Comparison of Different Methods For Effective Manual Chest Compression In Dental Chairs, During Cardiopulmonary Resuscitation (CPR): A Manikin Study

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Research Article

Keywords: compression, backrest, vertical displacement, significantly

Posted Date: December 8th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1091429/v1>

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Abstract

During cardiopulmonary resuscitation (CPR), almost commercially dental chairs lack sufficient stability to perform effective manual chest compression (MCC). In our previous study, our technique that stabilizing stool can significantly reduce vertical displacement in a dental chair's backrest. This study demonstrates that the efficacy of different methods for stabilizing 3 types of dental chair with a flat or a severely curved backrest exterior for effective MCC. Vertical displacement of the dental chair's backrest was recorded. The data was captured with three different stool positions (no stool, under MCC, under shoulders). Reduction ratios were calculated to evaluate the effectiveness of the stool positions. In all types of dental chair, the technique significantly reduced the vertical displacements of the backrest. The reduction ratio varied nearly 40% under the area for MCC and 65% under the shoulder with a severely curved backrest exterior. With a flat shape of dental chair, these ratios were around 90% versus without a stool. The technique is a firm support and reduce the displacement of any type of dental chair's backrest for effective MCC.

Introduction

The useful technique of stabilizing a dental chair for effective manual chest compression (MCC) has been previously reported^{1,2}. The technique utilizes a dental chair lowered to contact a stool placed under the reclined backrest to provide additional support. And that was adopted in the 2015 and 2021 European Resuscitation Council (ERC) Guidelines^{3,4}. However, the support effect differed depending on the position where the stool was placed. Particularly, when the dental chair had a severely curved backrest exterior, the stool which positioned under the shoulders compared to under the area of MCC significantly reduced vertical displacement and producing a larger reduction ratio². However, the previous study included only one type of dental chair.

The objective of this study was to compare the efficacy of three stool positions (no stool, under MCC or under shoulders) for stabilizing three types of dental chair.

Results

The vertical displacements of the dental chair backrest induced by MCC were assessed with and without the place of a stool (placed under MCC or under the shoulders). A total of 5400 MCCs were recorded, but 32 were excluded due to an unclear recording or inappropriate compression depth. The vertical displacement significantly reduced and the reduction rate increased in all situations when using the stool as a stabilizer. By the model of dental chairs have different characteristics for supportive effect depending on position of the stool. Particularly in chair of #1 which has a severely curved backrest exterior, there was significant difference in stool positions. As we placed a stool under the MCC in #1, the displacement of a backrest against MCC reduced to four tenths of the reduction rate. When a stool was set under the shoulders, the displacement decreased over 65% without a stool (Fig. 2,3). In contrast to chairs of #2 and #3 had flatter shapes. made little difference between under the shoulders and under MCC.

Discussion

When a patient suffers from cardiopulmonary arrest during dental treatments, many general practitioners feel agitation and impatience with one. Because they are not skilled at emergency life-saving procedure and difficult to make a calm decision or respond on what to do next smoothly. ERC and AHA guidelines emphasize the importance of minimizing interruptions during MCC. MCC should be started on a stable surface as soon as possible whenever cardiac arrest is suspected^{5,6}. However, when it is difficult to move the patient in a dental chair to the floor quickly and safely, CPR is performed on a patient in a dental chair, the backrest may not be supportive enough for effective resuscitation as a large vertical displacement of the backrest might decrease the efficacy of MCC⁷⁻¹⁰. Many modern dental chairs have curved ergonomic backrest designs which tend to gradually become flatter moving superiorly up to the patient's shoulder area. The chair exterior below the area of MCC often has a more pronounced curvature which negatively impacts the contact point of the stool and reduces stabilization. The chair exterior has a flatter shape more superiorly which provides a larger wider contact area for the stabilizing stool when positioned under the shoulders. In addition, the backrest of the dental chair is more stable as there is a distance between the patient seating position and a stool as a stabilizer.

This study had some limitations. First, this study included only three type of chair, there are many types of dental chairs used throughout the world. Next, the usefulness of other types of stabilizers remains to be verified and the stool was set in two particular positions. Additional studies should be conducted to evaluate other positions for the stabilizing stool to determine maximum effectiveness. Third, this study did not consider the effect of the dental chair cushioning, nor the use of a firm backboard during MCC^{11,12}. Finally, this study was performed with the use of a manikin model, so careful extrapolation of the results to human patients is indicated. However, no studies to date have demonstrated a significant reduction in vertical displacement by using the technique with several types dental chair. Positioning a stool to support the dental chair is simple and effective method for increasing the efficacy of MCC and should be utilized when performing CPR on a patient in a dental chair.

In this study, we demonstrated that the stool placing under the shoulders is more stability than under MCC to perform effective MCC in any type of dental chair. These results suggest that dental practitioners should prepare the appropriate method (position of the stool) in advance according to the shape of the dental chair's backrest exterior for effective MCC.

Methods

Three dental chairs (#1: EOMα[®]; GC, Tokyo, Japan, #2: EOM-PLUS SS[®]; GC, Tokyo, Japan, #3: EOM Σ[®]; GC, Tokyo, Japan) were used in this study. #1 exterior has a severely curved backrest exterior, #2 and #3 have a flatter shape.

The study procedure was performed according to a previously established method in which the CPR manikin (Resusci Anne[®] Torso Basic version 2011; Laerdal Medical AS) was positioned on the reclined

dental chair with the upper end of the manikin torso aligned with the top edge of the backrest (Fig. 1)^{1,2}. The superior surface of the backrest under the lower half of the manikin's sternum was positioned horizontally using a levelling instrument. The hand position for MCC was the center of the chest. A metal indicator (point P) was secured to the inferior surface of the dental-chair directly under the area for MCC and made parallel to the floor with a level gauge. The distance of point P relative to the inferior surface of the backrest remained fixed for the duration of the study. Displacement of point P was captured using video recordings and measured while each health care provider performed MCC on the resuscitation manikin. MCC depth was kept between 5.1 to 6.0 cm during the study. The actual MCC depth was evaluated with the manikin's Skill-Reporter system which has a green light that indicates MCC depths of 5.1 to 6.0 cm. Any compressions outside of that range (i.e., without the green light) were excluded. When compression depths were within 5.1 to 6.0 cm, the vertical displacement of the backrest from its initial position was recorded and included for analysis. Video data were transferred to a computer, and the backrest vertical displacement measurements were determined using the simultaneously captured ruler for reference. The stabilizing stool placed under the backrest of the dental chair for this study was round with a hard seating surface (diameter 30 cm; height 45 cm; FB-01ALLBK, Fuji Boeki Co., Ltd.). The superficial edge of the stool's seat was set to vertically contact the backrest either just under the area for MCC or under the shoulders.

Three basic life support provider in American Heart Association (A: 47-year-old male, 175 cm, 93 kg; B: 44-year-old male, 177 cm, 60 kg; C: 44-year-old female, 157 cm, 50 kg.) were tested at their convenience. Each study participant individually performed 10 contiguous rounds of MCC (20 compressions per round; 200 compressions total) at a pace of 100 compressions per minute in synchrony with a metronome for each of the 3 stool configurations (i.e., under MCC area, under shoulders, or no stool). A total of 600 chest compressions 5.1 to 6.0 cm in depth were recorded per participant.

Statistical analysis. The programming language R (version 4.0.2; The Comprehensive R Archive Network, USA) was used for statistical analysis. Displacement measurements (maximum distance of Point P from baseline during MCC) by three participants were analyzed separately at each of the three respective positional configurations. The change in vertical displacement for each of the two stool positions (under MCC or under the shoulders) compared with no stool position (baseline) was calculated using the following equation *

$$\text{reduction ratio} = 1 - \frac{\text{displacement with stool}}{\text{displacement without stool}} \quad (*)$$

Data sets were analyzed using the Shapiro-Wilk test to determine normality of distribution. The non-parametric data sets were then analyzed using the Wilcoxon rank sum test to determine statistical significance ($P < 0.001$).

Abbreviations

CPR: Cardiopulmonary resuscitation

MCC: Manual chest compression

ERC: EUROPEAN RESUSCITATION COUNCIL

AHA: American Heart Association

Declarations

Acknowledgments

Not applicable.

Author contributions

T.H: Writing—original draft, Conceptualization. **N.A.:** Data curation, Writing—review and editing. **Y.M.:** Software, Formal analysis, Investigation, Methodology, Writing—review and editing, Visualization. **M.T.:** Writing—review and editing, Supervision. **T.Y.:** Project administration, Investigation, Supervision. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare no competing interests.

Availability of data and materials

The data sets during and/or analysed the current study available from the corresponding author on reasonable request.

Informed consent

For this type of study, formal consent is not required.

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Figures

Figure 1

Manikin setup and positioning of the stabilizing stool. Upper end of the manikin torso was aligned with the top edge of the backrest (A; red line). The superior surface of the backrest under the lower half of the manikin sternum was positioned horizontally using a levelling instrument. The edge of the stool's seating surface was set to touch the backrest vertically under the area for manual chest compressions (A; blue line). The stool was set to touch the backrest vertically under the shoulders (B; green line). The center of the manikin's chest (C; red ellipse) was the hand position during chest compressions. Measuring vertical displacement and chest compression depth. A metal indicator (D: point P) was made parallel to the floor with a leveling gauge and secured to the inferior surface of the dental chair directly under the area for MCC next to a fixed vertical-measurement instrument. Chest compression depth was assessed using the manikin's Skill-Reporter system (E) with green lights indicating chest compression depths of 5.1–6.0 cm and red lights for 3.8–5.0 cm. The distance of point P relative to the inferior surface of the backrest remained fixed (F).

#1

#2

#3

(mm)

Figure 2

Vertical Displacement Measurements. The thick lines represent median values, the boxes represent interquartile ranges, over and under lines represent data ranges, and circles represent outliers. In dental chair of #2 and #3, there were significant differences in stool positions due to effect between under the shoulder and under the chest. In contrast to #1 made little difference. (Please note that the horizontal axis does not start with zero only in the alpha figure)

#1

#2

#3

Figure 3

Calculated Reduction Ratios. Measurements of dental chair backrest vertical displacement during MCC and calculated Δ reduction ratios. Results expressed as median (interquartile Δ range).