Resuscitation 128 (2018) 1–5

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Comparison of optimal point on the sternum for chest compression between obese and normal weight individuals with respect to body mass index, using computer tomography: A retrospective study

Juncheol Lee[a], Jaehoon Oh[a,b,*], Tae Ho Lim[a,b], Hyunggoo Kang[a,b], Jung Hwan Park[c], Soon Young Song[d], Ga Hye Shin[d], Yeongtak Song[a,b]

[a] Department of Emergency Medicine, College of Medicine, Hanyang University, Seoul, Republic of Korea
[b] Convergence Technology Centre for Disaster Preparedness, Hanyang University, Seoul, Republic of Korea
[c] Department of Endocrinology, College of Medicine, Hanyang University, Seoul, Republic of Korea
[d] Department of Radiology, College of Medicine, Hanyang University, Seoul, Republic of Korea

ARTICLE INFO

Keywords:
Basic life support
Body mass index
Cardiopulmonary resuscitation
Chest compression
Proper hand position

ABSTRACT

Background: Abdominal fatty tissue deposition in obese individuals could alter the proper hand position for chest compression during cardiopulmonary resuscitation, similar to that in pregnant women. This study aimed to identify the difference in body mass index between obese and normal weight individuals by measuring the optimal point of maximal left ventricular diameter (OP^{LV}), using computed tomography (CT).
Methods: We performed a retrospective analysis of chest CT scans between January 2012 and August 2016 and measured the sternal length and OP^{LV} and estimated the ratio of OP^{LV} to that individual sternal length. We also investigated whether OP^{LV} was within the clinically relevant range of 20 mm to the position advised by the Guidelines 2015. We compared these outcomes between the two groups.
Results: We randomly selected and analysed 50 of 7229 normal weight and 50 of 394 obese individuals from a database. The mean ± standard deviation of the ratio of OP^{LV} was 22.0 ± 5.7% and 14.8 ± 6.6% of the sternal length, as measured from its most caudal point, respectively, for the obese and normal weight groups ($p < 0.001$). Both are more caudal than at the middle point of "the lower half of the sternum" as currently recommended. Notably, 96% of the OP^{LV} in the obese group was within ± 20 mm of the guideline point versus 52% for normal weight group.
Conclusion: OP^{LV} on the sternum in obese individuals was more cranial than that in normal weight individuals. The optimal point for chest compression in obese individuals could be slightly more cranial than that in the others.

Introduction

The cardiopulmonary resuscitation (CPR) guidelines published by the International Liaison Committee on Resuscitation (ILCOR) emphasise that survival rates and good neurological outcomes of cardiac arrest patients are closely related to the quality of chest compression [1,2]. Hand position is an important factor for high-quality chest compression, and the site is "the lower half of the sternum", according to current guidelines [1,2]. The optimal hand position has been linked to a position of the maximal diameter and outflow tract of the left ventricle [3,4]. In addition, these guidelines state that the proper hand position for chest compression in pregnant cardiac arrest patients should be slightly more cranial on the sternum to adjust for the elevation of the diaphragm by the gravid uterus compared to that in non-pregnant patients [5,6].

Obesity is associated with a major risk factor for hypertension, dyslipidaemia, and diabetes mellitus, leading to coronary artery disease and heart failure [7,8]. These diseases are associated with an increased number of out-of-hospital cardiac arrests in obese patients [9,10]. Accumulation of abdominal fatty tissue in obese patients can cause

Abbreviations: CPR, cardiopulmonary resuscitation; ILCOR, International Liaison Committee on Resuscitation; BMI, body mass index; CT, computed tomography; PACS, picture archiving and communication system; S, sternal length; OP^{LV}, a point at which is maximal left ventricular diameter in relationship to the sternum; %S, OP^{LV} a percentage of the distance from the distal point of sternum to OP^{LV} in the whole length of that sternum; OP^{G}, Optimal point on the sternum recommended by Guidelines 2015; ANCOVA, analysis of covariance; SD, standard deviation; OHCA, out of hospital cardiac arrest; AHA, American Heart Association

* Corresponding author at: Departments of Emergency Medicine, College of Medicine, Hanyang University 222 Wangsimni-ro, Seongdong-gu, Seoul, 04763, Republic of Korea.
E-mail address: ojjai@hanmail.net (J. Oh).

https://doi.org/10.1016/j.resuscitation.2018.04.023
Received 20 December 2017; Received in revised form 12 April 2018; Accepted 18 April 2018
0300-9572/

weakness of tension and raise the diaphragm to a position higher than that in normal weight individuals [11–13]. Compared with other positions, the supine position could cause an enhancement in this effect in obese patients [11]. The proper hand position for high-quality chest compression may have to be shifted to a slightly more cranial place on the sternum in obese cardiac arrest patients, similar to that in pregnant women.

To the best of our knowledge, this is the first study to report hand position for chest compression during CPR in obese patients; there is no mention of obese as a specific subgroup potentially requiring adjustments in technique, in the current guidelines. In particular, the influence of body mass index (BMI) on the theoretically best position for chest compression is currently unknown. In this study, we aimed to determine whether that optimal point on the sternum for chest compression in high-BMI individuals is more cranial than that in individuals with normal BMI. We also related the measured position to those suggested by the guidelines and corrected for the width of a caregiver's hand by also scoring the positions within 20 mm above and below the numerically optimal guideline position.

Methods

Study design

We conducted a retrospective study to evaluate the differences in the optimal point of maximal left ventricular diameter (OP^{LV}) level on the sternum between the normal weight ($18.5 \leq BMI < 25\,kg/m^2$) and obese groups ($BMI \geq 30\,kg/m^2$), using chest computed tomography (CT). This study was performed at one academic tertiary hospital (Seoul, Republic of Korea) in February 2017 and was approved by the Institutional Review Board of Hanyang University Medical Centre (ref. no. 2016-06-030).

Study participants

We extracted the medical records of 12,390 individuals who underwent chest CT, from January 2012 to August 2016. Inclusion criteria were age > 18 years and no remarkable finding in the chest CT. Individuals with anatomical abnormalities in the chest, trauma-induced deformities, or pulmonary/heart structural deformities were excluded. We classified the selected individuals into low weight, normal weight, overweight, and obese groups, according to BMI. Further, we randomly included 50 individuals in the normal weight group and 50 individuals in the obese group through the Random Integer Set Generator (www.random.org).

We considered that a sample size of at least 100 individuals was required to observe a difference in the proportion of distance from the OP^{LV} level on the sternum to the entire sternal length between the two groups. We conducted a pilot study with 20 individuals who were not included in this study, using the soft package G-power 3.1.9® program (Heine Heinrich University, Düsseldorf, Germany) with an α error of 0.05 and power of 0.95, considering a drop rate of 20%, and found (mean ± SD) 13.2 ± 3.4% S-OP^{LV} versus 17.9 ± 7.7% S-OP^{LV}, respectively, for normal- and high-BMI individuals (effect size, 0.80) (Fig. 1).

Equipment and materials

The two types of CT equipment used in this study were Somatom Definition Flash® (Siemens Healthcare, Forchheim, Germany) and Brilliance 64 multi-detector CT scanner® (Philips Healthcare, Best, The Netherlands). The setting for the examination was as follows: 120 kVp, 50–80 mAs, 1.15-mm/s table feed, 0.5-s rotation time, 5-mm slice thickness, and 5-mm intervals. All CT images were stored in the picture archiving and communication system (PACS, Centricity, GE Healthcare, Milwaukee, WI, USA).

Data collection

We collected basic information such as sex, age, height, weight and BMI of all individuals. All CT images for each subject were reconstructed and shown as transverse views, sagittal views and coronal views, using PACS. Each image was simultaneously cross-linked to the images with other settings. Two radiologists reconstructed all images of each subject. They measured the following parameters, using a three-dimensional image solution program (Rapidia, version 2.8, Infinite, Seoul, Korea) with consensus (Fig. 2): sternal length (S), measured from the sternal notch to the distal end of the xiphoid process; the point at which the maximal left ventricular diameter projected onto the sternum (OP^{LV}), measured from the distal point of the sternum [3,14,15]; the location of the optimal point per guideline 2015 (OP^G) at 25% of the sternal length measured from its most distal point as the middle point of "the lower half of the sternum" as currently recommended; and the "guidelines area" of 20 mm cranial and caudal of OP^G; whether OP^{LV} was within guidelines area. This means that the OP^{LV} could be pressed when the performer compresses the OP^G, assuming the direct chest compression theory. This depends on the width of the hypothenar (approximately 40 mm) on which compression force from the hand's heel (approximately 70–80 mm width) is delivered with maximal compression force to the chest in cardiac arrest patients during chest compressions [16,17].

Primary and secondary outcomes

The primary outcome was the proportion of OP^{LV} (%S-OP^{LV}), defined as the proportion of the OP^{LV} to S. In addition, S, OP^G, OP^{LV} and the number of times OP^{LV} was applied within the guidelines area were investigated as secondary outcomes.

Statistics

Data were compiled using a standard spreadsheet application (Excel® 2016; Microsoft, Redmond, WA, USA) and analysed using SPSS version 21.0 KO for Windows (SPSS Inc., Chicago, IL, USA). Kolmogorov–Smirnov tests were performed to test for normal distribution for all data sets. Descriptive statistics were used to describe the baseline characteristics of the individuals and to present categorical variables as frequencies and percentages. Normally distributed data are presented as mean ± SD. Student's *t*-tests were used for comparisons of continuous variables, and the chi-square test or Fisher's exact test was used to analyse categorical variables. Analysis of covariance (ANCOVA) was performed to adjust for influencing factors and investigate the main factor influencing the outcomes [18]. A value of $p < 0.05$ was considered statistically significant.

Results

Fifty of 7229 individuals with normal weight and 50 of 394 obese individuals were recruited in this study; there were no exclusions (Fig. 1). The baseline characteristics of the individuals are summarised in Table 1. There were no significant differences in age or sex between the two groups. As expected, significant differences were observed in height, weight, and body mass index (BMI) between both groups.

The results for CT measurements are summarised in Table 2.%S-OP^{LV} for obese and normal weight individuals were 22.0% ± 5.7% and 14.8% ± 6.6%, respectively ($p < 0.001$). No significant differences in S and OP^G were observed between the two groups. The OP^{LV} was 42.3 mm ± 12.4 mm in obese individuals and 27.7 mm ± 13.3 mm in normal weight individuals ($p < 0.001$, Table 2). In obese individuals (48 of 50, 96%), the number of times OP^{LV} fell within the guidelines area was higher than that in normal weight individuals (26 of 50, 52%) ($p < 0.001$) (Fig. 3). We adjusted for the factors that could affect the results of%S-OP^{LV}, using ANCOVA. A significant difference was