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The Effect of Cardiac Arrest Simulation Training Using Mechanical CPR Device on Chest Compression Quality of Paramedics in Pre-Hospital

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Abstract

Background/Objectives: It is to establish a transport plan in a situation where it is difficult to maintain the quality of CPR due to the building structure by measuring the difference in quality of CPR in the field and transport process of pre-hospital cardiac arrest patients.

Method/Statistical Analysis: For this purpose, simulated CPR training for OHCA patients who were not seen in the field was performed on the 78 EMT trainees enrolled in firefighter school in K region. The simulated training was performed by dividing them into two groups such as one group using manual CPR and the other group using mechanical CPR (LUCAS2™) in the stage of field and the transport composed of stairs and corridors in a four-story building.

Findings: The quality of chest compression implemented at the field does not satisfy all the requirements of the guideline, but provided sufficient depth and rate of the pressure. The values of the measured CPR quality showed that CPR in the transport was lower than that in the field. The chest press quality was lower- in particular the depth of chest press was about 20mm lower and it did not meet the 2015 Guidelines of the CPR Association in Korea. On the other hand, the group using LUCAS2™ in the transport stage showed steady and even press depth and appropriate press and relaxation without degradation of the quality comparing to CPR in the field, all guidelines are satisfied. Although there is much controversy about the improvement of chest compression quality using CPR devices leading to improved survival rates, the use of CPR devices should continue to be considered in these unstable environments.

Improvements/Applications: Conclusively, in the transport process where there are structural difficulties, the group using LUCAS2™ could meet the Guidelines of the CPR Association when performing CPR which plays important role in increasing revival rate of OHCA patients. It can be the ground of using mechanical CPR devices in the future.

Keywords: *Pre-Hospital Cardiac Arrest, OHCA, CPR quality, Mechanical CPR device, LUCAS, Chest compression quality.*

Introduction

The most important thing in pre-hospital cardiac arrest is high quality cardiopulmonary resuscitation (CPR). The guidelines of the Korean Association of Cardiopulmonary Resuscitation (KACPR), revised in 2015, recommend the 5 cm depth of chest compression and suggest a rate of 100-120 times per minute in adult cardiac arrest patients. They suggest that cessation of chest compressions should be minimized to less than 10 seconds, and the artificial respiration should not be excessive [1].

In Korea, the person in charge of CPR at the pre-hospital level is 119 paramedics. Given the low bystander

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CPR in Korea, 119 paramedics' CPR skills are very important, and the ability cultivation for paramedic's professional CPR play a significant role in improving the survival rate of cardiac arrest patients.

This study is designed to reveal differences in the quality of CPR at fields and transport stages, particularly in structurally poor buildings, and to identify the effectiveness of mechanical CPR devices. The domestic research on the transport stage is very poor compared to efforts to improve CPR quality at the field and the hospital, and as a result of that, the situation is that the planning for proper transport of paramedics is also not organized. Due to various complex structure of building types, the quality of the manual chest compressions during the transfer process is likely to decrease [2]. In addition, when cardiac arrest occurs in complex, high-rise building types, the most big problem is the time delaying for that paramedics contact the patient and do the initial CPR, and it is highly likely that they will not be able to provide high quality CPR in process of transfer to the hospital and the process of transfer to the hospital and the overall transfer time will likely be long [3-4]. Therefore, it is desirable to establish a transport plan accordingly and to use additional equipment if possible, in order to reduce the quality degradation of pre-hospital CPR at poor fields and to provide stable and consistent high-quality CPR [5-6]. In particular, it is necessary to discuss the application of a mechanical CPR device in a step, corridor, or ambulance, where the quality of the chest compression is inevitably structurally low [7].

There are many pros and cons of idea on the effectiveness mechanical CPR device. The 2015 guideline ofKACPR describes that when mechanical CPR devices were applied to patients with pre-hospital cardiac arrest, they showed almost the same figure in short-term and long-term survival rates, and that there was no evidence that they should replace manual CPR in both the method of the load distribution belts applied and the piston method that presses the sternum [8-10]. Some of research shows that patients have more internal damage compared to manual CPR, as a result of the experiments with equipment like mechanical CPR device [11]. However, these results are an example of CPR in a typical environment. We cannot exclude the characteristics of the Korean living environment, which accounts for 60% of apartments where is poor for transporting patients. Therefore, although there were no significant differences in typical CPR procedures, the separate studies on device application in poorly structured buildings or other unfavorable conditions for patient transport are required. Significant improvement in survival rate and brain function recovery rate will be done if high quality chest compressions are possible during the transport stage from the field to the ambulance. Therefore, full-scale discussions on the application of CPR devices in poor conditions are required.

Method

Object of Study: The object of study is consisted of 55 firefighter and 23 new firefighter. The experiment was conducted on a total of 13 groups.

This study is organized into the team CPR simulation practice regular courses in the organization's curriculum. The researchers worked in the organization and have explained the purpose and effectiveness of the study directly to the objects of study. The additional training on the effectiveness and feedback of this study were given to the object of this study, and the face-to face consent from the study participants on the use of the result of study were obtained.

2. Study Design and Tool:

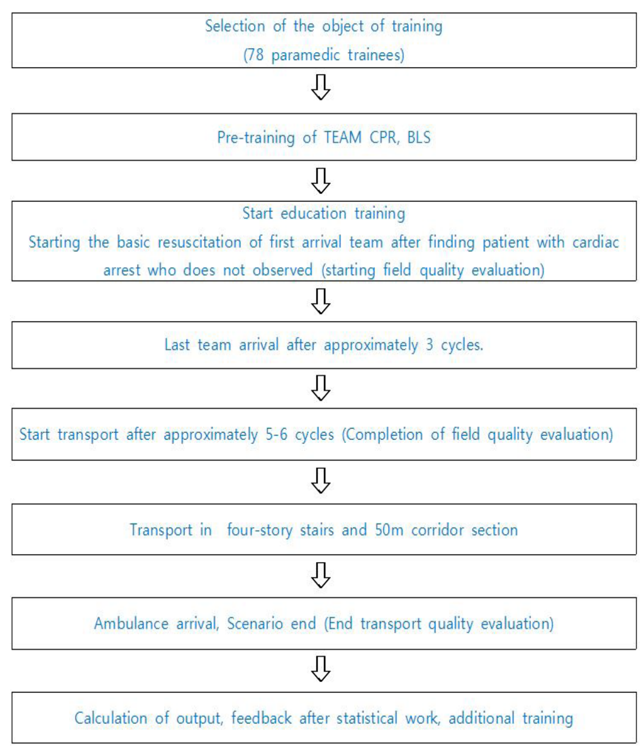

Figure 1. Study Design

In figure 1,assumption that emergency paramedics are dispatched, the scenario-type training method that provide the situation of pre-hospital cardiac arrest and perform the CPR are applied.

Figure 2. Descending through the stairs using a long spine plate

In figure 2,each team deal with the same situation of total one time, and the required time is about between 10 minutes and 15 minutes each. The scenario is a situation of cardiac arrest that has not been observed in a four-story building, and it will be divided into a case where CPR is performed in the field for about 10 minutes and perform the manual chest compressions during transport and a case that perform the chest compression using the mechanical CPR device. The transport was carried out using an ambulance stretcher for a distance about 50 meters to the ambulance after descending through the stairs using a long spine plate in a four-story building. All team evaluators consisted of the 6 members which are 3 first arrival team and 3 last arrival team, and each team's scenario have applied the same basic resuscitation scenario.

Figure 3. Descending through the stairs using a mechanical CPR device

In figure 3, three of the 13 teams are ordered to use a mechanical CPR device (hereinafter referred to as "LUCAS2") at the transfer stage to descend the stairs, pass the corridor, and transfer to the ambulance.

The training was conducted by one scenario with the field and transport, and the 26 data values were extracted from total 13 groups by pausing and restarting at stage of the end of the site and beginning of the transport in order to separate the data for numerical comparison.

The equipment such as LUCAS2 (PHYSSIO CONTROL, USA) and Resusci Anne Simulator TM (Laerdal, Norway) were used.

Result and Discussion

Quality comparison of manual chest compression in the field/transport stage: In the field, the depth and compression rate were 58.7 mm and 118.8 per minute. However, the figure was slightly lower in complete chest recoil rate and the exact compressive rate, which can be interpreted as excessive compression exceeding 60 millimeters.

In the transport stage, the speed of the chest compressions did not decrease with 119 times per minute, but the mean compressive depth was reduced by approximately 25 mm from approximately 58.7 mm at the field to 33.43 mm in transit ($p<0.05$). In addition, the exact compressive rate was also reduced from approximately 37.4% to 11.7% ($p = 0.031$).

This is consistent with the prior assumption that the quality of the chest compressions in the transport stage will be significantly lower than at the field stage.

In the transport stage, it is shown the significantly lower chest compressive depth than in the field. Fixing patients on mobile stretchers and transporting them to stairs or corridors has fundamental limitations in implementing quality chest compressions due to structural limitations, no matter how hard paramedics try. The resuscitation rate of the patient can be greatly reduced [12]. Therefore, if it needed to transport for a long time from the field to ambulance, the mechanical CPR device should be used or another tactical transport method should be considered.

Table 1. Quality of manual cardiopulmonary resuscitation in field and transport stage

Variable	Field		In transit		t	p
	M	SD	M	SD		
Mean chest compressive depth (mm)	58.7	2.8	33.4	5.6	10.597	0.000**
Complete chest recoil rate (%)	40.8	18.3	93.7	7.8	-7.001	0.000**
Exact chest compression rate (%)	37.4	26.2	11.7	9.1	2.451	0.031*
Chest compression (/min)	118.8	2.1	119.2	2.4	-0.352	0.731

*: p<0.05, **:p<0.001

Quality comparison of LUCAS chest compression in the field and transport stage: By recording mean 52.5 mm in field and also 53.0mm in transport, comparison results of chest compressions showed no statistically significant difference.

This is consistent with the prior hypothesis as a result from the mechanical characteristics of automatic cardiopulmonary resuscitation devices.

Table 2. Quality of mechanical cardiopulmonary resuscitation in field and transport stage

Variable	Field		In transit		t	p
	M	SD	M	SD		
Mean chest compressive depth (mm)	52.5	0.7	53.0	1.4	-0.447	0.698
Complete chest recoil rate (%)	89.0	2.8	95.0	1.4	-2.683	0.115
Exact chest compression rate (%)	86.5	4.9	96.0	1.4	-2.610	0.121
Chest compression (/min)	101.0	0.0	101.0	0.0	1.259	0.335

*: p<0.05, **: p<0.001

Quality comparison of chest compression of manual/LUCAS2 in transport stage: When comparing manual CPR and LUCAS2in the transport stage, the mean chest compressive depth of LUCAS2was 53.0mm and manual CPR was 33.4mm.The mean chest compressive depth of LUCAS2 in the transport stage is statistically significant difference compared to manual CPR ($p<0.002$) by recording the pressure depth and the number of pressures. In addition, LUCAS2 had better figures than manual CPR in the section of complete chest compressive rate (M-CPR 11.71%, LUCAS2™ 96.00% $p<0.005$).It can be seen that LUCAS2 provides significantly higher quality chest compression than manual chest compressions at the transport stage in side of chest compressive depth.

When comparing manual CPR and LUCAS2in the transport stage, the mean chest compressive depth of LUCAS2was 53.0mm compared that the mean chest compressive depth of manual CPR was 33.4mm. The mean chest compressive depth of LUCAS2 in the transport stage is statistically significant difference compared to manual CPR ($p<0.002$) by recording the pressure depth and the number of pressures consistent with the guidelines. In addition, LUCAS2 had better figures than manual CPR in the section of complete chest compressive rate ($p<0.005$).It can be seen that LUCAS2 provides significantly higher quality chest compression than manual chest compressions at the transport stage in side of chest compressive depth, complete chest recoil rate, exact chest compressive rate.

Table 3. Quality comparison of chest compression of manual/CPR device in transport stage

Variable	Field		In transit		t	p
	M	SD	M	SD		
Mean chest compressive depth (mm)	33.4	5.6	53.0	1.4	-4.664	0.002*
Complete chest recoil rate (%)	93.7	7.8	95.0	1.4	-0.221	0.832
Exact chest compression rate (%)	11.7	9.1	96.0	1.4	-12.421	0.000**
Chest compression (/min)	119.2	2.4	101.0	0.0	10.137	0.000**

*: $p<0.05$, **: $p<0.001$

The chest compressive depth of manual CPR at stable field was recorded to the mean 58.7 mm, and the chest compressive speed was recorded to 18 times per minute. This is in accordance with the standard "'The depth of chest compression should be about 5 cm [13], and not more than 6 cm [14]. The speed is suggested 100 ~ 120 times per minute and this can be said that the chest compression of the appropriate quality is made. However, there were many cases of excessive pressure of more than 60 mm and the many trainees were generally tended to show incomplete relaxation. This is an area that needs to be improved by education. In the transport stage, it is shown the significantly lower chest compressive depth than in the field. This suggests that serious problems may occur with coronary artery blood flow rate and cerebral blood flow rate in patients [15]. Fixing patients on mobile stretchers and transporting them to stairs or corridors has fundamental limitations in implementing quality chest compressions due to structural limitations, no matter how hard paramedics try [7].

Conclusion

As a result of this study, the field stage recorded the depth and speed of meeting the 2015 guideline of Korean Association of Cardiopulmonary Resuscitation. In comparison, the transfer stage, which consists of stairs and corridors, had a quality deterioration in chest compressive depth of about 20 mm. This suggests that there is a structural limitation where high quality CPR is difficult to take in the transport stage, which becomes a factor to reduce blood flow pressure in patients with cardiac arrest and thus reduces survival rate. On the other hand, the mechanical CPR device provided a constant chest compressive speed and depth without any quality deterioration in the transport stage compared to manual CPR.

In conclusion to sum up, paramedics cannot maintain proper CPR quality through manual CPR in the transport stage, and in such situations, mechanical CPR device can help maintain the quality of CPR. This pattern is similarly shown in precedent studies comparing manual CPR and mechanical CPR in structurally difficult situations such as latest stairs and corridors. Therefore, the results of this study have a same position as the conclusions and suggestions of precedent studies, and at least in order to maintain quality of CPR in the transport stage, mechanical CPR device should be actively considered.

Ethical Clearance: Not required

Source of Funding: Self

Conflict of Interest: Nil

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