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The effect of posture modification during continuous one-handed chest compression: A pilot study using in-hospital pediatric cardiac arrest simulation

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ABSTRACT

Background. We modified the posture of the one-handed chest compression (MOHCC) as follows: first, the axis of the rescuer's compression hand was adjusted to the lower half of the patient's sternum; second, the opposite hand was wrapped around the elbow joint of the rescuer's compression arm. This study evaluated the effect of the MOHCC on the mean chest compression depth (MCD) over time.

Methods. Thirty medical doctors conducted 2 min of continuous MOHCC without ventilation using the in-hospital pediatric arrest model (70-cm-high bed, 25-cm-high stepstool, a pediatric manikin and a cardiopulmonary resuscitation (CPR) meter). The MCD and mean chest compression rate (MCR) were measured at 30 s intervals using the Q-CPR review software.

Results. The MCD changed significantly over time (0–30 s, 41.9–44.7 mm; 30–60 s, 40.4–43.6 mm; 60–90 s, 39.2–42.8 mm; 90–120 s, 38.6–42.3 mm; [95% CI], P=0.002). However, it did not decrease significantly between 60–90 s and 90–120 s (P=0.173). The total decrease in MCD was 2.9 mm over a 2 min period. The MCR did not change significantly over time (0–30 s, 108.6–118.9 /min; 30–60 s, 107.9–119.1 /min; 60–90 s, 107.7–119.3 /min; 90–120 s, 107.4–119.0 /min; P=0.800).

Conclusions. Although the MCD changed significantly over a 2 min period, it did not decrease significantly after 90 s during performance of MOHCC. The MOHCC might be considered when the one-handed chest compression (OHCC) is selected as a chest compression method for cardiac arrest in small children.

Key words: cardiopulmonary resuscitation, cardiac arrest, child, fatigue

INTRODUCTION

Although the recent cardiopulmonary resuscitation (CPR) guidelines recommend that either one-handed chest compression (OHCC) or two-handed chest compression (THCC) could be used in children because of a lack of clinical trials comparing the outcomes and qualities of the two techniques, certain populations (e.g., small children) suffering cardiac arrest require OHCC rather than THCC. (1) How, then, should OHCC be performed? An accurate OHCC method is not described in the CPR guidelines. Is it acceptable simply to remove one hand?

During use of THCC for CPR, the upper body weight can easily be loaded onto the compression area; i.e., the lower half of the sternum. However, loading of the upper body weight onto the compression area during OHCC is difficult because of the unstable posture of the rescuer. Recently, it was reported that the compression depth decreased more rapidly during continuous OHCC compared to THCC. (2) Therefore, the chest compression provider should be changed frequently (e.g., within 1 min) to maintain adequate compression depth when continuous OHCC is used during CPR. However, frequent changes of rescuer results in increased hands-off time.

If the upper body weight could be loaded onto the compression area more stably during continuous OHCC, the requirement for changing the compression provider might be decreased. We modified the posture of OHCC to stabilize rescuer posture in two steps. First, the axis of the rescuer's compression arm was adjusted to compress the lower half of the patient's sternum vertically (figure 1). Second, the opposite hand was wrapped around the elbow joint of the rescuer's compression arm (figure 2). We named this posture modification the modified one-handed chest compression technique (MOHCC). This study was performed to evaluate the effect of the MOHCC on the mean compression depth over time.

METHODS

Study design

The study was planned as a prospective single simulation trial and was approved by the Chung-Ang University Hospital Institutional Review Board [Approval number: C2015071(1529)] and registered with the clinical trial registry platform (Clinical Research Information Service; Registered number: KCT0001514).

Study population

Medical doctors working in our emergency department of the university hospital were recruited. The inclusion criterion was being a certified Basic Life Support Provider of the American Heart Association within 2 years. The exclusion criteria were recent wrist or hand injuries. All participants provided written informed consent before the experiment commenced.

The sample size was calculated based on the mean compression depth. We set the two-sided significance level at 0.05 and the statistical power at 80%. Population variance was set at 26.3 according to a previous study. (2) We hypothesized that the MOHCC could reduce the decrease in compression depth by 50% (2.8 mm) compared with conventional OHCC. (2) The minimum number of participants was calculated to be 27 using web-based software (sample size calculator: one-sample mean). (3)

Study setting and protocol

The experiment was performed in the emergency department of a single university hospital. The simulated in-hospital pediatric arrest model included a 70-cm-high bed, a 25-cm-high stepstool, a Resusci Junior Basic and SkillGuide pediatric manikin (Laerdal Medical, Stavanger, Norway) and a CPRmeter (Laerdal Medical). No mattress was used and the visual feedback screen of the CPRmeter was shrouded during the experiment.

The participants performed 2 min of continuous chest compressions without ventilation using the MOHCC technique in this setting. The anthropometric data of the participants (height, body weight, and knee height) were collected before the experiment. The hand used for chest compression and the rescuer's location (right or left side of the manikin) were randomized using a randomization list, arranged by random number sequences with six permuted blocks. The participants assigned to group A used their right hand for the MOHCC technique and were positioned on the right side of the manikin, and vice versa for those assigned to group B (figure 2). We matched the compressing hand and rescuer's location (right to right and left to left) because the hypothenar area of the heel exerted a significantly higher force compared to the thenar area. (4)

We allowed the participants 1 min of practice to familiarize themselves with the MOHCC technique and the use of the CPRmeter immediately prior to the tests.

Outcome variables

The primary outcome variable was the mean chest compression depth (MCD) and the secondary outcome variable was the mean chest compression rate (MCR). Data were measured at 30 s intervals using the Q-CPR review software (ver. 3.1; Laerdal Medical).

Statistical analyses

All statistical analyses were performed using the IBM SPSS for Windows software package (ver. 20.0; IBM, Armonk, New York, USA). Data are presented as means ± SD. Repeated measures analysis of variance tests with Bonferroni correction were conducted to evaluate differences in the MCD and MCR values over time. A P-value of < 0.05 was considered to indicate statistical significance.

RESULTS

Characteristics of the participants

In total, 30 medical doctors participated. The mean age of participants was 28.8 ± 3.7 years. There were 28 males (28/30, 93.3%) and 2 females (2/30, 6.7%). The average height, weight, body mass index and knee height of the participants were 174.4 ± 6.8 cm, 77.2 ± 12.9 kg, 25.3 ± 3.7 kg/m2 and 45.1 ± 2.4 cm (range; 41–51 cm), respectively. Participants' knees were positioned within -4 to +6 cm from the bed height (70 cm).

Changes in the MCD and MCR during performance of the MOHCC

The MCD changed significantly over time [F(3,27)=6.620, P=0.002] (table 1). However, it did not decrease significantly between 60–90 s and 90–120 s (P=0.173). The MCR did not change significantly over time [F (3,27)=0.335, P=0.800].

Table 1. Changes in the MCD and MCR during performance of the MOHCC.

Parameters	0~30 s (95% CI)	30~60 s (95% CI)	60~90 s (95% CI)	90~120 s (95% CI)	*P-value
MCD (mm)	43.3±3.7 (41.9 to 44.7)	42.0±4.3 (40.4 to 43.6)	41.0±4.8 (39.2 to 42.8)	40.4±4.9 (38.6 to 42.3)	0.002
†Multiple comparison tests	a	b	c	c	
MCR (/min)	113.7±13.8 (108.6 to 118.9)	113.5±15.1 (107.9 to 119.1)	113.5±15.5 (107.7 to 119.3)	113.2±15.6 (107.4 to 119.0)	0.800
†Multiple comparison tests	a	a	a	a	

MCD, mean chest compression depth; MCR, mean chest compression rate; MOHCC, modified one-handed chest compression technique; 95% CI, 95% confidence interval.
*Statistical significances were tested by repeated measures analysis of variances.
†The same letters indicate non-significant difference between time intervals based on multiple comparison tests under Bonferroni correction. A P-value < 0.05 is presented in bold.

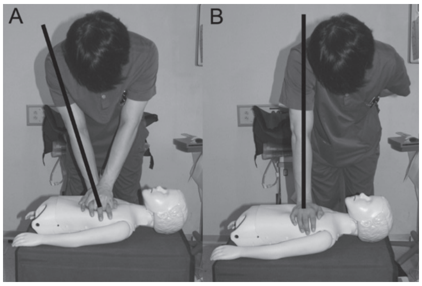

Figure 1. First step of the posture modification of the one-handed chest compression technique: adjustment of the axis of the rescuer's compression arm.

A Axis of the right arm (black line) during the two-handed chest compression technique.
B Axis of the right arm (black line) during the one-handed chest compression technique.

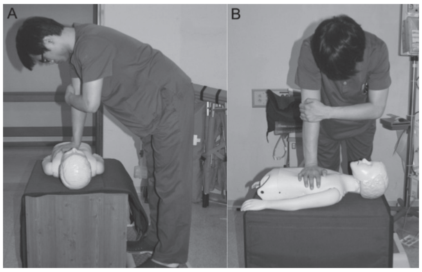

Figure 2. Second step of the posture modification of the one-handed chest compression: fixation of the elbow joint of the rescuer's compression arm.

A Side picture of the rescuer.
B Front picture of the rescuer.

DISCUSSION

Although the MCD changed significantly over a 2 min period, it did not decrease significantly after 90 s. Furthermore, the total decrease in MCD during MOHCC was 2.9 mm over a 2 min period. The total decrease in MCD during conventional OHCC in a previous study was 5.6 mm, which is ~50%. (2)

If greater chest compression depths are required, the THCC should be selected as the chest compression technique. (2,5-8) However, if the OHCC is considered because of the risk of CPR-related injury, MOHCC could be used instead of conventional OHCC because of its efficacy in reducing the decrease in MCD.

The MCD decrease can also be reduced by alternating compression hands at certain time intervals. (9,10) The lack of any difference between the OHCC conducted using the dominant and non-dominant hands suggests the feasibility of this technique. (11) However, alternating compression hands might result in increased hands-off times. Therefore, if the reduction in MCD decrease between the MOHCC and alternating-hands techniques is similar, the MOHCC might be better. Further study of this matter is warranted.

This study had several limitations. First, although the MOHCC resulted in an only slight decrease in MCD, further studies (e.g., estimating the potential reduction in MCD decrease, and comparing the CPR quality between the MOHCC and conventional OHCC) are needed because this work constituted only a single trial. Second, the present study was conducted in a hospital setting, such that the results cannot be applied to other settings (e.g., kneeling beside the patient). Third, although we hypothesized that the MOHCC would stabilize rescuer posture and facilitate loading of the rescuer's upper body mass, the precise levels of posture stabilization and upper body mass loading could not be determined because only performance data were measured (e.g., MCD and MCR). Further studies are thus needed. Fourth, all participants in the present study were medical doctors. Therefore, our results could not be applied to non-medical doctors (e.g., lay rescuers, nurses and emergency medical technicians).

CONCLUSIONS

Although the MCD changed significantly over a 2 min period during performance of the MOHCC, it did not decrease significantly after 90 s. The MOHCC might be considered when OHCC is selected as a chest compression method for small children suffering cardiac arrest.

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