

Evaluation of Chest Compression Quality and Appropriateness in the Pediatric Cardiopulmonary Resuscitation

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Abstract

Background/Objective: This study aimed to verify the quality and the appropriateness of pediatric CPR chest compressions according to 2015 Korean Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.

Method/Statistical Analysis: The participants of this study were 64 EMT and nursing students who were qualified as BLS providers. Four sets of 5 CPR cycles were performed with one hand and two hands at the ratio of chest compression (30 times) to respiration (2 times), and fatigue was confirmed by NRS (numeral rating scale). Collected data were analyzed using frequency, descriptive statistics, paired t-test, and repeated measure ANOVA by SPSS 22.0.

Findings: While the total number of chest compressions (629.6 times vs. 618.3 times, $p=.016$) and hands-off time (6.6 sec vs. 6.9 sec, $p=.006$) were effective for one-handed chest compression, average pressure depth (42.2mm vs. 43.8mm, $p<.001$), sufficient chest compression depth rate (83.0% vs. 89.1%, $p=.038$) and fatigue (7.0 points vs. 6.2 points, $p=.040$) were more effective in two-handed chest compressions. In addition, there were significant differences in the average chest compression depth over time ($p=.003$) and the total elapsed time ($p=.332$), but no significant difference in inappropriate chest compression.

Improvements/Applications: Performing pediatric CPR according to the 2015 Guidelines for Pediatric Cardiopulmonary resuscitation is acceptable, but it is necessary to consider two-hand chest compression more than one hand compression.

Keywords: Chest compression; children; cardiopulmonary resuscitation; depth; quality.

Introduction

Rapid cardiopulmonary resuscitation (CPR) by bystanders is one of the key factors in the survival chain to save a patient from cardiac arrest^[1]. Fast and effective cardiopulmonary resuscitation by bystanders in children, as in adults, helps the return of spontaneous

circulation and neurological recovery. In children, the difference in survival rate varies according to the cause of cardiac arrest. In the cardiac arrest due to respiratory arrest, the survival rate of neurologically normal person is about 70%, and 20-30% in the case due to ventricular fibrillation^[2]. The quality of chest compressions is an important factor in CPR. It is also important to deliver chest compressions of sufficient depth^[1]. If an infant is unresponsive and not breathing, 30 chest compressions should be performed immediately, since proper chest compressions under cardiac arrest maintain blood flow to major organs and increase the possibility of spontaneous circulatory recovery. Appropriate chest compressions in children should be delivered at a

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rate of 100-120 times per minute at a depth of at least one-third of the diameter (chest thickness) between anterior and posterior thorax, or depth of 4-5cm^[3-5]. In a preceding study, spontaneous circulatory recovery was best when chest compressions were performed at a rate of 125 times per minute^[6], while other studies reported that the best survival discharge rates were at a rate of 100-120 times per minute^[7]. Another important factor in the quality of cardiopulmonary resuscitation is the problem of incomplete recoil that can occur during chest compressions. No human studies have yet been conducted but animal testing has confirmed that the relationship between incomplete recoil and cardiac output is inversely proportional. Therefore, effective pediatric cardiopulmonary resuscitation requires the chest compression at least one-third of the depth (approximately 4-5cm), anterior and posterior diameter, of thoracic cavity with palms of one or both hands on the lower half of the sternum. Whether one hand or two hands are used, the proper depth should be maintained for each pressure applied without pressing the xiphoid process while ribs and chest being relaxed back to its normal position after each chest compression^[8-9]. Another important aspect of CPR quality is the chest compression fraction. This is the proportion of chest compressions in the total cardiopulmonary resuscitation. The higher the chest compression fraction, the less the hands-off time and the higher the chest compression fraction, the higher the survival rate^[10-11]. Yet another concern in the quality of CPR is the rescuer's fatigue which was associated with inappropriate speed, depth and chest recoil from chest compression^[12]. However, differences in the quality and the appropriateness of chest compression between one-handed or two-handed pediatric CPR have not been sufficiently demonstrated yet and required further research. Therefore, this study examined the quality and the appropriateness of chest compressions using one or two hands for pediatric CPR to provide the basic data for improving the quality of pediatric CPR in the future.

Method

This study was a single group, post-design experimental study to check the quality and the appropriateness of one- or two-handed chest compressions in pediatric CPR.

The participants of this study were those who completed Basic Life Support (BLS) provider qualification and agreed to participate among the

third and fourth-grade students in the department of emergency technology and nursing at one university in Jecheon. The number of subjects was 64 using G*Power 3.1.9 with the effect size of .30, the significance level of .05, and power of .80. 70 patients were selected in consideration of the dropout rate, and the final analysis included 64 people except dropouts.

All cardiopulmonary resuscitation procedures were assessed and recorded with the Laredal Resusci Junior QCPR™ mannequin. According to the results of previous studies evaluated to assess the quality and the appropriateness of one- or two-handed chest compressions in pediatric CPR, in single pediatric cardiopulmonary resuscitation, if a child (i.e., the mannequin) was unresponsive and not breathing, the CPR provider placed the patient on flat floor and 30 chest compressions at a rate of 100-200 times per minute, at least one-third, 4-5cm depth, of the thoracic cavity, should be delivered immediately^[4]. The chest compression time averaged 7.28 minutes after the on-site arrival time following the report to 119 emergency services while averaging 10.86 minutes from the emergency scene to the hospital^[13]. Assessment of the quality and appropriateness of chest compressions in adult CPR found changes in the average chest compression depth and appropriate compression rates over time^[14]. Based on this prior study and its theoretical basis, to evaluate the quality and the appropriateness of one- or two-handed chest compressions in pediatric CPR, 30 chest compressions and two artificial respirations were delivered in four sets (eight minutes) of five cycles using one-handed method on the first day and two-handed method on the second day. The age, height, weight, and qualification year of BLS provider were recorded as general characteristics of the subjects. The quality of chest compressions was checked for total number of chest compression, average pressure depth, sufficient chest compression depth ratio, sufficient chest compression recoil rate, average compression rate, and hands-off time. The adequacy of chest compression over time was determined by measuring the average chest compression depth with number of inappropriate chest compression, meaning that the fewer inappropriate chest compression, the more appropriate the chest compression were. The fatigue level of the subjects was assessed using with the numerical recording scale (NRS) immediately after the CPR was completed. CPR difficulty was evaluated on the scale of 0 to 10, where 10 points was the most difficult. The ratio of chest compression to artificial respiration was

30:2, but respiration was excluded from the evaluation criteria to assess the quality and the appropriateness of chest compression.

This study was conducted from May 14-17, 2019, by the researcher who has no conflict of interest in the subject. SPSS Windows 22.0 was used to analyze the collected data and the general characteristics of the subjects were presented using descriptive statistics of frequency, percentage, mean, and standard deviation. Differences between the quality of one-handed and two-handed chest compression were analyzed by paired t-tests while the appropriateness of chest compression over time being analyzed by paired t-test and repeated measurement of ANOVA.

The data were collected after obtaining approval from the Institutional Review Board (IRB) (IRB No: D*-2019-04-001-02) of D University located in Jecheon for ethical consideration of the subjects. The Researcher without conflict of interest explained to the participants about the purpose, method, expected results, and method of handling unexpected problems. The confidentiality of the study and the voluntary participation were also explained. The survey with the evaluation was conducted after receiving written consent from the subjects who agreed to participate in the research.

Result

[Table 1] shows that forty female students (62.5 percent) and 43 (67.2 percent) BLS providers certified in 2017 were included in the study. The average age, height, and weight of the participants were 20.94 (±1.75) years, 167.5(±8.43)cm, and 62.41(±0.87kg, respectively. As [Table 2] indicates, analysis of the quality of chest compressions delivered by one- and two-handed pediatric CPR showed that the total number of chest compressions (629.6 times vs. 618.3 times, one-handed vs. two-handed, respectively; p=.016) and the hands-off time (6.6sec vs. 6.9sec, one-handed vs. two-handed,

respectively; p=.006) were more effective in one-handed chest compressions. The average compression depth (42.2mm vs. 43.8mm, one-handed vs. two-handed, respectively; p<.001) was more appropriate for two-handed chest compressions. The sufficient chest compression depth rate (83.0% vs. 89.1%, one-handed vs. two-handed, respectively; p=.038) and fatigue score(7.0 points vs. 6.2 points, one-handed vs. two-handed, respectively; p=.040) were better in two-handed chest compression. However, there was no significant difference between sufficient chest compression recoil rate (98.2% vs. 96.0%, one-handed vs. two-handed, respectively; p=.079) and average compression rates (108.9 times vs. 108.8 times, one-handed vs. two-handed, respectively; p=.924).

Table 1. Analysis of the frequency of the subject’s common matters (n=64)

Variable	Category	N (%)	Mean±SD
Gender	Male	24(37.5)	
	Female	40(62.5)	
Age	19~20	11(17.2)	20.94±1.75
	21-25	51(79.7)	
	26 or higher	2(3.1)	
Weight	40~50kg	6(9.4)	62.41±10.87
	51~60kg	22(34.4)	
	61~70kg	18(28.1)	
	71~80kg	11(17.2)	
	81~90kg	6(9.4)	
Height	140~150cm	1(1.6)	167.5±8.43
	151~160cm	9(14.1)	
	161~170cm	29(45.3)	
	171~180cm	20(31.3)	
	181~190cm	5(7.8)	
BLS provider certified	2017	7(10.9)	
	2018	43(67.2)	
	2019	14(21.9)	

Table 2. Chest compressions quality (n=64)

Variable	One-hand	Two-hands	t	p
Total number of chest compressions (n)	629.6±47.88	618.3±42.90	2.476	.016
Mean chest compression depth (mm)	42.2±0.30	43.8±0.24	-4.149	<.001
Sufficient chest compression rate(%)	83.0±21.73	89.1±15.17	-2.114	.038
Sufficient chest compression recoil rate (%)	98.2±8.02	96.0±6.82	1.786	.079
Mean chest compression speed	108.9±8.16	108.8±7.68	0.095	.924
Hands off time (sec)	6.6±1.14	6.9±1.10	-2.832	.006
Fatigue (NRS)	7.0±1.88	6.2±2.43	1.879	.040

In the appropriateness of chest compressions, the mean depth of chest compression (2min: 43.3mm vs. 44.3mm, $p=.007$; 4min: 42.5mm vs. 44.1mm, $p<.001$; 6min: 42.6mm vs. 44.2mm, $p=.001$; 8min: 42.7mm vs. 44.4mm) differed statistically over time ($p=.003$) and with the total time elapsed ($p=.043$). Inadequate chest compressions (2min: 11.8 times vs. 11.7 times, $p=$

.954; 4min: 15.6 times vs. 10.5 times, $p=.051$; 6min: 16.4 times vs. 9.9 times, $p=.028$; 8min: 15.8 times vs. 12.6 times, one-handed vs. two-handed, respectively; $p=.324$) did not differ significantly over time ($p=.332$) and with the total time elapsed ($p=.280$), but the degree of appropriateness was high for two-handed chest compression [Table 3] [Figure 1].

Table 3. Appropriateness of chest compression (n=64)

Variable		One hand compression	Two hands compression	t	p	F	p
Mean chest compression depth	(2 min)	43.3±2.50	44.3±2.37	-2.80	.007	-3.042	.003
	(4 min)	42.5±3.10	44.1±2.63	-4.02	<.001		
	(6 min)	42.6±3.53	44.2±2.51	-3.35	.001		
	(8 min)	42.7±3.94	44.4±2.86	-3.14	.003		
Inappropriate number of chest compression	(2 min)	11.8±14.39	11.7±14.47	.058	.954	0.993	.332
	(4 min)	15.6±20.89	10.5±16.94	1.98	.051		
	(6 min)	16.4±20.93	9.9±17.16	2.24	.028		
	(8 min)	15.8±21.54	12.6±19.09	.993	.324		

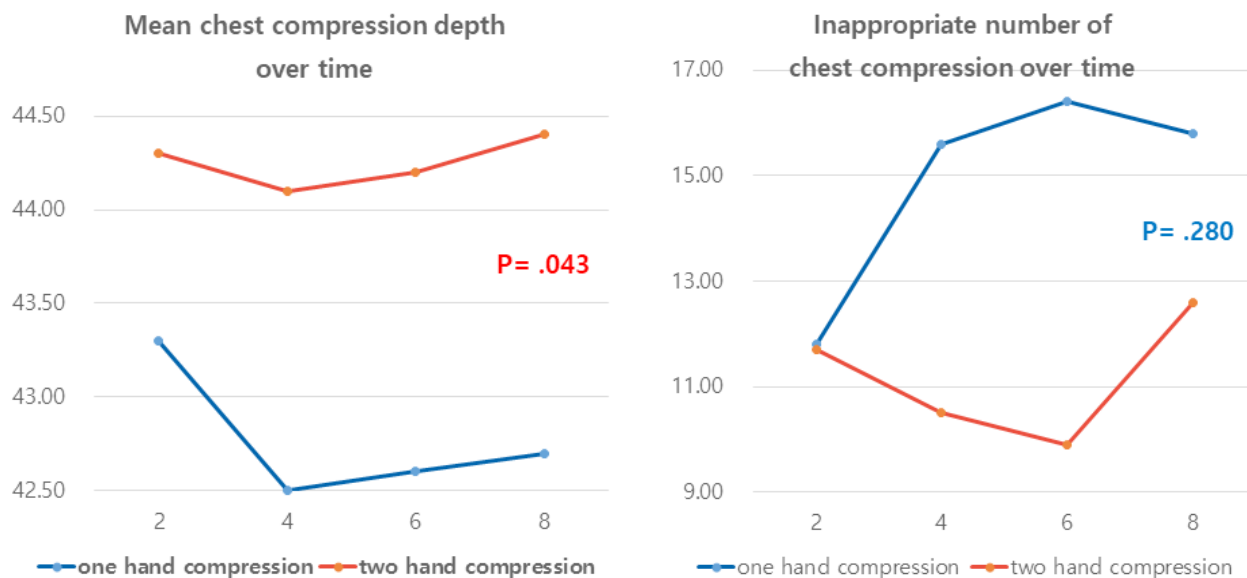


Figure 1. Assessment of adequacy of chest compressions over time (n=64)

Discussion

This study was conducted to evaluate the quality and the appropriateness of one- or two-handed chest compressions in pediatric CPR to provide the basic data for effective pediatric cardiopulmonary resuscitation. In the aspect of quality of chest compression in pediatric CPR, the total number of chest compression and the hands-off time were more effective for one-handed chest compression. The average compression depth was

more appropriate for two-handed chest compression, as was the sufficient chest compression depth rate. However, there was no significant difference between the compression recoil rate and the average compression rate between one- and two-handed CPR. These results support recommendations in the 2015 Guidelines for Pediatric Cardiopulmonary Resuscitation that suggest the use of one- or two-handed chest compression. However, the fatigue rate was higher when only one

hand was used compared to chest compression with two hands. This agrees with the results of previous study that suggested that the quality of chest compression decreased due to higher fatigue rates in adult CPR when only chest compression was delivered, compared to standard CPR [14]. The quality of chest compression is the most important factor in effective CPR, emphasizing the importance of chest compression of sufficient depth [1]. Therefore, the quality of chest compression may decrease as fatigue increases in pediatric CPR, so it is necessary to consider two-handed CPR.

The mean chest compression depth was within 4-5cm, as suggested in the 2015 Guidelines. Two-handed chest compression was more effective than one-handed compression as shown different significantly over time and over total time elapsed. However, there was no statistically significant difference over time and over total time elapsed in inappropriate chest compression rate, but there were more improper chest compressions in one-handed chest compression than in two-handed chest compression. The results were attributed to higher fatigue scores in one-handed chest compression provider than in two-handed chest compression provider, resulting in the increase in inappropriate chest compression. In addition, inappropriate chest compression is the measure of the quality of chest compression, indicating that the two-handed method was more appropriate. Furthermore, there is no previous study comparing the appropriateness of one- or two-handed chest compression in pediatric CPR, so no study can compare directly with this study. Thus, additional studies on two-handed chest compression are needed.

Conclusion

This study was aimed to assess the quality and the appropriateness of chest compression in pediatric CPR according to 2015 Korean Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Evaluation of the quality of chest compression in pediatric CPR showed that the total number of chest compression and the hands-off time were more effective in the one-handed method, but the average compression depth applied was more appropriate in the two-handed method. Furthermore, the ratio of sufficient chest compression depths and the fatigue were significantly higher for two-handed chest compression. In the appropriateness of chest compression, the average chest compression depth was significantly improved over time and over the total time elapsed in two-handed chest

compressions, but there was no significant difference in inadequate chest compression. Based on these results, this study is meaningful to provide the basic data for improving the quality of the 2015 Korean Guidelines by evaluating the quality and the appropriateness of one- or two-handed chest compression in pediatric cardiopulmonary resuscitation. In addition, one- or two-handed chest compression method in the 2015 Guidelines may be used in pediatric cardiopulmonary resuscitation, but it is necessary to perform chest compression with two hands rather than one hand, suggesting follow-up studies in various ages and groups. Furthermore, since children have the high possibility of cardiac arrest due to respiratory problems, further studies are needed to assess the quality and the appropriateness of one- or two-handed chest compression, including respiration.

Ethical Clearance: Not required

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Conflict of Interest: Nil

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