

Case Report

Deterioration of Cardiopulmonary Resuscitation Performance on a Moving Stretcher

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Keywords

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Abstract

Objectives: Performing effective cardiopulmonary resuscitation (CPR) is essential for favorable outcomes after cardiac arrest. However, maintaining high-quality CPR while transporting a patient on a stretcher is challenging, due to multiple distracts on rescuers attention from CPR. We hypothesized that quality of compression is influenced by the speed of the stretcher movement.

Methods: This study is a prospective randomized, crossover simulation study. EMTs of the fire department were recruited. Participants were enrolled if their quality of CPR were adequate on standing position (compression depth ≥ 5 cm). Each participant performed chest compression in three scenarios for one cycle (30 compressions) in a random order. Scenarios were differentiated by the speed of stretcher; stopped (0 km/hr), walking (4 km/hr), and running (8 km/hr). The primary outcome was the percentage of adequate compression depth.

Results: In total, 35 participants were included for the final analysis. All were male, median age was 39 yr (Interquartile range (IQR):31-44). Average duration of job experience was 3 yr (IQR:2-10). Percentage of adequate compression depth decreased significantly when the stretcher moved (91.6% (stopped) vs 70.8% (walking), 70.6% (running)). Compression rate was also increased during running state ($p=0.02$).

Conclusion: We found that compression depth was significantly influenced by movement of stretcher.

INTRODUCTION

Performing effective cardiopulmonary resuscitation (CPR) is essential for favorable neurological outcomes after cardiac arrest [1-4]. High-quality chest compression is one of the most important parts of effective CPR because it maintains cardiac output and brain perfusion [5].

Recent studies have shown that out-of-hospital cardiac arrest (OHCA) patients had poor survival rates when they received CPR during transport [6,7], which is likely due to frequent interruption and deterioration of chest compression quality [8-11]. Maintaining high-quality CPR while transporting a patient on a stretcher is challenging due to the height and width of the stretcher, which may consequently distract rescuer attention from CPR. Watching for steps and rescuer fatigue may also be obstacles in achieving appropriate chest compressions [8]. In order to avoid this problem, on-site termination of resuscitation

(TOR) is one strategy employed in advanced prehospital systems [12-14]. However, cultural and legislative issues prohibit terminating CPR in the field in many nations, especially in Asia [12,15]. Under these circumstances emergency medical technicians (EMTs) have no choice but to continue CPR during transport process.

Studies of stretcher-CPR have focused on comparisons of CPR quality between stretchers and the ground, most of which is due to the height of stretcher [5,16]. However, movement of the stretcher may also be a factor, because higher stretcher speeds demand more energy and concentration. We hypothesized that quality of compression is influenced by the speed of stretcher movement.

MATERIALS AND METHODS

Study design and protocol

This study was approved by the Samsung Medical Center Institutional Review Board. This study has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Subjects received written information about the study and provided written informed consent. The study was a prospective randomized, cross-over simulation study using the cardiopulmonary resuscitation (CPR) manikin Training system (Ambu® Smart Man, USA). The manikin was an adult model. Study subjects were emergency medical technicians (EMT) in a fire department with training and experience on stretcher CPR. Subjects received written information about the study and provided informed consent. Subjects also had to show appropriate compression depth (average depth greater than 5 cm) during one-cycle on a stopped stretcher to be enrolled for the study. We excluded these subjects to minimize the effect of stretcher height, which is a known factors diminishing quality of compression.

Three different stretcher speed scenarios were used in this study: stopped, walking, or running. Each participant performed chest compression for one cycle (30 compressions) at each of the three speed, with a 1-minute break between scenarios. The stretcher was pulled by a research assistant with help by a secondary person measuring distance and time lapse. The order of the stretcher speeds was randomly assigned to each participant via the cluster randomization method. Each participant went through one of six sets of scenarios (Figure 1). For stopped chest compression, participants performed continuous chest compression on a manikin placed on a stretcher (Model DLX-EZ Saver, SUNGWOO Special Vehicles CO., height: 850mm). For walking and running scenarios, participants performed continuous chest compression beside the stretcher while it was moving at a walking (about 3-4 km/h) or running pace (about 7-8 km/h). For participant safety, the straddling technique was not allowed. Bag-valve-mask ventilation was not performed. Stretcher speed was controlled manually by measuring the distance and time before and during each scenario.

Data collection

Before participating in the scenarios, all participants were

asked to complete a questionnaire describing their age, gender, height, weight, and job experience. Compression variables including the total number of compressions, compression depth, compression rate, number of compressions at the correct depth (greater than 5cm), and number of complete releases (depth of hands on chest less than 0.1 inch) were collected by the manikin using the PC Skill Reporting system software provided by the company (Ambu® SmartMan, USA).The system provides a function of counting exact number of compression per minute. Participants were blinded from the outcome of their performance.

Outcome measures

The primary outcome measure in this study was the percentage of chest compressions at a depth greater than 5cm. Secondary outcome measures included compression rate and percentage of compressions with correct release.

Data analysis

Sample size calculation indicated that 35 participants would be required to detect a 35% change in compression depth between walking and running, with a significance level of 0.05 and 90% power.

Data were entered into a Microsoft Excel 2010 (Microsoft Corporation, USA) spreadsheet and analyzed using STATA 11 for Windows (Stata Corp LP, College Station, TX). Continuous variables are presented as medians and interquartile range and compared using the Wilcoxon's signed-rank test. Categorical variables are presented as number and percentage and analyzed using the Chi squared test. Outcome measures are reported as medians (interquartile range) and compared using the Kruskal-Wallis test, or reported as mean±SD and compared with ANOVA. A *p* value less than 0.05 was considered significant.

RESULTS AND DISCUSSION

Seventy-one EMTs were involved in this study, but only 35 participants (89.7%) were included in the final analysis. Three participants were excluded due to input errors, and one due to poor data quality (Figure 2). Median age was 39 yr (Interquartile range (IQR): 31-44). All were male with height of 176 cm (IQR:

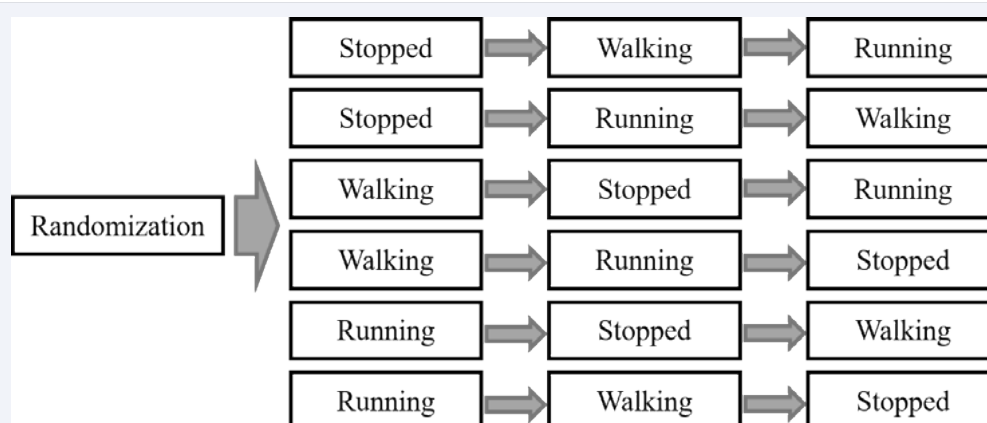


Figure 1 Description of randomization process. Each participant went through one of six sets of scenarios after randomization generated by computer software.

172-180) with weight of 77 kg (IQR: 70 – 80). Calculated body mass index (BMI) was 24.5 (IQR: 22.9-26.2). The duration of job experience was 3 yr (IQR: 2-10).

The average percentage of correct compression depth was 91.6% (95% CI 86.9%-96.2%) when the stretcher was stopped, 70.8% (95% CI 59.3%-82.3%) at walking pace, and 70.6% (95% CI 59.1%-82.2%) at running pace. There was a significant difference in compression depth between stopped and walking ($p=0.001$, mean difference 20.7%, 95% CI 8.60%-32.9%). The average depth also showed significant decrease with moving speed ($p=0.02$) (Table 1).

The average compression rate was 128 per minute (95% CI: 107-146) at stopped stage, 125 (95% CI: 115-146) at walking pace, and 154 (95% CI: 122-158) at running pace. Though the trend showed significant association ($p=0.02$), we found significant difference only between walking and running pace ($p=0.03$). There was no significant association between correct release and moving state ($p=0.07$) (Table 2).

This study demonstrated that stretcher movement was

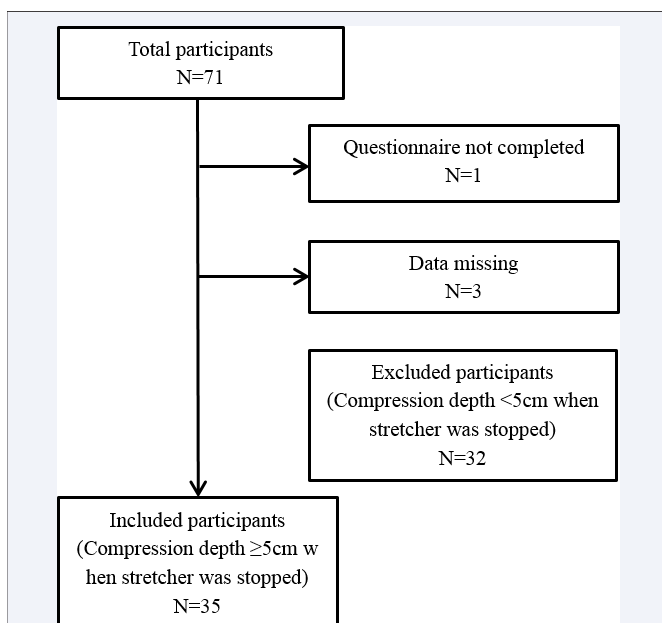


Figure 2 Enrollment of study participants. Participants were excluded from the study if their average compression depth was < 5cm when the stretcher was stopped.

Table 1: Baseline characteristics of study participants.	
Variable	Participants (n=35)
Age (years)	39 (31-44)
Male (n)*	35 (100.0)
Height (cm)	176 (172-180)
Weight (kg)	77 (70-80)
BMI	24.5 (22.9-26.2)
Job experience (years)	3 (2-10)
Variables were presented as median (interquartile range).	

associated with quality of chest compression. Previous studies also reported that CPR quality deteriorates during stretcher CPR [5,16,17]. However, those studies compared compression quality on a stretcher with compression on the floor only, while we assessed the potential association between CPR quality and stretcher speed, in the hopes of determining an ideal stretcher speed when transporting patients who require CPR. We tried to minimize the effect of stretcher height on CPR quality, which is a known major obstacle for compression quality [18].

This result could be especially valuable to Asian countries. With advanced EMS system, some protocols recommend terminating care in the field if the OHCA patient has a very low chance of survival, rather than attempting to transport them to a hospital [19,20]. However, in the majority of Asian countries including Korea, it is very difficult for an EMT to declare death [15,21].

In this study, stretcher movement was a risk factor, and stretcher speed appeared to impact CPR quality. Stretcher movement was associated with decreased compression depth and increased rate. This suggests that additional measures are required to improve quality of CPR on a stretcher, which can deliver uniform compression quality regardless of its speed. Novel technology such as mechanical CPR or a feedback device may be a solution.

This study has several limitations. First, we excluded participants who did not perform well in order to focus on the effect of stretcher speed. Although necessary, this method makes it difficult to apply the results of this study to the emergency medical service (EMS) system as a whole.

Second, only male EMTs were included in the final analysis as a result. It is widely known that CPR performance is associated with rescuer height, weight, and BMI [22,23], and gender. Though the majority of EMTs are male in most parts of the world, readers should be cautious when applying the results of this study to female EMTs. The displacement of mattress along with its softness is also a contributing factor of CPR quality, which was not considered in this study [24,25].

Third, we only measured performance for one cycle of CPR. Providers may become fatigued more quickly in moving situations. Limiting the observation interval to a single cycle may have increased the possibility of a type II error. Another limitation may be the fact that this study did not use additional CPR performance indicators.

Finally, we did not verify the exact speed of the stretcher each time. We measured traveling distance and time before and during the study to standardize the speed. However, a study assistant pulled the stretcher, and thus human error is a possibility.

CONCLUSION

In this study, the compression quality is worse when the stretcher moves faster. The depth showed less quality when walking and running, the rate was faster when running.

Table 2: Differences of chest compression performance based on moving speed of a stretcher.

N=35	Stopped	Walking	Running	p-value
% of correct depth†	91.6 (86.9-96.2)	70.8 (59.3-82.3)*	70.6 (59.1-82.2)***	0.001
Depth (cm)	5.82 (5.21-6.45)	5.41 (4.98-6.30)	5.31(4.44-6.22)***	0.02
Rate (per min)	128 (107-146)	125 (115-146)	143 (122-158)**	0.02
% of correct release‡	42.4 (29.1-55.6)	55.3 (42.7-68.0)	51.5 (40.4-62.7)	0.07

Data were analyzed using student t-test and reported as mean (95% CI). *p* values were from ANOVA.

* *p*-value <0.05 for stopped vs. walking

** *p*-value <0.05 for walking vs. running

*** *p*-value <0.05 for stopped vs. running

†% of correct depth; percentage of chest compressions at a depth greater than 5cm

‡% correct release; percentage of chest compressions with a depth of hands on chest less than 0.1 inch

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