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Original Research Article

Chest Compressions with Two Hands versus Chest Compressions with One Hand and Continuously Open Airway. A Comparative Study

Anna Christakou[1], Marios Giannoulis[2]

[1]ICU Physiotherapist, Department of Critical Care Medicine,Medical School, General Hospital Evagelismos, National and Kapodistrian University of Athens, Greece
[2]Physiotherapist, Department of Experimental Surgery andSurgical Research, Medical School, National and Kapodistrian University of Athens, Greece.

Corresponding Author: Anna Christakou

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ABSTRACT

Chest compressions play a fundamental role to the cardiopulmonary resuscitation (CPR). Little research has examined the effectiveness of the single-hand technique with continuous chin lift of the victim in the quality of CPR. The purpose of the study was to investigate the differences between the two-handed technique and the single-handed technique with continuous chin lift of the victim, regarding the aspects of: (a) compressions' depth, (b) compressions' rate, (c) correct decompressions, (d) mean time of pauses between compressions, and (e) rescuer's fatigue. One hundred twenty volunteer Basic Life Support trained participants, aged from 18 to 46 years old, took part in the study. The experimental group (n=60) performed the single-handed technique and the control group (n=60) the two-handed technique.The participants performed chest compressions using an Advanced Cardiac Life Support manikin connected to a personal computer with SkillReporter™ software. The results revealed significant differences in the variables of compressions' depth and the mean-time of pauses between compressions. The single-handed technique has benefit over the two-handed technique only in the mean-time of pauses between compressions. The present study shows that the single and two-handed compression techniques do not appear to differ in the most basic aspects of the quality of the CPR's chest compressions. Further research should be conducted to investigate and establish the effectiveness of the single-handed compression technique on the adult CPR.

Key words: Resuscitation, single-handed technique, compressions' depth, rate, fatigue

INTRODUCTION

Chest compressions play a fundamental role to the CPRand to the survival of cardiac arrest victims. [1-4] Current guidelines advocate that the ideal chest compression technique is summarised into the following: compression of the chest at a rate of $100/min^{-1}$ with two hands, to a depth of at least 5cm (for adults) and not over 6cm, and applying complete decompression after each compression. [5]

The quality of CPR is likely an important contributor to successful outcome, thus the refinement of chest compressions in CPR has become a focus of research. The conditioning of a certain chest compression technique remains open to discussion in relation to basic aspects such as depth, rate, correct decompressions and rescuer's fatigue. The single-handed technique refers to the usage of the dominant hand upon the chest of the victim, followed by a simultaneous chin lift to the victim with the non-dominant hand of the rescuer. Therefore, no ventilations take place using the single-handed technique and the rescuer can achieve uninterrupted compressions.The single-handed technique may lead to decrease of gas that is inhaled in the stomach due to loosening of the lower esophageal sphincter. The stomach inflation of the victim, which occurs in the wake of rescuer's ventilations, could lead to elevation of intra-abdominal pressure that may impair hemodynamic and coronary perfusion pressure. Thus, it is critical to maintain low intra-abdominal pressure to increase the possibilities of a better outcome. In addition, the continuously open airway, achieved via chin-lift from the rescuer in the single handed technique, may provide better oxygenation of the victim, resulting in increased possibilities of return of spontaneous circulation. Also, the uninterrupted compressions probably contribute to the increase of coronary perfusion pressure and exhaled CO_2 and, therefore, may lead to return of spontaneous circulation. [6] Nevertheless, uninterrupted compressions play a significant role to the augmentation of survival rates compared to the conventional CPR. [7] The restoration of coronary perfusion pressure is the most important predisposing factor of successful defibrillation. [8] Summarising, the single-handed technique may lead to increased possibilities of return of spontaneous circulation which is the ultimate goal of a successful CPR effort. [9,10]

No previous studies have investigated the effect of the single-handed technique to adult manikins. In pediatric CPR, it has been shown that the two-handed compressions produce higher mean and peak compression pressures when compared to single-handed compressions. Also, 29 to 30 participants found the two-handed technique easier to perform. [11] Pesca et al. [12] showed that CPR compression rate is similar with single-and two-handed pediatric compressions techniques, but compression rate decreased more quickly with the single-handed technique. Similarly, the majority of doctors and nurses preferred the two-handed compression technique for reasons of ease, control and uniformity with other CPR techniques.

The aim of the present study was to evaluate the differences between the single-handed technique and the conventional technique of two-handed in an adult manikin. It was hypothesized that the participants of the single-handed technique would achieve compressions with better depth and rate, lesser incomplete decompressions, lesser pauses between compressions and lower rescuers' fatigue than the control group. Examining the possible differences between these two techniques of chest compressions is not only a question of theoretical importance, but also one with clinical relevance. The potential benefits of using the single-handed technique to the adult CPR might be important in the CPR's quality and the prevalence of this technique might contribute to the improvement of adult survival rates.

METHODOLOGY

Participants

The present study was a randomized controlled crossover trial which was approved by the National Resuscitation Committee and the University of Human Ethics Board. Also, the procedure was in accordance with the ethical standards of the Committee on Human Experimentation of the Institution as well as to the Declaration of Helsinki.

The sample consisted of 120 newly volunteer Basic Life Support (BLS)trained individuals (42 men and 78 women), aged from 18 to 46 years old (27.42±7.58). All participants had been trained in BLS, completing the training session during the same day of the present study. The inclusion criteria were: (a) to be adults, (b) to have been certified as BLS Providers from the Resuscitation Committee, and (c) to have the physical suitability to perform the resuscitation algorithms.Participants were randomly divided into two groups, one experimental and one control, by the method of drawing lotsby the researcher other than the one who performed the evaluation throughout the study. Each group consisted of 60 participants, with the experimental group consisting of 18 men and 42 women, and the control group consisting of 24 men and 36 women. All participants were informed about the procedures of the study and signed a written informed consent form. Participants had the right to interrupt their participation from the study at any time, and were informed that any publication of the results would be anonymous.

Measures

Compressions were performed on an Advanced Cardiac Life Support (ACLS) manikin (Laerdal® Resusci-Anne manikin, Laerdal Medical, Stavanger, Norway) weighted to 50 kg, placed on a firm mid-thigh height table. An electronic metronome (Flash metronome, www.gieson.com) with an audible beeping tone was used to guide chest compression rate. The manikin was connected to a computer and chest compression quality data was collected using SkillReporting Software, Version 2.2.1 (Resusci Anne Skill Reporter, Laerdal Medical). This software was used to record: the session duration, total number of compressions delivered, compression rhythm, compression depth, mean time of pauses between compressions and the number of "shallow compressions" (below 50 mm) in accordance with the consensus on uniform reporting of CPR quality. To measure the effect of compression rates on performance decay in the quality of compressions, rescuer's decay point was defined as the time to 10% deterioration in chest compression depth from baseline, for 5 successive chest compressions. All of the above variables were calculated automatically, except for the decay point which was calculated manually from the Skill-Reporter software graphics.

For the evaluation of the dominant hand's strength, the Jamar hand dynamometer (Lafayette Instrument Co. Inc. LafayetteIN, USA) was used. The measurement of hand's strength is a reliable index of muscle strength of the whole upper limb. [13,14] The dynamometer of the present study is characterised with high internal validity. [15] Also, it displays high inter-rater and continuous measurements reliability. [16,17]

Kundra [10] reported that chest compressions are being applied with fewer mistakes when the dominant hand is in touch with the victim's sternum. For the conditioning of handedness of the participants, Connor and Conclin [18] defined the dominant hand posing the question "Which of your two hands is the stronger?" This condition was followed in the present study. The above question was used to define which hand is dominant, in order for the participants to place it in the center of the victim's chest during the test.

Structured questionnaires were used which included closed-ended questions for the evaluation of characteristics of participants. These questions included participants' age, gender, weight, height, physical activity, smoking, educational level, previous CPR education, and experience in performing CPR in the clinical action.

Procedure

Procedure was undertaken in the auxiliary building of a hospital, in a class used for the conduct of educational sessions of BLS and ACLS training. Participants took part after finishing their BLS training and receiving their certificate of competency. They underwent a measurement of their dominant's hand muscle strength using the hand dynamometer. Then, they were randomly allocated to one of two groups by the method of drawing lots. No stratification by either the demographic data or the subject group took place.

After the randomization, each participant entered a room where was the ACLS manikin connected to a portable personal computer containing the SkillReporting Software. Before starting the respective scenario, each participant received a brief description of the procedure. Written and verbal information about the study setup were given to all of the participants by another BLS and ACLS instructor who were responsible for the study's measurements.

The control group performed the widely used CPR algorithm of chest compressions to ventilations at a rate of 30:2, on the ACLS manikin, for 2 minutes. The participants were asked to place their dominant hand first on the surface of the sternum. The 2minutes duration of the procedure was put in consistence with the Guidelines 2010, which suggest every 2minutes interchange of the rescuers in order for them not to get exhausted due to fatigue.

The experimental group performed the single-handed technique, which included continuous compressions with the dominant hand, whilst the other hand maintained the chin lift of the victim. The duration of the test was the same as the control group (2 minutes). In this algorithm, no ventilations take place. After the procedure's fulfilment, the recorded data were saved to the personal computer's hard disc via the SkillReporter software to be debriefed after the end of the procedure. The participants were thanked for their volunteering participation.

Statistical Methods

The independent variable of the study was the compression technique. The five dependent variables were: (a) the depth of compressions, (b) the rhythm of compressions (compression rate), (c) the number of incomplete chest decompressions, (d) the mean time of pauses between compressions, and (e) the presence of rescuers' fatigue. All dependent variables were evaluated by conducting Mann-Whitney U statistical tests, except the rhythm of compressions which was evaluated by a t-test. Also, x^2 were conducted to compare the baseline characteristics of the two groups. The SPSS 17.00 was used for all statistical analyses.

RESULTS

There were no significant differences in any of the baseline characteristics (e.g., age, height, weight, smoking, time from last CPR application, hand strength) between the two groups except the number of the CPR skills (x^2=10.00, df=3, p=0.02). In particular, the two groups were homogeneous in: physical activity (x^2=1.93, df=3, p=0.59), gender (x^2=1.32, df=1, p=0.25), educational level (x^2=1.01, df=2, p=0.60), smoking (31.6% smokers for both groups), number of CPR clinical seminars (x^2=2.91 df=2, p=0.23), time from last CPR training (x^2=5.69, df=3, p=0.13), and hand dominance (x^2=3.33, df=1, p=0.07).The power analysis (d=0.5 level of mistake, α=0.05) showed 0.78 for the sample of 60 participants for each group. Table 1 shows the demographic data of the participants.

Table 1.Sampledemographics.

Characteristics		Control group (Two-handed)		Experimental group (Single-handed)	
		Frequency f	Percentage (%)	Frequency f	Percent-age (%)
Gender	Male	24	40.0%	18	30.00%
	Female	36	60.0%	42	70.00%
Education	Compulsory	1	1.67%	0	0.00%
	High school diploma	24	40.00%	24	40.00%
	Graduate degree	35	58.33%	36	60.00%
Smoking	Yes	19	31.67%	19	31.67%
	No	41	68.33%	41	68.33%
Completionof 2 min. CPR	Yes	57	95.00%	28	46.67%
	No	3	5.00%	32	53.33%
Dominant hand	Right	57	95.00%	51	85.00%
	Left	3	5.00%	9	15.00%
Seminars of CPR training	0-1	34	56.70%	42	70.0%
	1-3	19	31.70%	15	25.0%
	3+	7	11.70%	3	5.0%
Weeks from last CPR training	Just trained	20	33.33%	27	45.00%
	1-4 weeks	23	38.33%	26	43.33%
	5-12 weeks	3	5.00%	2	3.33%
	12+ weeks	14	23.34%	5	8.34%
Number of applied CPR in clinical action	0	38	63.33%	54	90.0%
	1-2	6	10.00%	2	3.33%
	3-5	5	8.34%	3	5.00%
	5+	11	18.33%	1	1.67%
Frequency of physical activity	0 days	5	8.33%	2	3.33%
	1 day per week	19	31.67%	21	35.00%
	2-5 days per week	30	50.0%	33	55.00%
	6-7 days per week	6	10.0%	4	6.67%

Mann-Whitney U test showed statistical significant difference: (a) of the exact value of compression depth between the two groups (U=857.00,p<.001), with the group of the two-handed achieving higher value (M=2.43cm) than those of the single-handed group (M=1.63cm) and (b) of the mean time of pauses between compressions (U=17.00, p<.001), where the mean time for the single-handed group was better (0.28±1.11) than the two-handed group (7.25±2.01)(Table 2). No statistically significant differences between the two groups was observed in the below variables of: (a) compression rate (t=-0.79, p=0.43), (b) incomplete decompressions (U=1537.00, p=0.17), and (c) time-point of rescuer's fatigue appearance (U=1614.05, p=0.14) (Table 2).

Table 2. Descriptive statistics and differences between the control and experimental groups.

	Control group (Two-handed group)		Experimental group (Single-handed group)		Mann-Whitney U	
Variables	M	SD	M	SD		
Compression depth	2.43	0.95	1.63	0.69	857.00**	
Number of incomplete decompressions	25.57	43.98	62.37	95.33	1537.00	
Mean time of pauses between compressions	7.25	2.01	0.28	1.11	17.00**	
Time spot of rescuers fatigue	8.25	25.25	10.27	21.87	1614.05	
Compressions rate	146.35	26.55	150.70	33.72	_	t-test = - 0.79

***p*<.01

DISCUSSIONS

The purpose of the present study was to assess differences between the two-handed technique and the single-handed technique regarding compressions' depth and rate, correct decompressions, mean time of pauses between compressions and rescuers' fatigue.

The results showed that the two-handed group achieved statistical higher compression depth values than the single-handed group. However, both groups did not achieve the desired goal of at least 5cm of depth; particularly their depth values were significantly lower. International Liaison Committee on Resuscitation (ILCOR) Guidelines recommend that compressions must be exerted to a depth of approximately 5 to 6cm vertical to the sternum. [1,3,5,19-24] This result is consistent with previous studies which confirms the inadequacy of chest compressions in CPR. [1,3,12,25-27]

Many studies advocate that the pauses between compressions are a common phenomenon in CPR. [20,28-30] According to Guidelines 2010, the lesser the pauses between compressions, the better the outcome. [31] Every pause that lasts more than 1.5sec is regarded as "no flow time", that is an interval of no blood flow in coronary vessels due to compression. [20] In Kramer-Johansen's study, [20] the interval was 10.60sec with the two-handed technique, whereas in the present study, it was 7.25sec, respectively. However, there has not been any previously published research examining the differences of the number of pauses between different techniques of chest compressions and/or the effectiveness of the single-handed technique on the pauses. Thus, this is the first study which reports the single-handed technique's benefit over the two-handed technique in the mean-time of pauses between compressions. We therefore recommend future studies to examine the effectiveness of the single-handed technique on the pauses between compressions.

Compressions' rate did not differ significantly between the two groups. However, the overall values in both groups were higher than ILCOR Guidelines recommendation of 100 to 120 compressions per minute. [31] In particular, the single-handed CPR's rate of compressions was 150.70 compressions/min in comparison of 146.30 compressions/min of the two-handed technique. This result is in agreement with Peska, [12] who found that both the two-handed and single-handed technique does not differ in paediatric CPR, but achieving higher rates than recommended. It remains questionable whether high compression rate is beneficial for the adult victim or not. [1,3] The relationship between compressions' depth and rhythm was examined by Monsieurs et al [33] and Field et al. [1] which both suggested that when the rate of compressions increases, compressions' depth declines.

Also, the results of the present study did not show a statistical difference between the two techniques of chest compressions in the variable of incomplete decompressions. However, the participants of the single-handed technique were more prone to the leaning effect with a mean number of inadequate decompressions of 62.37 (SD= 95.33) to 25.57 (SD= 43.98) of the group of the two-handed technique. Eighty per cent of both groups applied inadequate compressions. Fried et al [34] and Aufderheide et al [35] reported that the equivalent percentage of their findings is fewer than 50%. It is highlighted that low number of incomplete decompressions got through with increase of survivor rates. More research should assess the leaning effect after using the single-handed technique.

In addition, the exact time-point of rescuers' fatigue did not differ significantly between the two groups. Rescuer's fatigue affects the quality of compressions within the first minute of resuscitation. [36,37] Hong [37] suggested that the exact time-point of rescuers' fatigue was between 20 and 40sec. for the single-handed technique which included ventilations. This result is contradictory to our study's finding. Specifically, the accurate time-point, when the two groups begun developing fatigue, was 10.27th sec from the start of the 2 min procedure for the single-handed group and 8.25th sec for the two-handed group. Also, 23.3% of single-handed rescuers developed fatigue, at the same time as control's group percentage was 11.7%. Additional research should be conducted to investigate the effectiveness of the single-handed technique on rescuer's fatigue.

Regarding the completion of 2 minutes CPR procedure, the two-handed group accomplished the procedure of 95% as opposed to the single-handed participants who finished the procedure to 46.7%. This finding confirms Ashton's [38] results that the continuous application of compressions is more laborious than the interval. The single-handed participants performed sustained compressions with no lapses, in opposition to the two-handed. The continual compressions may cause an increase to rescuers' fatigue in the single-handed group. The single-handed group probably developed higher fatigue values from the beginning of the test, affecting its compression depth, which found significantly lower than the two-handed technique group.

Future experiments should investigate: (i) the correlation of the somatometric characteristics of participants with compressions depth, rate and pauses during the compressions, (ii) the impact of gender to the quality of compressions, (iii) the effect of a high number of incomplete decompressions to survival rates of swine models, and (iv) the correlation of the dominant hand's strength with the increase or decrease of inadequate decompressions.

Limitations

Our single centre study had several limitations. Firstly, the participants did not perform the compressions to a human body, but to a manikin. Previous studies have demonstrated that the manikin exerts greater resistance to the rescuer's hand in comparison to the human body. [12,39] This difference might have affected the quality of compressions and it might have contributed to the increase of rescuer's fatigue. Secondly, although the duration of CPR in both groups is limited in 2 minutes which is in accordance to guidelines, it is very rare in actual practice and is not capable of surfacing proof of actual differences in fatigue using the two or a single handed technique. Thirdly, knowing the participants that they are being assessed, they might have developed the Hawthorn effect, which refers to an amelioration of their performance due to previous information about results' analysis. Fourthly, a 90% of the experimental and 63.3% of the control group had never applied CPR in clinical action which might have deteriorated their performances, because they had no knowledge about the potential errors during the CPR process. Fifthly, the procedure of the study took place after the participants' BLS seminar which might have an adverse effect to the rescuer's stamina during the test.

CONCLUSION

The present study reveals that the single and two-handed compression techniques do not appear to differ in the most basic aspects of the quality of the adult CPR's chest compressions such as rate, correct decompressions and rescuer's fatigue. Therefore, we recommend continuing using the two-handed method of compressions to CPR. However, due to single-handed technique's benefit over the two-handed technique in the mean-time of pauses between compressions, further research should be conducted to investigate and establish the effectiveness of the single-handed compression technique on the adult CPR.

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