). Identifying the factors that influence the Return of Spontaneous Circulation (ROSC) in patients with out-of-hospital cardiac arrest (OHCA), where a rapid response is required, may improve community participation and emergency care. Previous studies have shown that pre-hospital factors that are closely related to the patient survival rate include: whether the patient was witnessed, if witnesses performed cardiopulmonary resuscitation (CPR), and whether the ROSC occurred spontaneously (8, 9). However, the factors that affect ROSC have not been studied in depth by country or region. Because the environment and emergency medical care resources in each country are different, rapid treatment and methods of coping with patients who have pre-hospital cardiac arrest may also differ. This study aimed to identify the factors that may improve rate of ROSC in patients with pre-hospital cardiac arrest.

2. Methods

2.1. Study design and setting

This retrospective cross-sectional study is a secondary data analysis of cardiac arrest patients, who were managed in the pre-hospital setting by paramedics, from January 1, 2019, to December 31, 2019, in Daegu, South Korea. The association of arrest characteristics with ROSC were analyzed and independent predictive factors of ROSC were reported. The data in this study were approved and obtained from the emergency activity log and cardiopulmonary arrest detailed situation chart prepared by paramedics at the DMC Fire Department. We obtained approval from the K University Institutional Review Board (IRB) for the exemption of deliberation (IRB- 1041459-202103-HR-003-01). We anonymized the emergency activity log and the details of the cardiopulmonary arrest detailed situation table.

2.2. Participants

Cases for which CPR was withheld or suspended by paramedics due to apparent death or other causes were not considered. Specifically, the subjects included in this study were cases of cardiac arrest provided by the Daegu Metropolitan City Fire Department.

2.3. Data gathering

For data collection, the purpose and suitability of the study were explained to the head of the DMC Fire Department, and data use was approved. This study selected and investigated items that may affect ROSC, as suggested by the emergency activity log and the detailed cardiopulmonary arrest schedule prepared by paramedics. In addition, vaguely written items, for example, subjects with blanks on whether or not to recover spontaneous circulation or subjects whose occurrence location is not clear, were reassessed until the two researchers agreed.

Table 1: Baseline characteristics of studied out-of-hospital cardiac arrest cases

Characteristics	Number (%)
Underlying disease	
Yes	1879 (90.3)
No	202 (9.7)
Occurrence place	
House (parking lot, yard)	2034 (86.9)
Ambulance	99 (4.2)
Nursing institution (medical facility)	101 (4.3)
Other	106 (4.6)
Witnessed	
Yes	722 (26.3)
No	2028 (73.7)
CPR performed	
Yes	963 (35.9)
No	1721(64.1)
Using mechanical chest compression device	
Yes	856 (39.6)
No	1307 (60.4)
Using first-aid defibrillator	
Yes	223 (8.1)
No	2527 (91.9)
Epinephrine administered	
Yes	380 (31.7)
No	819 (68.3)
Intubation performed	
Yes	504 (42.0)
No	695 (58.0)
Recovery of spontaneous circulation	
Yes	187 (14.3)
No	1120 (85.7)

* The sum of the case numbers may not match the total number due to the missing data.
CPR: cardiopulmonary resuscitation.

The dependent variables were the ROSC and independent variables were the type and place of occurrence, whether there were witnesses to the cardiac arrest, if CPR was performed, if a mechanical compression device or first-aid defibrillator was used, whether epinephrine had been administered intravenously, and if intubation was performed.

The raw data were provided by the DMC Fire Department, and to ensure the anonymity of patients, data such as name, gender, age, and occupation of the patients were deleted. In this study, two experts in the relevant field gathered and selected variables suitable for this study. And the selected variables were used after final review by one emergency medical expert.

2.4. Statistical analysis

In this study, the IBM SPSS/WIN 23.0 Program was used for data analysis. To confirm the difference in ROSC based on

Table 2: Association between different pre-hospital arrest characteristics and return of spontaneous circulation (ROSC) before arriving to emergency department

Characteristics	ROSC*		P
	Yes (n = 187)	No (n = 1120)	
Underlying disease			
Yes	159 (15.7)	852 (84.3)	0.850
No	9 (16.4)	46 (83.6)	
Place of occurrence			
House (parking lot, yard)	101 (12.0)	742 (88.0)	
In an ambulance	13 (13.8)	81 (86.2)	0.872
Nursing institution (medical facility)	6 (9.5)	57 (90.5)	
Other	7 (13.0)	47 (87.0)	
Witnessed			
Yes	122 (19.9)	490 (80.1)	0.001
No	65 (9.4)	630 (90.6)	
CPR performed			
Yes	117 (16.0)	616 (84.0)	0.044
No	58 (11.1)	464 (88.9)	
Using mechanical chest compression device			
Yes	61 (7.1)	795 (92.9)	0.001
No	107 (27.6)	281 (72.4)	
Using first-aid defibrillator			
Yes	89 (40.3)	132 (59.7)	0.001
No	98 (9.0)	988 (91.0)	
Epinephrine administered			
Yes	87 (23.0)	291 (77.0)	0.001
No	13 (6.4)	189 (93.6)	
Intubation performed			
Yes	80 (15.9)	422 (84.1)	0.052
No	20 (25.6)	58 (74.4)	

* The sum of the case numbers may not match the total number due to the missing data. Data are presented as number (%).
CPR: cardiopulmonary resuscitation.

the subjects' general characteristics, we calculated the frequency and percentage and performed a cross-analysis using a χ^2-test. We conducted a complex sample logistic regression analysis to identify the factors that affected ROSC. In this study, statistics were applied to the raw data without manipulation or alteration.

3. Results

3.1. Baseline characteristics of participants

2750 out-of-hospital cardiac arrest cases, which were managed by paramedics in pre-hospital setting were studied. Table 1 summarizes the baseline characteristics of studied arrest cases. 2034 (86.9%) cases of arrest had occurred at home, 2028 (73.7%) were not witnessed, and CPR was not performed for 1721 (64.1%) cases.

3.2. Associated factors of ROSC before arriving to ED

The recovery of spontaneous circulation was experienced by 187 (14.3%) cases. Table 2 evaluates the association of ROSC with different pre-hospital arrest characteristics. Based on univariate analysis, ROSC before arriving to ED was more probable if the cardiac arrest was witnessed (χ^2 = 29.727, p < 0.001), if CPR was performed (χ^2 = 6.232, p = 0.044), if a mechanical compression device was used (χ^2 = 95.596, p < 0.001), if a first-aid defibrillator was used (χ^2 = 146.241, p < 0.001), and if intravenous access was secured (χ^2 = 25.364, p < 0.001). Multivariate regression analysis introduced using mechanical compression device (OR: 0.18; 95% CI = 0.08 - 0.40; p = 0.001), using first-aid defibrillator (OR: 3.13; 95% CI = 1.40 - 6.99; p = 0.005), administration of epinephrine (OR: 6.57; 95% CI = 2.16 - 19.53; p = 0.001), and intubation (OR: 1.82; 95% CI = 1.04-3.19; p = 0.001) as independent predictive factors of ROSC before arrival to ED (table 3).

4. Discussion

It seems that chest compression by hand instead of using chest compression device, using defibrillator, epinephrine administration, and intubation may increase the probability of ROSC in pre-hospital arrest cases.

This study showed that mechanical compression devices

Table 3: Association between different pre-hospital arrest characteristics and return of spontaneous circulation (ROSC) before arriving to emergency department

Characteristics	B	OR	95% CI	P
Using mechanical chest compression device				
Yes	-1.70	0.18	0.08-0.40	0.001
No	1.00	1.00		
Using first-aid defibrillator				
Yes	1.14	3.13	1.40-6.99	0.005
No	1.00	1.00		
Epinephrine administration				
Yes	1.88	6.57	2.16-19.53	0.001
No	1.00	1.00		
Intubation performed				
Yes	0.60	1.82	1.04-3.19	0.001
No	1.00	1.00		

OR: odds ration; CI: confidence interval.

are less effective than manual CPR in achieving ROSC. This result contradicts prior studies (10, 11) that showed that mechanical compression devices were more effective than CPR in achieving ROSC and a review of 1,187 systems that showed no significant difference between mechanical compression devices and hand CPR in achieving ROSC (12). This conflict may be a result of the situational environment, as paramedics in Korea tend to prefer hand CPR over mechanical compression unless the ambulance ride is long. In addition, mechanical compression devices are not always available in ambulances across Korea.

This study determined that a first aid defibrillator increased the probability of ROSC by 3.13 times. A previous study (13) suggested that improvements in CPR quality and automated external defibrillator (AED) availability can improve the likelihood that a patient will survive heart failure. The latest advanced life support (ALS) guidelines suggest that about 20% of patients with out-of-hospital cardiac arrests experience ventricular tachycardia or ventricular fibrillation (14). In pre-hospital patients, especially during ventricular tachycardia or ventricular fibrillation, a reduction in the time before AED is applied increases the probability of obtaining ROSC (15). This finding is consistent with the results of a study conducted only on cardiac arrest patients who had been treated using an AED, which showed that defibrillation was possible 63.6 ~ 70.8% of the time, resulting in a high rate of ROSC (16, 17). Therefore, early application of an AED to restore appropriate rhythms can achieve ROSC and contributes to the survival of pre-hospital cardiac arrest patients.

This study also showed that intravenous administration of epinephrine increased the likelihood of ROSC before arrival at the emergency room. Previous studies found (18) that epinephrine injection during an out-of-hospital cardiac arrest increases the probability of both ROSC and short-term survival. In general, epinephrine should be injected as soon as possible when arrhythmia does not respond to AED (19). In another study (20), the average time before intravenous injection during cardiac arrest outside the hospital was 19.4 minutes. People who receive injected epinephrine within 10 minutes are approximately 4.52 times more likely to show ROSC than those who receive it within 30 minutes. Although this study only investigated the administration of epinephrine, based on previous studies, it is believed that the rapid injection of epinephrine, will have a positive effect on ROSC. These findings suggest that when pre-hospital cardiac arrest occurs, rapid treatment by paramedics and fast and skilled application of intravenous epinephrine is needed. However, paramedics have different proficiencies, so the success of intravenous epinephrine application can vary. Korea is training paramedics on securing intravenous access, but the difference in paramedic skill levels must be corrected.

Finally, in this study, intubation increased the probability of ROSC before arrival in the emergency room. In cardiopulmonary resuscitation, cardiac output and coronary perfusion pressure are related to ROSC in cardiac arrest patients, and provision of sufficient respiratory volume through appropriate intubation during CPR is an important factor in ROSC (21). Therefore, it is considered that intubation can contribute to improving the survival rate of out-of-hospital cardiac arrest patients.

The various independent variables that were identified should be verified. The effects of time on spontaneous circulation should be evaluated. For example, the relationship between the time of emergency room arrival or the time to achieve intravenous access and the probability of ROSC must be examined.

In addition, the samples provided in this study are raw data, in which personal characteristics, such as gender, age, and occupation, which may affect ROSC, have been deleted to ensure anonymity. So, if these factors are presented more

clearly, it can help to identify their probable effect on ROSC. we suggest that continuous CPR education should be provided for residents. CPR education is being provided on a regional basis in Korea, but has not been implemented across the country. Therefore, national support may improve the CPR capabilities of local people. Increasing the number of emergency rooms is also necessary, as this tends to be proportional to the population, making them unavailable to residents who live outside of cities.

5. Limitations

This study used raw data of acute cardiac arrest patients in Daegu Metropolitan City during 1 year in 2019. However, it should be noted that there is a limit to confirming the factors influencing ROSC in patients with acute cardiac arrest with one year of data from one region. Because, a capital city with a population close to 10 million like Seoul or the current COVID-19 situation could affect ROSC. Therefore, a study using multi-year data will be helpful in more accurately identifying the influencing factors.

6. Conclusion

It seems that chest compression by hand instead of using chest compression device, using defibrillator, epinephrine administration, and intubation may increase the probability of ROSC in pre-hospital arrest cases.

7. Declarations

7.1. Acknowledgments

We would like to thank the Daegu Metropolitan City Fire Department and its staff for their cooperation in the research. It is expected that this study will contribute to the improvement of ROSC.

7.2. Authors' contributions

Conceptualization: Hyun-Ok Jung, Seung-Woo Han
Data curation: Hyun-Ok Jung, Seung-Woo Han
Methodology: Seung-Woo Han
Project administration & Supervision & Validation: Seung-Woo Han
Writing-original draft, review & editing: Hyun-Ok Jung, Seung-Woo Han

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7.4. Conflict of interest

No potential conflict of interest was reported by the authors.

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