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ORIGINAL RESEARCH

Straddle versus Conventional Chest Compressions in a Confined Space; a Comparative Study

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Abstract: **Introduction:** When cardiac arrest occurs in a confined space, such as in an aircraft or ambulance, kneeling by the patient's side may be difficult. Straddle chest compression is an alternative technique that can be used in a confined space. This study was performed to compare the quality of chest compressions in straddle versus conventional CPR on a manikin model. **Methods:** The participants were randomized into two groups using the sequential numbered, opaque, sealed envelope method chosen through block-of-four randomization: straddle and conventional chest compression technique. Each participant performed a maximum of 4 minutes of hands-only chest compressions, and quality parameters (compression rate and depth) were recorded from the defibrillator's monitor. **Results:** 124 participants with mean age of 26.67 ± 6.90 years (27.58% male) were studied. There was no difference in the mean compression rate between the conventional and straddle chest compression techniques (126.18 ± 17.11 and 127.01 ± 21.01 compressions/min, respectively; p = 0.811) or their mean compression depth (43.8 ± 9.60 and 43.4 ± 9.10 mm, respectively; p = 0.830). The participants' comfort and fatigue were assessed through changes in their vital signs. In both methods, statistically significant differences were observed in vital signs before and after performing chest compression, but the differences were not clinically significant. In addition, there was no difference between the 2 groups in this regard. **Conclusion:** The quality of CPR using the straddle chest compression was as good as conventional chest compression technique. No significant differences were found in the quality of chest compressions or the participants' comfort and fatigue levels.

Keywords: cardiopulmonary resuscitation; heart arrest; heart massage; emergency medical service; ambulances

1. Introduction

Sudden cardiac arrest can occur in either an emergency room or outside a hospital, which is one of the leading causes of death in many countries worldwide (1). The survival rate after receiving life support inside and outside hospitals ranges from 2% to 10% and from 7.4% to 27%, respectively (2-5). Basic life support (BLS) after sudden cardiac arrest can increase the survival rate (6).

Chest compression is an important step in basic life support, which is considered a standard procedure for healthcare providers and lay-rescuers at the scene of sudden car-

diac arrest. Chest compression is more effective when the patient is lying in supine position on a relatively hard surface such as ground or floor (7, 8). The compression depth should be at least 2 inches or 5 centimeters, but not exceed 2.5 inches or 6 centimeters for adult cardiac arrest patients (9, 10). The chest should be released and allowed to recoil completely before the initiation of another compression (11, 12). The compression rate should be at least 100-120 compressions per minute. It is important to ensure that no interruptions occur while performing chest compression (13, 14). Those performing cardiac massage for patients with sudden cardiac arrest should not stop chest compression unless the patient should be evacuated from the scene or electrical defibrillation should be performed, otherwise its effectiveness will decrease. (15). In out-of-hospital cardiac arrest (OHCA), some patients should be immediately transported to a hospital to receive definite treatments such as extracor-

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poreal cardiopulmonary resuscitation in refractory shockable cardiac arrest, thus, chest compressions must be continued during transport. However, performing chest compression when positioned beside the patient on a moving vehicle will alter the quality of chest compression and cause injury to providers. Another situation is in an aircraft where it may be difficult for providers to kneel down and perform chest compression when positioned lateral to the patient due to confined space.

Alternative techniques are available to perform chest compression in confined space areas such as ambulances or aircrafts (16). Chest compression when the provider is positioned over the patient's head (over-the-head CPR) or straddled over the patient's legs (straddle CPR) may be useful in situations where space is limited (17, 18).

As mentioned above, straddle CPR may be useful to perform chest compression during transportation of the patient on an ambulance with high speed and limited spaced, because straddling over the patient's legs is stronger and safer than standing beside the stretcher. However, the quality of chest compression in straddle technique has not been studied in detail. The objectives of this study were to 1) compare the quality of conventional and straddle chest compressions using a manikin model and 2) study the comfort and fatigue of providers by measuring the changes in their vital signs before and after performing the two different chest compression techniques.

2. Methods

2.1. Study design and setting

This was a cross-sectional comparative study with stratified randomization of participants. The study was conducted from December 2016 to January 2017 at the Faculty of Medicine Ramathibodi Hospital, a university-affiliated super tertiary care hospital in Bangkok, Thailand. Participants consisted of individuals in both healthcare (emergency physicians, general practitioners, nurses, ambulance staffs, medical and paramedic students) and non-healthcare (airline staff, flight attendants, and cabin crew members) professions, were enrolled to the study then provided written informed consent. The participants were stratified into two groups according to their profession, and were then divided into straddle chest compression or conventional chest compression group using the sequential numbered, opaque, sealed envelope random sampling method through block-of-four randomization. All participants studied a diagram showing the technique of chest compression.

The Ethics committee of Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand approved of this study in terms of Human Rights Related to Research Involving Human Subjects (Ethics code: MURA2017/23).

2.2. Participants

The participants in this study were emergency physicians, general practitioners, nurses, ambulance staff, and medical and paramedic students of Faculty of Medicine Ramathibodi Hospital. Airline staff, flight attendants, and cabin crew members of the Airports of Thailand Public Company Limited (AOT) were also included. The exclusion criteria were participants who discontinued chest compression due to injury and occurrence of any problems for the study devices during the study.

2.3. Data gathering

All participants' characteristics including: age, sex, body mass index, occupation, previous BLS training, previous experience in chest compression, and number of exercises per month were recorded. Vital signs of participants including their systolic blood pressure, pulse rate, and respiratory rate were measured immediately both before and after the procedure. Participants in each group pressed down on the chest of Laerdal® Resusci Anne manikin model connected with the ZOLL® X Series® monitor defibrillator and CPR Stat-Padz® Multi-Function electrode pads that provided continuous and summarized recording of chest compression quality. Participants were blinded to the real-time quality results while performing chest compression to reduce potential bias. They were required to perform continuous compressions on the chest without stopping until they felt too tired to continue, this period did not exceed 4 minutes. The following variables were recorded for both conventional and straddle chest compression techniques: overall mean compression rate and overall mean compression depth. Mean compression rate and mean compression depth were also recorded at each specific time interval (minutes 0-1, 1-2, 2-3 and 3-4, respectively).

2.4. Statistical Analysis

In accordance with the study by Lei Z and Qing H (19), which compared the quality of conventional chest compression on the floor and straddle chest compression on the moving ambulance stretcher using a manikin model, the sample size was calculated using STATA version 12.0 (StataCorp, College Station, TX, USA). We performed two-sample comparisons of the mean with a power of 0.9, sample size ratio of 1:1, P-value of 0.05, and two-sided tests. The minimum required sample was 124 participants. The data were recorded using Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA, USA) and were analyzed using STATA version 14.0. Chi-square or exact probability test were applied to compare independent categorical variables, while independent t-test were used to compare continuous variables. Paired t-test or Wilcoxon signed-rank test were used to compare dependent continuous vari-

ables according to data distribution. P-value of <0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics of participants

There were 124 enrolled participants in this study, which consisted of 111 (89.5%) individuals in the healthcare professions and 13 (10.5%) in non-healthcare professions. Nobody discontinued the chest compression to be excluded. Participants were divided into 2 groups; 60 in the conventional chest compression and 64 in the straddle chest compression group. Differences in baseline characteristics were not statistically significant between the two groups (table 1).

3.2. Comparisons

As shown in table 2, there were no statistically significant difference in the quality of chest compression in terms of the overall mean compression rate (p = 0.863) and depth (p = 0.830). The fatigue associated with conventional and straddle chest compression were assessed by measuring the participants' vital signs before and after performing the compression. Although the systolic blood pressure, pulse rate, and respiratory rate were significantly different before and after performing the compression in both groups, the differences were not clinically significant (table 3).

4. Discussion

Chest compression is a lifesaving procedure, which increases survival rate among cardiac arrest patients, especially in out-of-hospital cardiac arrest (OHCA), where survival rate is low. According to recommendations of the American Heart Association (AHA) in 2015, patients with cardiac arrest must be immediately resuscitated by performing high-quality chest compression with a compression rate of about 100-120 compressions per minute, compression depth should be between 2-2.5 inches or 5-6 centimeters. The chest should be released and allowed to completely recoil before initiating another compression and unnecessary interruptions should not occur in performance of chest compression. Conventional chest compression by kneeling or positioning lateral to the patient's side may be difficult and inappropriate in places such as an aircraft or high-speed moving ambulance, where the spaces are confined or limited. Straddle chest compression is an alternative method, which allows for rescuers to continue chest compression without unnecessary interruption. In the present study, which aimed to compare the quality of straddle and conventional chest compression technique on a manikin model, the results revealed that there are no statistically significant differences in compression rate or depth between the two techniques neither overall nor at

each specific time point (minutes 0-1, 1-2, 2-3 and 3-4, respectively). The overall mean compression rate (throughout the 4-minute evaluation period) was not significantly different between the two groups (125 compressions/min in conventional and 126 compressions/min in straddle technique), which were faster than the standard recommendation by the AHA2015 (100–120 compressions/min). The overall mean compression depth was also not significantly different between the two groups (43.80 ± 9.60 mm in conventional and 43.90 ± 9.10 mm in straddle technique). The compression depth of both techniques was lower than the standard recommendation by the AHA2015 (50–60 mm). These key results suggest for further training to maintain high quality chest compression in rescuers, both those in healthcare professions and those in non-healthcare professions. The participants' comfort and fatigue were assessed by measuring changes in their vital signs, there were no statistically significant differences in these regards between the two techniques. However, vital signs slightly increased after performing chest compressions in both groups but they were not clinically significant. In a previous study by Handley AJ and Handley JA (17), which aimed to compare the quality of performing chest compressions in a narrow area by two techniques: straddle over the head and straddle over the body, the result revealed that the two alternative techniques were useful in situations where space was limited. Lei Z and Qing H (19) also compared the quality of standard chest compression performed on the floor and straddle chest compression performed on a stretcher using a manikin model. The result showed no difference in chest compression quality between these two compression techniques. Straddle chest compression can be performed both in-hospital and out-of-hospital depending on the situation. For patients with in-hospital cardiac arrest, straddle chest compression can be performed on the stretcher while transporting patients to operating theater or catheterization laboratory. Straddle chest compression can also be performed for out-of-hospital cardiac arrest patients who are in a confined space or who are in moving ambulances due to the need for immediate transport to receive definite treatment.

5. Limitation

Our study has some limitations. First of all, a manikin model is unrealistic so the result of study must be cautiously interpreted and may not be generalizable to real clinical situations. Second, most of the participants were in the healthcare profession with variations in terms of experience and skills so the study's results may not be generalizable to real-life rescuers that consists of both healthcare and non-healthcare workers who will encounter out-of-hospital cardiac arrest patients. Third, the experiment was conducted by placing

Table 1: Comparing the baseline characteristics of participants between conventional and straddle chest compression group

Characteristics	Conventional (n = 60)	Straddle (n = 64)	P-value
Age (years)			
Mean ± SD	25.77 ± 6.60	27.58 ± 7.21	0.149
Gender			
Male	40 (66.67)	40 (62.50)	0.708
Female	20 (33.33)	24 (37.50)	
BMI (kg/m2)			
Mean ± SD	23.69 ± 5.11	22.76 ± 4.55	0.286
Occupation			
Healthcare	54 (90.00)	57 (89.06)	0.893
Non-healthcare	6 (10.00)	7 (10.94)	
Previous BLS training			
Yes	44 (73.33)	52 (81.25)	0.390
No	16 (26.67)	12 (18.75)	
Previous experience in chest compression			
Yes	39 (65.00)	45 (70.31)	0.568
No	21 (35.00)	19 (29.69)	
Exercise for physical fitness (/month)			
0	18 (30.00)	14 (21.88)	
1-4 times	36 (60.00)	46 (71.88)	0.408
≥ 5 times	6 (10.00)	4 (6.25)	

Data are presented as mean ± standard deviation or number (%). BMI: body mass index; BLS: basic life support.

Table 2: Comparison of quality of chest compression between conventional and straddle chest compression techniques

Variable	Conventional (n = 60)	Straddle (n = 64)	P-value
Compression (compressions per minute)			
Overall	126.18 ± 17.11	127.01 ± 21.01	0.811
Minute 0-1	126.89 ± 17.18	127.47 ± 19.95	0.863
Minute 1-2	125.97 ± 17.47	125.84 ± 20.56	0.971
Minute 2-3	124.23 ± 16.59	126.02 ± 20.32	0.634
Minute 3-4	124.43 ± 17.72	121.81 ± 17.62	0.539
Compression depth (millimeters)			
Overall	43.80 ± 9.60	43.40 ± 9.10	0.830
Minute 0-1	45.60 ± 8.10	45.70 ± 8.60	0.945
Minute 1-2	43.18 ± 9.83	43.00 ± 9.70	0.937
Minute 2-3	41.89 ± 11.14	39.76 ± 10.07	0.325
Minute 3-4	39.90 ± 11.27	39.20 ± 10.07	0.767

Data are presented as mean ± standard deviation.

Table 3: Comparison of vital signs before and after chest compression between conventional and straddle chest compression techniques

Vital signs	Conventional (n = 60)			Straddle (n = 64)		
	Before	After	P	Before	After	P
SBP (mmHg)	125.5 ± 18.2	132.8 ± 7.5	<0.001	120.8 ± 5.1	131.8 ± 3.7	<0.001
PR (/min)	83.5 ± 18.2	93.6 ± 15.4	<0.001	79.9 ± 13.9	93.15 ± 16.7	<0.001
RR (/min)	16.6 ± 1.0	23.9 ± 3.4	<0.001	16.3 ± 0.7	23.7 ± 3.7	<0.001

Data are presented as mean ± standard deviation. SBP: systolic blood pressure; PR: pulse rate; RR: respiratory rate.

the manikin on the floor, not on a stretcher in a moving ambulance. Thus, the result may not be the same in a situation that chest compression must be continued while transporting the patients.

6. Conclusion

The present study showed that the quality of chest compression using straddle technique was as good as conventional technique. No significant differences were found in the quality of chest compression or the participants' comfort and fa-

tigue levels.

7. Declarations

7.2. Author contribution

PS, TC and CY conceived and designed the experiment, and defined the intellectual content; TC and PS performed the literature search; TC, PS, JP and PK performed the experiment and collected the data; CJ and CY performed the statistical analysis and data interpretation; PS, CJ and CY drafted the manuscript. All authors reviewed and approved the final draft of manuscript.

7.4. Conflict of interest

None.

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