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ORIGINAL RESEARCH

Is a mechanical-assist device better than manual chest compression? A randomized controlled trial

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Background: Chest compression quality is a determinant of survival from sudden cardiac arrest. The CPR RsQ Assist Device (CPR RAD) is a new cardiopulmonary resuscitation device for chest compression. It is operated manually but it does not pull up on the chest on the up stroke. The aim of this study was to compare the CPR RAD with standard manual compression in terms of chest compression quality in a manikin model.

Methods: Participants were randomly assigned to either the device or manual chest compression group. Each participant performed a maximum of 4 minutes of hands-only compression with or without the device. During chest compression, the following quality parameters from the manikin were recorded: compression rate, compression depth, and correctness of hand position.

Results: Duration of chest compression was significantly higher in device users compared with manual compression (223.93±36.53 vs 179.67±50.81 seconds; $P<0.001$). The mean compression depth did not differ in a statistically significant way between manual compression and device at 2 minutes (56.42±6.42 vs 54.25±5.32; $P=0.052$). During the first and second minutes, compression rate was higher in cases of standard compression (133.21±15.95 vs 108±9.45; $P<0.001$ and 127.41±27.77 vs 108.5±9.93; $P<0.001$). There was no statistically significant difference in the percentage of participants who employed compression that was too shallow or exhibited incorrect hand position.

Conclusion: The CPR RAD is more effective in chest compression compared with manual chest compression, as using the device led to better results in terms of fatigue reduction and correct compression rate than standard manual compression.

Keywords: chest compression, CPR RsQ Assist device, outcomes

Introduction

Chest compression is one of the most important procedures in cardiopulmonary resuscitation. Several factors should be considered during chest compression such as depth, rate, and location. The desired depth of chest compression is 5–6 cm at a rate of 100–120 times/minute.[1,2] The quality of chest compression is directly associated with survival rate.[3,4]

The main problem that occurs in chest compression is fatigue on the part of the person conducting the compression. The American Heart Association recommends alternating compressors every 2 minutes. Several studies have shown that the automatic chest compression device (ACCD) is more effective than manual chest compression[5–7] and that the device has been shown to yield more effective chest compression rates than the standard manual method (69% vs 35%).[5] Several types of ACCDs (ie, mechanical resuscitation devices) are used in clinical practice.[5–7] The

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CPR RsQ Assist Device (CPR RAD) is an ACCD that is operated manually but cannot make a fully reversible of the chest wall. Currently, there is no previous study in which randomized controlled trials comparing the CPR RAD and manual methods have been conducted.

Methods

This study was a randomized controlled trial conducted at the Department of Emergency Medicine, Mahidol University, Bangkok, Thailand. Medical personnel including medical students, physicians, nurses, emergency medicine technicians, and hospital staff were invited to participate in the study. Eligible participants were randomly assigned to either the manual or device group. The randomization method used sequentially numbered, opaque, sealed envelopes (SNOSE) and six-block randomization. The study protocol was approved by the Institutional Review Board, Mahidol University (MURA2015/602).

All participants gave informed consent prior to study participation and were given instruction on the CPR procedures outlined in the 2015 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[8] Then the participants were asked to perform chest compression on the Resusci Anne® SkillReporter™ for a maximum of 4 minutes or until fatigued. The manual group performed standard chest compression, while the device group performed chest compression using the CPR RAD with a set rate of 100 times/minute.

The data recorded in this study included duration of chest compression, chest compression rate, average chest compression depth, percentage of shallow compression, percentage of compression with incorrect hand position, and percentage of incomplete decompression. Shallow compression was defined as compression with a depth of <50 mm.

Sample size calculation

In a previous study, effective chest compression rates using the active compression device and standard manual method were shown to be 69% and 35%, respectively.[5] With a confidence of 95% and power of 80%, the required study population was 78 subjects, with 39 in the manual group and 39 in the device group.

Statistical analysis

The characteristics of all participants in each group were compared by using descriptive statistics. Chest compression results were also compared between the device and manual groups using descriptive statistics where appropriate. All statistical analyses were performed by using STATA software version 14 (StataCorp LP, College Station, TX, USA).

Results

There were 80 participants in the study; 39 in the manual group and 41 in the device group. There were no statistically significant differences between the groups in terms of age, sex, CPR experience, and percentage of participants who had completed a CPR course (Table 1).

The average duration of chest compression was significantly longer in the device group than in the manual group (223.93 vs 179.67 seconds; $P<0.001$). The manual group had a significantly higher average chest compression rate at 1 and 2 minutes than the device group, while the average chest compression rate was significantly higher in the device group at minute 4 (90 vs 44.21 times/minute) as shown in Table 2.

Table 1 Clinical characteristics between the manual chest compression group and chest compression with automatic chest compression device group

Factors	Manual group (N=39)	Device group (N=41)	*P*-value
Age, years	25.54 (8.88)	24.46 (3.63)	0.486
Female sex, n (%)	19 (48.72)	24 (60.98)	0.271
Body weight, kg	62.22 (14.47)	61.54 (14.81)	0.835
Height, m	1.66 (0.08)	1.65 (0.08)	0.346
Body mass index, kg/m^2	22.36 (3.8)	22.63 (4.6)	0.778
Occupation, n (%)			0.407
Medical student	24 (61.54)	25 (60.98)	
Doctor	8 (20.51)	13 (31.71)	
Nurse	4 (10.26)	1 (2.44)	
Paramedic	1 (2.56)	0 (0)	
Hospital staff	2 (5.13)	2 (4.88)	
Completion of ACLS course, n (%)	34 (87.18)	38 (92.68)	0.476
Experience with chest compression, n (%)	30 (76.92)	35 (85.37)	0.334

Note: Data presented as mean (SD) unless indicated otherwise.
Abbreviations: ACLS, advanced cardiac life support; SD, standard deviation.

Table 2 Chest compression results between the manual chest compression group and chest compression with automatic chest compression device group

Chest compression outcomes	Manual group (n=39)	Device group (n=41)	*P*-value
Time to stop chest compression, seconds	179.67 (50.81)	223.93 (36.53)	<0.001
Compression rate/minute			
0–1 minute	127.41 (27.77)	108 (9.45)	<0.001
1–2 minute	90.74 (51.57)	108.55 (9.93)	<0.001
2–3 minute	44.21 (52.89)	97.9 (30.74)	0.190
3–4 minute		90 (39.11)	<0.001
Compression depth after 2 minute, mm	56.42 (6.42)	54.25 (5.32)	0.052
Overall compression depth, mm	49.21 (6.04)	46.35 (6.40)	0.045
Percentage of shallow compression			
0–1 minute	25.90 (35.55)	34.39 (35.21)	0.273
1–2 minute	46.49 (39.88)	61.22 (41.77)	0.159
2–3 minute	55.14 (44.46)	72.69 (37.81)	0.343
3–4 minute	62.18 (44.21)	80.23 (33.70)	0.106
Percentage of compression with incorrect hand position			
0–1 minute	10.43 (25.37)	31.41 (41.59)	0.632
1–2 minute	18.53 (31.67)	30.82 (41.64)	1.000
2–3 minute	17.18 (33.78)	23.37 (37.53)	1.000
3–4 minute	23.44 (39.87)	19.29 (35.24)	0.642
Percentage of incomplete release			
0–1 minute	6.78 (18.59)	0.90 (3.75)	0.999
1–2 minute	7.13 (19.82)	2.32 (9.92)	0.999
2–3 minute	6.25 (20.35)	1.92 (10.59)	0.999
3–4 minute	5.51 (15.43)	0.16 (0.81)	0.999

Note: Data presented as mean (SD).
Abbreviation: SD, standard deviation.

There was no significant difference in average depth of chest compression between the two groups at 2 minutes (56.42 vs 54.25 mm; *P*=0.052). At 4 minutes, the average depth of chest compression was deeper in the manual group than in the device group (49.21 vs 46.35 mm; *P*=0.045) as shown in Table 2. There was no difference between the two groups in the following areas at 4 minutes: percentage of shallow compression, incorrect location of chest compression, and incomplete release of chest compression (Table 2).

Discussion

Use of the CPR RAD led to better chest compression procedures than the manual method in terms of continuity and appropriate compression rate. The manual method had better compression depth than the CPR RAD, but other indicators of compression quality were comparable including shallow compression, incorrect hand position, and incomplete release.

Participants in the manual group stopped chest compression at a significantly shorter duration than those in the device group (Table 2). The device group almost reached the 4-minute study limit (223 seconds), while the manual group stopped chest compression at 3 minutes (179 seconds). However, the average compression rate in the manual group decreased dramatically after 3 minutes (from 90 to 44 times/minute). The American Heart Association recommends rotating compressors every 2 minutes when using the manual method. According to one study, >90% of CPR PRO® device users preferred the device as it results in less fatigue.[6]

The appropriate rate for chest compression is between 100 and 120 times/minute. The CPR RAD is helpful in ensuring a correct and consistent compression rate. The manual group had a higher-than-recommended average compression rate at the first minute (133 times/minute), but the rate decreased over the duration of the procedure. On the other hand, the device group had quite consistent rates for the first 3 minutes. At the 4th minute, the compression rate was somewhat lower than the recommended compression rate (90 times/minute). Therefore, the device contains a metronome but the manual group did not have the metronome. Use of the CPR RAD also yielded a more adequate compression rate compared to that of an automatic ACCD reported in a previous study (108 vs 139 times/minute).[7] Unlike other ACCDs, the CPR RAD has a red signal that blinks at a regular interval, which may help to ensure regular and adequate compression rates.

Another factor that may contribute to effective chest compression is the depth of the compression. Adequate circulatory perfusion requires a compression depth of 5–6 cm.[1,2] Both

the groups exhibited appropriate compression depth after 2 minutes, but after that, the average depths in both the groups were lower than the desired level (Table 2). These findings may indicate participants' fatigue, even when using the chest compression device. In fact, compression depth was significantly lower in the device group than in the manual group on average. The manual group seemed to exhibit stronger compressions, particularly in the first 2 minutes (Table 2).

Regarding other results, there were comparable percentages of shallow compression, incorrect hand position, and incomplete release in both the groups (Table 2). The manual group exhibited better performance in terms of shallow compression and correct position than the device group. These findings indicate that manual compression yielded better results in terms of landmark accuracy and harder compression. Unlike the CPR RAD, users of the CPR PRO have been shown to have better hand position than those employing manual chest compression (4.0% incorrect hand position in the CPR PRO).[6] The device is round in shape, which may be confusing to users attempting to accurately place it over the chest wall (Figure 1). The use of ACCD may require more practice than manual compression. However, the device had a non-significantly better outcome in incomplete release than the manual group. The device enabled greater regularity in terms of rhythm of chest compression due to the presence of the red signal, resulting in more appropriate chest-release time than the manual method (Table 2).

We would still recommend rotating compressors performing chest compression with the CPR RAD after 3 minutes. This is because the compression rate dropped below 100 times/minute and the percentage of shallow compression was high at 80% after 3 minutes. Because the CPR RAD is a semi-ACCD, it still requires physical exertion on the part of the rescuers. Even with the red signals from the machine, the compression rates were not adequate or were not in time with all of the signals. These findings indicated fatigue on the part of the participants, even with the ACCD.

There are some limitations in this study. First, the results of this study may not apply in real clinical situations. The results were recorded using a manikin, but may be used as preliminary data for further research regarding clinical use of the CPR RAD. Second, participants varied in terms of experience, with most being medical students. As a result, some results were not consistent with the standard recommendations. However, some results, such as shallow compression and correct position, were better in the manual group as mentioned earlier. The CPR RAD device may require more practice or training than the manual procedures. Finally, these results only apply to the CPR RAD and not other kinds of devices. Some CPR techniques may be useful in the combination with the CPR RAD such as using inclined step stool.[9,10]

Figure 1 CPR RsQ Assist Device (CPR RAD) used for chest compression.

Conclusion

The CPR RAD is more effective in chest compression compared with manual chest compression, as using the device led to better results in terms of fatigue reduction and correct compression rate than standard manual compression.

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Disclosure

The authors report no conflicts of interest in this work.

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