学 位 論 文 の 要 旨

氏 名　佐藤 直

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著 者 名	Nao Sato, Kenji Karino, Makoto Hirose, Satoru Okamoto, Tomoko Osaka, Hatsue Matsumura, Yoshiaki Iwashita

論 文 内 容 の 要 旨

INTRODUCTION

In 2000, the American Heart Association and the International Liaison Committee on Resuscitation jointly published the Guidelines 2000 (G2000), which has become the standard for cardiopulmonary resuscitation (CPR) worldwide. A high chest compression depth CCD has been associated with survival outcomes, with a depth of ≥50 mm increasing the rate of survival after resuscitation. In particular, with a CCD of ≤40 mm, the success rate of defibrillation shocks decreases considerably, impacting the survival rate after resuscitation. However, the CCD remained shallow even when lightweight rescuers adopted the correct posture. Given this, many researchers have concluded that underweight rescuers require additional attention and specialized training. Bucki et al. reported that increasing knee flexion above 90° during chest compressions increased pressure. When studying residents' shoulder positions, Mayrand et al. found that compressions at <90° resulted in significantly shallow depths. Therefore, these studies highlight the effectiveness of focusing on posture in increasing the CCD. However, the optimum angle is unknown, and there have been no reports comparing the effectiveness of chest compressions at different angles. When performing chest compressions, the rescuer's shoulder acts as the point of effort, the palm placed on the sternum acts as the point of load, and the intersection between the frontal plane of the manikin/patient chest and the extension line of the rescuer's shoulders and hips acts as the fulcrum point. According to the leverage principle, when a certain amount of force is applied to the point of effort, longer distances between the point of effort and the fulcrum lead to an increase in the force applied to the point of action. Therefore, when the rescuer's weight is applied to the point of effort, the force of chest compressions can be increased by adopting a forward-leaning posture that places the point of effort anteriorly to the position of the palms, which act as the point of load. Therefore, we attempted to compare the CCD at 90° and 100° in lightweight Asian females. We hypothesized that the CCD would be greater at 100° than at 90° in a simulated cardiac arrest model.

MATERIALS AND METHODS

This study included 35 female students from Shimane University with a standing height of ≤165 cm who were in their fifth and sixth year of study at the Department of Medicine and had received basic life support training within a year before participating in this study. The participants performed 30 chest compressions at 90° and 100° from the frontal plane of the chest. Chest compressions were performed on the floor using a CPR training manikin The participants were classified into three groups according to the depth of the chest compressions at 90°. The chest compression angle (CCA) was measured using Kinect V2, a non-contact motion-capture device. After performing chest compressions, the mean CCA used in 30 compressions was calculated based on the angles measured using Kinect. The angle was considered to be 90° when the measured mean angle was 90°±3° and 100° when the measured mean angle was 100°±3°. Participants whose CCAs deviated from these ranges in either case were excluded from the analysis. The distance between the participant's shoulders and the point of intersection between the extension line of the participants' hips and the frontal plane of the manikin's chest was named distance "a," while the distance between the participant's shoulders and the location of the participant's palms placed on the manikin's chest was referred to as distance "b." Distance "c" refers to the distance of the remaining side of the triangle. The CCFORCE and CCD and the residual force on the chest wall during decompression for each chest compression were compared using CPRmeter-2. This study was conducted to compare CCDs at two chest compression angles.

Preliminary calculation

In conventional chest compression, a right triangle is formed following the Pythagorean theorem: $a^2=b^2+c^2$. In a forward-leaning posture, which displaces the point of effort anteriorly, the CCA is obtuse; therefore, in accordance with the triangle cosine theorem, the formula is revised to: $a^2=b^2+c^2- 2bc\mathrm{Cos}\theta$. According to the type 2 leverage principle, the force applied to the point of action depends on the distance from the fulcrum to the point of force if the distance from the fulcrum to the point of action is similar. Furthermore, the CCFORCE increases with distance "a."

RESULTS AND DISCUSSION

This study showed that the CCD was deeper at a CCA of 100° than at 90° in lightweight females. Of the 35 participants, 3 were excluded from analysis because their compression angles deviated from the prescribed angle. The remaining participants were classified into three groups:

those who achieved a CCD of ≤40 mm at a chest compression angle (CCA) of 90° were assigned to group 1, those who achieved a CCD of 41–49 mm were assigned to group 2, and those who achieved a CCD of ≥50 mm were assigned to group 3. Among them, the participants whose CCD was ≤40 mm at a CCA of 90° showed a statistically significant increase in CCD at a CCA of 100°. Overall mean CCD increased from 90° to 100° (44.3±8.2 mm vs. 48.1±7.2 mm; $p<0.05$). Mean CCD changes between 90° and 100°were 34.4±4.7 mm vs. 42.9±4.8 mm ($p<0.05$) in group 1, 44.9±2.5 mm vs. 47.0±4.2 mm ($p=0.17$) in group 2, and 53.0±2.7 mm vs. 55.4±5.6 mm ($p<0.05$) in group3. With a CCA of 90° and 100°, the 32 participants showed CCFORCEs of 45.7±7.5 kgf and 49.5±7.2 kgf, respectively ($p<0.05$). In a regression equation using CCFORCE as the explanatory variable and CCD as the objective variable, the following formula was derived: $y=0.959x + 0.579$ ($r=0.913$, $p<0.05$), showing a strong correlation between the CCFORCE and CCD in the 32 participants. The CCD and CCFORCE are strongly correlated; thus, an increase in the CCFORCE increases the CCD. To increase the CCD of lightweight rescuers, we observed the posture of the chest compression and applied the lever principle. This anterior leaning position leads to an increase in distance "a" and an increase in the CCFORCE. The CCD and CCFORCE are strongly correlated; thus, an increase in the CCFORCE increases the CCD.

The residual force on the chest wall during recoil was also measured. Based on the results of the 32 participants, the measured values were 1.9±2.2 kgf and 3.6±3.8 kgf at 90° and 100°, respectively ($p<0.05$). Our study showed that the residual force was higher at a CCA of 100° than at a CCA of 90° in all groups. However, we do not know which is more harmful to the patient, allowing a shallow compression depth of less than 40 mm or an increase in the residual force. Our study has three main limitations. First, this was a simulation model study, and how this applies to real patients remains unclear. Second, chest compression at a CCA of 100° produced a horizontal force, which may lead to rib fractures. Therefore, additional research is needed on the association between horizontal force and the risk of rib fractures. Third, in group 1, the mean CCD was lower than the recommended value of 50 mm in most participants. However, 7 of the 10 participants with an initial CCD of ≤40 mm achieved a great depth at a CCA of 100°. Any improvement in CCD will increase the chances of successful defibrillation.

CONCLUSION

By setting the CCA at 100°, the CCD was significantly increased in lightweight rescuers in this simulation study. However, the depth was still less than the guideline-recommended depth. Further research using more realistic scenarios (perhaps in combination with feedback systems), longer periods of compression, and clinically relevant models is needed.