Asian First Responder’s Tolerance for Sustaining Chest Compressions During Resuscitation

Sheng Ang Zhou
Department of Emergency, Zhejiang Provincial People’s Hospital, Hangzhou 310014, China
People’s Hospital of Hangzhou Medical College, Hangzhou 310014, China

Andrew Fu Wah Ho
SingHealth Emergency Medicine Residency Program, Singapore Outram Road, Singapore 169608

Nan Liu
Department of Emergency Medicine, SingHealth Emergency Medicine Residency Program, Singapore Outram Road. Singapore 169608

Marcus Eng Hock Ong
Department of Emergency Medicine, Singapore General Hospital, Singapore Outram Road, Singapore 169608
Health Services and Systems Research, Duke-NUS Medical School, Singapore 8 College Road, Singapore 169857

Yueliang Zheng
Department of Emergency, Zhejiang Provincial People’s Hospital, Hangzhou 310014, China
People’s Hospital of Hangzhou Medical College, Hangzhou 310014, China

Pin Pin Pek
Department of Emergency Medicine, Singapore General Hospital, Singapore Outram Road, Singapore 169608

Wenwei Cai*
Department of Emergency, Zhejiang Provincial People’s Hospital, Hangzhou 310014, China
People’s Hospital of Hangzhou Medical College, Hangzhou 310014, China
*Corresponding author(E-mail: 1361215187@qq.com)

Abstract
The latest ILCOR guidelines recommend a target compression depth of at least 5 cm and rate of >100/minute. The aim of the present study was to investigate the first responder’s tolerance for sustaining external chest compressions (CCs) in a manikin training setting. Three cycles of chest compressions (about 6 minutes) were performed by 91 volunteers on a Cardiopulmonary Resuscitation (CPR) manikin (The Resusci Anne® QCPR®). The performance data collected included compression depth (CD) and compression rates (CR). A total of 91 medical school students from China participated in the study. The participants’ heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) before and after participation were documented. The participants’ body mass index (BMI), their right upper arm circumference (AC) and fatigue severity score (FSS) also were documented. The mean depth of compression (male vs female) over 3 cycles were 49.27±7.39 mm vs 43.04±8.15 mm, 46.8±9.28 mm vs 40.02±8.10 mm, and 45.55±9.41 mm vs 38.46±8.67 mm, respectively. The changes in the SP, DP, HR and FSS after CPR between genders were not significant (p>0.05). CD was significantly associated with gender and BMI. However, there was no statistical significance between the three cycle’s CDR and right upper AC. In conclusion, Asian first responder’s tolerance of sustaining external chest compression may be below current recommended guidelines and thus require frequent rotations for chest compression during resuscitation.

Key words: Chest Compression; Depth; Tolerance; Fatigue.
La Tolerancia de los Primeros Respondedores de Asia a Mantener las Compresiones Torácicas Durante la Reanimación

Resumen
La última ILCOR Guidelines recomiendan un objetivo de al menos 5 cm de profundidad de la compresión y la tasa de > 100 / minuto. El objetivo del presente estudio fue investigar la primera respuesta es la tolerancia para sostener las compresiones torácicas externas (CCS) en un maniquí de entrenamiento. Tres ciclos de compresiones torácicas (unos 6 minutos) fueron realizadas por 91 a voluntarios en un maniquí de reanimación cardíopulmonar (RCP) (El Resusci Anne® QCPR®). Los datos de rendimiento obtenidos incluyeron la profundidad de la compresión (CD) y tasas de compresión (CR). Un total de 91 estudiantes de medicina de China participó en el estudio. Los participantes’ Heart Rate (HR), presión arterial sistólica (PAS), la presión arterial diastólica (PAD) antes y después de la participación fueron documentados. Los participantes’ Índice de masa corporal (IMC), circunferencia del brazo superior derecho (AC) y fatiga gravedad puntuación (FSS) también fueron documentados. La profundidad media de compresión (macho y hembra) durante 3 ciclos fueron el 49.27 ± 7.39 mm vs 43.04 ± 20 mm, 46.8 ± 9.28 mm vs 40.02 ± 8.10 mm, y 45.55 ± 9.41 mm vs 38.46 ± 0.07 mm, respectivamente. Los cambios en el SP, DP, HR y FSS después de CPR entre géneros no fueron significativas (p > 0.05). CD fue significativamente asociados con el género y el IMC. Sin embargo, no hubo significación estadística entre los tres ciclos, CDR y right upper AC. En conclusión, Asian First Responder es la tolerancia de la compresión torácica externa puede estar por debajo de los actuales directrices recomendadas y, por tanto, requieren de frecuentes rotaciones para la compresión del pecho durante la reanimación.

Palabras clave: La Profundidad de la Compresión Torácica; la Tolerancia; Fatiga

1. Introduction
Quality of chest compressions (CCs) are a key element in chain of survival. According to the 2010 American Heart Association (AHA) cardiopulmonary resuscitation (CPR) guidelines, the rescuers should provide CCs to victims of cardiac arrest. In addition, high quality CC, which is defined as a compression depth of at least 50 mm and a rate of at least 100 CCs per minute, should be performed [1]. However, it is more difficult for the rescuer to meet the guidelines due to the increased fatigue [2]. Since physical fatigue of the rescuer influences the quality of CCs in the sustaining procedure, the guidelines recommend rotating the operator every 2 minutes [3,4]. The guidelines do not consider fatigue when determining the rotation time [5]. At present, there are few studies objectively reporting on the fatigue of the CPR operator, and few among the Asian population. The present study analyzed the variation of the depths and rates of CCs obtained in a manikin training setting to observe the tolerance of a group of Asian people for sustaining CCs.

2. Methodology
A total of 91 medical school students (male, n=28, female, n=63) trained recently for CPR for over 4 hours were randomly selected for the study. Basic parameters of all participants are shown in Table 1. This study was a prospective randomized trial conducted in a medical school. This design was chosen to show the tolerance in the fatigue and performance level following 3 cycles of the standard 30:2 CPR method. This study was approved by the ethics committee of Zhejiang province people’s hospital.

<table>
<thead>
<tr>
<th>Table 1. Characteristics of Participants</th>
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<tbody>
<tr>
<td>Male (n=28)</td>
</tr>
<tr>
<td>Weight (kg)</td>
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<tr>
<td>Height (cm)</td>
</tr>
<tr>
<td>Right Upper AC (CM)</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
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<tr>
<td>HR before (B/m)</td>
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<td>HR after (B/m)</td>
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</table>
### 2.1 Study protocol

The participants had no musculoskeletal injuries, sprains, or pain. The participants practiced CPR on manikins before they began the tests. All were notified to attend a CPR trial, but did not know the details of the trial. Before the trial, all participants had an adequate rest of over 3 hours. Three cycles, five groups of standard 30:2 CPR each, were then performed kneeled on a manikin (The Resusci Anne® QCPR®, Leardal Medical Corporation, Stavanger, Norway) which was placed on the floor. At the end of each participation, the Resusci Anne were recovered in a comfortable posture.

Effective CC was identified as CCs with a depth of more than or equal to 50 mm. Each participant was instructed to perform continual external CC on the Resusci Anne manikin. The CC duration was over 5 minutes for each session, without interruption or feedback about the compression. The order of participants was randomized.

### 2.2 Work while performing chest compression

Physical parameters, including compression depths (CDs), compression rates (CRs), the participants’ heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured before and after participation. The ACs were measured at the midpoint of the lateral epicondyle of homeron and olecranon and the steroid process of the ulna in their relaxed and fall posture. The fatigue severity scale (FSS) was used to rank the intensity of compression from 0 (none) to 20 (extreme exhaustion) once the participant completed the session.

### 2.3 Performance of chest compression on the manikin

Our experimental model consisted of the Resusci Anne manikin located on the floor and the participants kneeled beside it to perform CCs. The manikin was wirelessly connected to a terminal, and CC performance data were transmitted from the manikin to the computer. Data were collected using the Laerdal PC Skill Reporting System (PC Skill meter; Laerdal Medical, Stavanger, Norway). Data output from the Laerdal PC Skill Reporting System included compression depth (CD), compression rate (CR).

### 2.4 Data analysis

Statistical analyses were performed using SPSS version 20.0. Continuous variables, including height, weight and BMI, chest compression data and physical variables are expressed as mean ± SD. The quality of CCs are measured as three factors, the compression rate (CR), the compression depth reduction (CDR) and the satisfaction rate of compression depth (SRCD). CDR is the gap between the least ideal CD (50 mm) with the actual CD (positive number). SRCD is defined as the percentage of the sufficient compression (CD >50 mm) numbers in each cycle. The alteration of the three factors tend to relate with quality of CC and was analyzed using a paired t-test, which also can reflect the tolerance of the participants. P<0.05 was taken as statistically significant.

We also conducted a subgroup analysis separately for female and male participants. The compression performance between each cycle was analyzed using a paired t-test. Additionally, the fatigue severity scale (FSS) at the end of each session was analyzed using a chi-squared test.

We divided the participants into 3 subgroups according to BMI (BMI ≥ 25, BMI ≥ 18.5, BMI < 18.5 kg/m²), and right upper arm circumference (AC) (AC > 30, AC ≥ 20, AC <20 cm). The compression performance between each cycle was analyzed using a paired t-test.
3. Results

3.1 Comparison of CDs, CDRs, CRs (Male vs. Female)

The CDs per cycle were significantly different between the 2 subgroups in the 1st, 2nd and 3rd cycle (P=0.001) (Table 2). The mean CDs in the male subgroup were 45.55 ± 9.41 mm in the 3rd cycle, while the mean CDs in the female subgroup were 40.02 ± 8.1 mm in the 2nd cycle and lowered to 38.46 ± 8.67 mm in the 3rd cycle.

Table 2. Comparison of CDs, CDRs, CRs (Male vs. Female)

<table>
<thead>
<tr>
<th></th>
<th>Male (n=28)</th>
<th>Female (n=63)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD (1st Cycle)</td>
<td>49.27±7.39</td>
<td>43.04±8.15</td>
<td>3.458</td>
<td>0.001</td>
</tr>
<tr>
<td>CD (2nd Cycle)</td>
<td>46.8±9.28</td>
<td>40.02±8.10</td>
<td>3.524</td>
<td>0.001</td>
</tr>
<tr>
<td>CD (3rd Cycle)</td>
<td>45.55±9.41</td>
<td>38.46±8.67</td>
<td>3.507</td>
<td>0.001</td>
</tr>
<tr>
<td>CDR (1st Cycle)</td>
<td>3.29±5.05</td>
<td>7.71±7.1</td>
<td>-2.973</td>
<td>0.004</td>
</tr>
<tr>
<td>CDR (2nd Cycle)</td>
<td>4.88±7.8</td>
<td>10.43±7.29</td>
<td>-3.286</td>
<td>0.001</td>
</tr>
<tr>
<td>CDR (3rd Cycle)</td>
<td>6±7.84</td>
<td>11.98±7.86</td>
<td>-3.354</td>
<td>0.001</td>
</tr>
<tr>
<td>CR (1st Cycle)</td>
<td>153.51±23.1</td>
<td>150.08±22.29</td>
<td>0.671</td>
<td>0.504</td>
</tr>
<tr>
<td>CR (2nd Cycle)</td>
<td>152.84±22.92</td>
<td>150.07±21.78</td>
<td>0.551</td>
<td>0.583</td>
</tr>
<tr>
<td>CR (3rd Cycle)</td>
<td>151.88±23.07</td>
<td>149.87±22.78</td>
<td>0.388</td>
<td>0.699</td>
</tr>
</tbody>
</table>

*Values are mean ± standard deviation.
*CD: Compression Depth; CDR: Compression Depth Reduction; CR: Compression Rate

The pace of CDRs in the 2 subgroups in the three cycles were also significantly different (P=0.001, 0.001, 0.004) (Table 2). However, the differences in CRs between the 2 subgroups were not statistically significant (P>0.05) (Table 2).

3.2 Comparison of BMI and CDRs, SRCRD

The participants were separated into 3 subgroups by BMI as described above and CDRs were measured in each cycle. There was a sufficient difference between them (Figure 1).

3.3 Comparison of Right Upper AC and CRs

We separated the participants into 3 subgroups by their right upper AC. There were no statistically significant differences between them (Figure 2).
3.4 Comparison of FSS

According to the chi-squared test, the FSS showed no significant difference between genders (P>0.05) (Table 3).

<table>
<thead>
<tr>
<th></th>
<th>Male(n, %)</th>
<th>Female(n, %)</th>
<th>(\chi^2)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhausted 19-20</td>
<td>2(7.14%)</td>
<td>8(28.57%)</td>
<td></td>
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</tr>
<tr>
<td>Very Tired 17-18</td>
<td>3(10.71%)</td>
<td>16(57.14%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tired 15-16</td>
<td>8(28.57%)</td>
<td>16(57.14%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A little Tired 13-14</td>
<td>11(39.29%)</td>
<td>17(60.71%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy 11-12</td>
<td>4(14.29%)</td>
<td>4(14.29%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxed 9-10</td>
<td>0(0.00%)</td>
<td>2(7.14%)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>5.41</td>
<td>0.354</td>
</tr>
</tbody>
</table>

4. Discussion

The present study indicated that the quality of continuous CCs among the participants (young and healthy medical students) could hardly achieve the 2010 AHA cardiopulmonary resuscitation guidelines by analyzing the reduction of the depth of CCs. The AHA guidelines mainly refer to databases of CPR in Caucasian people. The standard for CPR operation was based around qualities of Caucasian people. However, differences in physique and tolerance between different groups of people prompted us to understand the tolerance from a small sample of 91 Asian medical students. The study showed that Asian people could not achieve the standards of the AHA CPR guidelines (CD ≥ 50 mm). This contributed to the mortality of cardiac arrest in Asian people. If yes, the rescuer can be rotated more frequently to satisfy the needs of depth as the tolerance cannot be changed. If not, the standard of depth of compression would need to be lowered in Asian people. The result in females were not as strong as with males. Thus, in the situation of cardiac arrest, male bystanders should first be considered to perform CCs.

The HR, BP and FSS were positively related to the reduction of CCS, during compression. We believed that monitoring the alternations of HR and BP might prompt or predict the fatigue of participants. It is known that fatigue affects the quality of CCs. Ochoa et al. [6] found that even in the first minute of CCs, the quality of CCs had deteriorated as reduction of depth, rate and insufficiency of chest resilience, without the operator noticing. Sugerman et al. [7] studied in-hospital cases of CPR and found reduction of CDs after 90 sec which reflected the fatigue of the operators. Furthermore, Ashton et al. recommended rotating the rescuer performing CCs at 1 min intervals [8]. The AHA guidelines suggested to rotate position every 2 minutes during dual station operation [3]. In this study, it was necessary to rotate more frequently than every 2 minutes to improve the quality of CCs.
The guidelines suggested that the CR should be above 100 cpm, but did not clearly explain how to calculate this parameter [3]. The mean CRs appeared faster than the normal frequency documented before. Due to issues with the method of calculation, it was exported directly from the terminal without adding the time of artificial respiration. There was no significant difference between the mean value of CRs in each cycle. Ashton et al. reported that, even the frequency increased in the procedure as compensation for fatigue [8]. But it was found that increased fatigue in the rescuers can result in a deterioration tendency in the percentile of effective compression during CPR.

Figure 1 shows that the participants with higher BMI were more efficient at CCs. Even the CDR in the subgroup with BMI > 25 kg/m² in the 3rd cycle was superior to the subgroup with BMI < 25 kg/m² in the 1st cycle. It was reported that the pressure on the chest should be at least 50 kg in a high quality CC [9]. Hasegawa et al. suggested that individuals with a lower body weight should rotate at 1 min intervals to maintain high quality CPR and thus improve the survival rates and neurological outcomes of victims of cardiac arrest [10]. Thus, we suggest if there is a “big man” present, he should be the first choice to perform CCs. This is why the arms of the rescuer are required to be perpendicular to the patient’s chest, using their own weight. To date, there are no studies on the relation between CCs and AC. Our study showed there was no statistical difference between the right upper ACs and CRs. We believe that participants for neonatal resuscitation should shorten their rotating time to roughly 1 min as described in a previous study [11].

In this study, all participants performed CPR in a kneeling position. Another study reported that in order to minimize rescuer fatigue, it was recommended to alternate rescuers every 2 min while kneeling or standing on a stool, and every 1 min while standing on the floor [12]. We suggest a kneeling position for Asian people.

This study has limitations. First, the study was based on a manikin. The CCD may be different from that in real cardiac arrest in consideration of chest stiffness and damping [13]. Second, the mean age of the research subjects was below that of real bystanders. A further study including a more varied group is needed. Third, we analyzed the data in cycles. If detail optimization can be reached as in every 50 compressions, this may be superior.

5. Conclusions

In conclusion, on the tolerance of Asian people in sustaining external CCs may be quite different from the updated data of the AHA which suggests changing bystander after 1 cycle or every 2 minutes. To Asian first responders, shortening the alternation frequency of personnel is a practical and effective method to ensure the quality of CCs.

Males performed better than females in this trial, as well as those participants with high BMI did better than those with low BMI. Thus, the authors thought males or people with high BMI should be considered the first choice to perform CPR. Besides, it is very necessary to stress and regulate CD in the training of CPR to public, even medical profession.

Acknowledgements

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References


