Original Article

Correlations between quality indexes of chest compression

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BACKGROUND: Cardiopulmonary resuscitation (CPR) is a kind of emergency treatment for cardiopulmonary arrest, and chest compression is the most important and necessary part of CPR. The American Heart Association published the new Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care in 2010 and demanded for better performance of chest compression practice, especially in compression depth and rate. The current study was to explore the relationship of quality indexes of chest compression and to identify the key points in chest compression training and practice.

METHODS: Totally 219 healthcare workers accepted chest compression training by using Laerdal ACLS advanced life support resuscitation model. The quality indexes of chest compression, including compression hands placement, compression rate, compression depth, and chest wall recoil as well as self-reported fatigue time were monitored by the Laerdal Computer Skills and Reporting System.

RESULTS: The quality of chest compression was related to the gender of the compressor. The indexes in males, including self-reported fatigue time, the accuracy of compression depth and the compression rate, were higher than those in females. However, the accuracy of chest recoil was higher in females than in males. The quality indexes of chest compression were correlated with each other. The self-reported fatigue time was related to all the indexes except the compression rate.

CONCLUSION: It is necessary to offer CPR training courses regularly. In clinical practice, it might be better to change the practitioner before fatigue, especially for females or weak practitioners. In training projects, more attention should be paid to the control of compression rate, in order to delay the fatigue, guarantee enough compression depth and improve the quality of chest compression.

KEY WORDS: Cardiopulmonary resuscitation; Chest compression; Quality indexes; Correlation

World J Emerg Med 2013;4(1):54–58

DOI: 10.5847/wjem.j.issn.1920-8642.2013.01.010

INTRODUCTION

Cardiopulmonary resuscitation (CPR) is a kind of emergency treatment for cardiopulmonary arrest, and chest compression as the most important and necessary part of CPR requires the practitioners to compress the

center of the victim's chest deeply and quickly as soon as possible after cardiopulmonary arrest occurs. The kind of practice can maintain the function of cardiac pump by forcing the heart to pump blood, and creating certain negative pressure of the chest to force blood backflow

at the meantime.^[1,2] High-quality chest compression can maintain effective blood circulation and guarantee blood supply for critical organs in a short term after cardiopulmonary arrest occurs, which acts as the most basic treatment before advanced treatment is available. It increases the survival rate and decreases the irreversible damage to the nervous system caused by hypoxia-ischemia and ultimately improves the prognosis of patients.^[2,3] "2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care" (2010 AHA guidelines) as one of the most authoritative guidelines was published in 2010 and demanded for better performance of chest compression practice. It called for a rate of "at least 100 beats/min" and a depth of "at least 5cm" while offering chest compression in CPR,^[4] which directly raised the difficulty of practicing chest compression for practitioners. So far, the research based on clinical CPR practice was rare,^[5] while most of the published articles reported the practice of CPR still owe specification among healthcare workers.^[6] In the current research project, the research team offered training to healthcare workers by using Laerdal ACLS advanced life support resuscitation model, and monitored the quality issues of chest compression, including compression hands placement, compression rate, compression depth, and chest wall recoil, as well as self-reported fatigue time by Laerdal Computer Skills and Reporting System. After the training, data were analyzed to explore the inner correlation of the quality indexes in order to guide later CPR training and clinical practice.

METHODS

Study population and design

Totally 219 subjects were selected randomly from an AAA hospital by convenient sampling. All the recruits only practiced chest compression based on "2010 AHA guidelines" for 2 minutes in this study by the Laerdal ACLS advanced life support resuscitation model. The quality indexes of chest compression, including compression hands placement, compression rate, compression depth, and chest wall recoil, were monitored by the Laerdal Computer Skills and Reporting System. Meanwhile, self-reported fatigue time was recorded. The recruits were required to keep the knee position to the chest level of the model during the practice of chest compression, to ensure the shoulders to be just above the center of the model's chest in order to compress vertically.

Data collection

The basic information including age, gender, title, and education level, etc was recorded before the training. Data about the quality indexes of chest compression were recorded by the Laerdal Computer Skills and Reporting System and logged into a computer. Accuracy of four quality indexes including compression hands placement, compression rate, compression depth, and chest wall recoil was presented in the form of percentage. Compression rate was also presented in the form of average rate, and self-reported fatigue time was presented in degree of second. Among the six variables, accuracy of hands placement was calculated with the number of compressions with correct hands placement divided by the total number of compressions (%); the average rate of chest compression was the mean compression rate recorded by the recording system (beats/min); accuracy of compression rate was calculated with the number of compressions with a rate over 100 beats/min divided by the total number of compressions (%); accuracy of deep-compression was calculated with the number of compressions with depth more than 5 cm divided by the total number of compressions (%); accuracy of chest recoil was calculated with the number of compressions with complete chest recoil divided by the total number of compressions (%); self-reported fatigue time was the time when the practitioner experienced decrease of compression depth because of fatigue which directly reported by the practitioners after finishing the compression (s).

Statistical analysis

Data were analyzed using SPSS version 12.0 (SPSS Inc, Chicago, IL, USA). Basic information about the subjects was descriptively expressed. One-way ANOVA and Student's *t* test was used to assess the differences between different genders, ages, titles, and education levels of the recruits. Correlation analysis was used to explore the relationship among the quality indexes of chest compression. A *P* value <0.05 was considered statistically significant and a *P* value <0.01 was considered highly statistically significant.

RESULTS

Basic information

In the 219 subjects in the current study, 77 (35.16%) were male and 142 (64.84%) female, with an average age of 31±5.34 years. There were 113 (51.6%) with a primary title, 102 (46.6%) with a secondary title, and only four (1.8%) with a senior title. Totally 166 (75.8%)

practitioners had a doctoral degree, 23 (10.5%) had a master degree in medical science, and 30 (13.7%) recruits had a bachelor degree or below.

Relevant factors of chest compression quality indexes

There was no significant difference between the chest compression quality indexes among practitioners with different ages, titles and education levels (results omitted). Self-reported fatigue time, accuracy of deep-compression, and accuracy of chest recoil were found to be different between males and females. The self-reported fatigue time and accuracy of deep-compression were higher in males than in females, whereas the accuracy of chest recoil was lower in males. The detailed data are shown in Table 1.

Correlations between chest compression quality indexes

Correlative analysis revealed that self-reported fatigue time was positively related to the accuracy of hands placement and accuracy of deep-compression, but it was negatively related to the accuracy of compression rate and chest recoil. Detailed results are presented in Table 2.

Table 1. Student's *t* test of chest compression quality indexes between different genders

Variables	Male (n=77) (mean±SD)	Female (n=142) (mean±SD)	<i>t</i>	<i>P</i>
SRFT (s)	70.91±32.47	50.16±24.26	5.348	0.000 [#]
AHP (%)	81.16±34.56	84.54±30.17	-0.723	0.471
ARCC (beat/min)	132.64±20.56	130.03±24.78	0.833	0.406
ACCR (%)	99.10±2.83	93.75±19.08	2.446	0.015 [*]
ADC (%)	23.51±35.38	9.67±19.27	3.751	0.000 [#]
ACR (%)	69.56±35.40	83.36±27.22	-3.215	0.000 [#]

*: *P*<0.05; #: *P*<0.001; SRFT: self-reported fatigue time; AHP: accuracy of hands placement; ARCC: average rate of chest compression; ACCR: accuracy of compression rate; ADC: accuracy of deep-compression; ACR: accuracy of chest recoil.

Table 2. Correlation analysis of chest compression quality indexes

Variables	SRFT	AHP	ARCC	ACCR	ADC	ACR
SRFT	—	0.166 [*]	-0.106	-0.246 [#]	0.366 [#]	-0.178 [#]
AHP	0.166 [*]	—	-0.026	-0.032	0.036	-0.012
ARCC	-0.106	-0.026	—	0.343 [#]	0.086	-0.086
ACCR	-0.246 [#]	-0.032	0.343 [#]	—	0.122	-0.023
ADC	0.366 [#]	0.036	0.086	0.122	—	-0.080
ACR	-0.178 [#]	-0.012	-0.086	-0.023	-0.080	—

*: *P*<0.05, #: *P*<0.01; SRFT: self-reported fatigue time; AHP: accuracy of hands placement; ARCC: average rate of chest compression; ACCR: accuracy of compression rate; ADC: accuracy of deep-compression; ACR: accuracy of chest recoil.

DISCUSSION

The relationship between gender and quality indexes of chest compression

The current study revealed that self-reported fatigue time and the accuracy of deep-compression were significantly higher in males than in females, whereas the accuracy of chest recoil was significantly lower in males. "Switch chest compressors approximately every 2 minutes" was still kept in the "2010 AHA guidelines".^[4] In the current study, operators self-reported fatigue time was significantly lower than 2 minutes, especially in females. According to the guidelines that the compression rate of CPR should be at least 100 beats/min, the accuracy of compression rate was significantly higher in males, but no significant difference was found in the average compression rate between males and females. The results indicated that males might perform better in the control of frequency, and the variability of female was obviously possible to be related to the weaker muscle strength and shorter fatigue time. One report^[7] pointed out that the quality of chest compression was not related to gender, but with a small sample size. Another study^[8] also revealed the relationship of operator's gender, age and other factors that the quality of chest compression was different between males and females. Obviously, the depth of chest compression in males was higher than in females, which was consistent with the finding from the current study.^[8] Therefore, for female operators performing CPR, shorter exchanging time was recommended to ensure the compression quality. Meanwhile, a study concerned with the quality of chest compression in women with different weight classes showed that women with lighter weight were more difficult to achieve enough depth and meet the standard of the guidelines.^[9] This study was not concerned with males, but combined with the results of our study. It could be concluded that the higher accuracy of deep-compression in males might be related to the higher body weight, and the lower accuracy of chest recoil in males in the present study might also be related to the deeper compression of males.

The relationship between the quality indexes of chest compression

Chest compression is the most important as well as the most error-prone part of CPR.^[10] The important quality indexes of chest compression include the compression hands placement, compression rate, compression depth, and chest wall recoil, which are correlated with each other. The results of this study

indicated that self-reported fatigue time was related to every item except the accuracy of compression rate. Self-reported fatigue time is the time until the operator feels fatigue, the main factor which leads to the decreased quality of chest compression.^[7,11] This study showed a weak positive correlation between self-reported fatigue time and the accuracy of hands placement and the accuracy of deep-compression, which suggests that while the compressors reported a longer fatigue time, their compression was shown to be with a higher accuracy of hands placement and a higher accuracy of deep-compression. Some researchers pointed out that when dynamically monitoring the quality of chest compression, the depth of compression decreased significantly by minute,^[11] indicating that fatigue acted as a main factor in inducing shallow compression^[7,12] and the conclusion was consistent with that of our experiment. At the meantime, the compressors perceived fatigue in a short time naturally led to distraction or adjusting the posture and location of hands or other methods to save strength, which might cause the correlation between fatigue time and compression depth and the accuracy of hands placement. It could be concluded that a high level physical appearance is necessary to ensure the high quality of chest compression, and switching the compressor when the compressor perceived fatigue as soon as possible in order to improve the quality of chest compression.

In our study, there was a negative correlation between self-reported fatigue time and the accuracy of compression rate, and also between self-reported fatigue time and average compression rate. This correlation indicates that the longer fatigue time the compressor reported, the lower average compression rate was presented. Though the new guidelines required a rate of at least 100 beats/min for chest compression, the operator always pressed too quickly because of tension in a critical situation.^[13,14] In our study, the rate of chest compression was generally higher than an average compression rate of more than 130 beats/min, and the average fatigue time was about 1 minute, far less than 2 minutes as it is described in the new guidelines or other studies.^[7] The above findings revealed that fast compression would lead to premature fatigue, eventually shallow compression depth, inaccurate hands location, decreased compression rate,^[15] and worse chest wall recoil.^[16] Therefore, the operator could improve the quality of chest compression by controlling the frequency to delay the fatigue, especially to keep enough compression depth and chest wall recoil, and to eliminate the invalid compression and elevate the effect of chest compression.

In accordance with the guidelines, standard and high-quality chest compression is always the most important part and or step to ensure effective circulation and blood supply in CPR. But a 5 cm compression depth could not be easily achieved by most compressors in the current samples, and a compression rate of 100 beat/min was much higher. Obviously, regular training is particularly important for medical workers. In CPR training, practitioners should understand the interaction between various quality indexes and make the operator to control the controllable factors such as compression rate. In practice, by appropriately controlling the rate of compression, the compressor could achieve enough compression depth and delay the appearance of fatigue, thus improving the accuracy of other quality indexes to achieve high-quality chest compression, and ultimately increasing the success rate of CPR.

ACKNOWLEDGEMENTS

We are very grateful to Dr Li Yan for her guidance in writing the article. We are also appreciating the professional guidance and support from Professor Xiang-jun Bai. And sincere thanks are also given to all colleagues in the Emergency Department of Tongji Hospital.

Funding: The study was supported by a grant from the Natural Science Fund of Hubei Province (2011CDB195)

Ethical approval: Not needed.

Conflicts of interest: The authors have no competing interests relevant to the present study.

Contributors: Huang SF was in charge of the project and contributed to study design, data collection and analysis, and writing the manuscript. Zhang FL also contributed to data analysis, and writing the article, and Yan L contributed to writing and revising the article. Bai XJ contributed offered advices in the study. All authors read and approved the final version of the manuscript.

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Received October 13, 2012

Accepted after revision January 26, 2013