Usefulness of a stool to stabilize dental chairs for external chest compression

CURRENT STATUS: ACCEPTED

BMC Emergency Medicine – BMC series

Norimasa Awata
Kyushu University

Takashi Hitosugi
hitosugi.takashi.724@m.kyushu-u.ac.jp
Kyushu University
Corresponding Author
ORCID: 0000-0003-3963-541X

Yoichiro Miki
Kyushu University

Yoshifumi Kawakubo
Kyushu university

Takeshi Yokoyama
Kyushu university

DOI:
10.21203/rs.2.9600/v1

SUBJECT AREAS
Critical Care & Emergency Medicine

KEYWORDS
Cardiopulmonary resuscitation (CPR), external chest compression (ECC), dental chair, stool, dental surgery
Abstract

Objectives: Cardiopulmonary resuscitation (CPR) requires immediate start of external chest compression (ECC) and cardioversion as soon as possible. During dental surgery, CPR should be started in the dental chair considering difficulty to move the patient from the dental chair to the floor. However, all types of dental chairs are not stable for ECC. We previously developed a procedure to stabilize a dental chair by using a stool. ERC guideline 2015 adopted our procedure when cardiac arrest during dental surgery. The objective of this study was to verify the efficacy of a stool as a stabilizer in different types of dental chairs. Materials and methods: Three health care providers participated in this study, and 8 dental chairs were examined. ECC were performed on a manikin that was laid on the backrest of a dental chair. A stool was placed under the backrest to stabilize the dental chair. The vertical displacement of the backrest by ECC were compared between with and without a stool, and recorded by a camcorder. Results: In all 8 dental chairs, the method by using a stool significantly reduced the vertical displacements of the backrest by ECC. The reduction ratios were between nearly 39~85%, although it was different by chairs. Conclusions: Our procedure to stabilize dental chairs by using a stool significantly reduced the displacement of a backrest against ECC in all chairs. Clinical relevance: Effective ECC could be performed in dental chairs by using a stool when sudden cardiac arrest occurs during dental surgery.

Introduction

Dental office is a special circumstance and sudden cardiac arrest and asphyxia due to aspiration of dental materials into the trachea are two major life-threatening emergencies. We have already proposed supine abdominal thrust as a relief for asphyxia in the dental chair [1]. When the relief go wrong, however, the patient may lead to cardiac arrest.
immediately. Or cardiac arrest might occur alone, as dental treatment is often stressful for patients, and sometimes worsens basic illness. An ideal cardiopulmonary resuscitation (CPR) requires immediate start of external cardiac compression (ECC) and cardioversion as soon as possible. The patient should be placed on a hard surface to ensure the effectiveness of external cardiac compression (ECC). On the other hand, CPR should be started in the dental chair, considering the difficulty of moving the patient to the floor. However, all types of dental chair are not always stable for ECC, because there is no steady support between the backboard of the dental chair and the floor. These condition may alter the effectiveness of ECC.

We previously reported the usefulness to stabilize a dental chair by using a stool for effective chest compression [2]. In summary, we devised a method possibly to stabilize the dental chair and increase the efficacy of ECC. This procedure was adopted in the ERC guideline 2015; Section 4. Cardiac arrest in special circumstances, Cardiac arrest in the dental surgery [3]. A stool is placed under the tilted or horizontal backrest, and then the dental chair is lowered so that the backrest come into contact with the stool to support the backrest of the dental chair. To our knowledge, however, there are many kinds of dental chairs, and the shapes of their backrest are different. In addition, the dental chairs have different seat-padding. Therefore, we are afraid whether our procedure is effective in all types of dental chairs or not. Moreover, the specific effect of the technique on the stability of the popular dental chairs during ECC remains unclear.

The objective of this study was to evaluate the efficacy of a stool as a stabilizer for effective ECC. We compared the performance of ECC in different types of dental chairs between with and without a stool. The vertical displacement by ECC was recorded by a camcorder. We hypothesized that a stool as a stabilizer may reduce the vertical displacement by ECC and increase the efficacy of ECC in dental chairs when the same
quality of ECC technic are provided.

Materials And Methods

Study design and setting

Eight different dental chairs were used in this study. #1 (EOMαll®; GC, Tokyo, Japan), #2 (EOM Σ®; GC, Tokyo, Japan), #3 (EOM-PLUS SS®; GC, Tokyo, Japan), #4 (SPACELINE EMCIA Type III UP®; MORITA, Tokyo, Japan), #5 (SPACELINE EMCIA Type II®; MORITA, Tokyo, Japan), #6 (STAGE II®; YOSHIDA, Tokyo, Japan), #7 (NOVA SERIO®; YOSHIDA, Tokyo, Japan), #8 (Celeb BM Type Clair®; TAKARA, Tokyo, Japan). Each dental chairs were installed in four private dental offices. Three health care providers, who completed AHA-certified Basic Life Support course, participated in this study; A: 47 years-old man, 175cm, 93kg. B: 44 years-old man, 177cm, 60kg. C: 44 years-old woman, 157cm, 50kg.

The CPR manikin (Resusci Anne Torso Basic version 2011; Laerdal Medical AS, Stavanger, Norway) was laid on the horizontal backrest of the dental chair. The upper end of the torso of the manikin was aligned with the top edge of the backrest (Figure.1A, Red line). The surface of the backrest under the lower half of the sternum of the manikin was levelled using a levelling instrument (Z-340; Hozan Co., Osaka, Japan).

The hand position for ECC was the center of the chest (the lower half of the sternum, Figure 1B) as recommended in the European Resuscitation Council Guidelines for Resuscitation (2015) and the 2015 American Heart Association (AHA) Guidelines. 3 health care providers performed ECC on the resuscitation manikin in eight different dental chairs.

The displacement of the point P (Figure 2.A) on the lower surface of the backrest (vertically under the area for ECC) was fixed a vertical-measurement instrument (Figure 2.B). The instrument was attached a metal indicator which was levelled using a levelling instrument (Z-340; Hozan Co., Osaka, Japan). The point P was measured at the same time
as ECC-induced vertical movements of the backrest. The depth of ECC was tried to be kept between 5.1 to 6.0 cm in both cases with and without a stool. The actual depth of ECC was evaluated by the skill-reporter® system equipped with the manikin. The green light of the skill-reporter® indicates 3.8 to 5.0 cm of ECC depth, and red light indicates 5.1 to 6.0 cm of ECC depth (Fig.2.C). When the compression depth in the chest of manikin by ECC was 5.1 to 6.0 cm, the vertical displacements of the backrest from its basal position (the width of a starting point to an ending point) were recorded by the camcorder (HC-W580M; Panasonic, Osaka, Japan). Video data were transferred to a computer (Dell; Windows 7, intel: Core i3, Cupertino CA, USA) using a camcorder's dedicated software (HD Writer 3.1; Panasonic, Osaka, Japan). The vertical displacements (degree of instability) of the backrest were measured using the simultaneously captured ruler as a reference.

To compare the efficacy of a stool as a stabilizer on ECC in eight types of dental chair, a round stool with a hard seating surface (45cm in diameter, 46cm in height; FB-01ALLBK, Fuji Boeki Co., Ltd. Fukuoka, Japan) was placed under the backrest of the dental chair. The edge of the seating surface of the round stool was set to (vertically) touch the backrest under the area for ECC (Figure 1A, Green line). ECC was performed with or without the round stool as a stabilizer. The manikin was on a fully reclined chair.

Protocol

Three health care providers individually performed ten rounds of continuous ECC for 20 times each at a pace of 100 compressions per minute by synchronizing to a metronome. Participants used a ECC technique allowing complete chest recoil. The health care providers and the research team were blinded to the information during recording. Therefore, for each participant, 200 records of chest compressions were gotten for each dental chair.
Statistical analysis

The programming language R (version 3.4.3; The Comprehensive R Archive Network, USA) was used for statistical analysis.

Normality Test and Non-parametric Statistical Test

Each combined measurement data set of the chair’s reference point displacement during ECC treatment by 3 practitioners were applied to the Shapiro-Wilk test (with the function shapiro.test) to see whether they were sampled from a population with the normal distribution. In view of the non-normal distributions, data was analyzed using the non-parametric Wilcoxon rank sum test (wilcox.exact: exactRankTests package).

Results

The vertical displacements of the backrest of the dental chair induced by ECC were investigated with or without a round stool as a stabilizer. 4,800 times of ECC was recorded, but 34 of them was excluded as inappropriate compression or unclear recording. The stool which placed under the backrest as a stabilizer significantly reduced the vertical displacements of the backrest in all eight dental chairs. For example, the largest stabilization (85%) was typically observed in Chair #2: the displacement of the backrest by ECC was 4.1 ± 1.3 mm with the stool, while that was 26.8 ± 4.5 mm without one. The reduction ratios were between nearly 39~85% and different by chairs (Figure 3).

Discussion

The efficacy of a stool as a stabilizer for ECC was investigated in eight dental chairs with ECC in this study. To our knowledge, this is the first report to compare the stability in many types of dental chairs using our method. This study showed that the stool significantly reduced the vertical displacement of the backrest against ECC. All health care providers, including petite woman (157cm, 50kg) and burly man (175cm, 93kg), could
perform stable ECC in all chairs with a stool.

ERC and AHA, current guidelines emphasize the importance of pushing hard and fast, and of minimizing interruptions during compression.\(^3\)\(^4\) ECC should be started on the stable surface as soon as possible when cardiopulmonary arrest was suspected. During CPR in the dental chair, however, backrest of dental chairs may be not firmly supported for ECC.

Most types of dental chairs were composed of two parts, the backrest and the seat. The backrest was usually connected to the seat by the hinge (joint) and the seat was supported by the pedestal. These supports are sufficient for dental treatment, but usually insufficient for ECC. Previously, we developed a method to stabilize a backrest of a dental chair by using a stool. This method has been adopted in the ERC Guideline 2015; Section 4. Cardiac arrest in special circumstances, Cardiac arrest in the dental surgery [3].

However, there are many types of dental chairs in the world, and these chairs equip different types of backrest, cushion, pad-softness and a hinge (joint) between the backrest and the seat. It was not clear whether ECC would be performed effectively or not on every types of dental chair. Therefore, we investigated the method of a stool as a stabilizer [2].

In CPR, the amount of power required to depress a sternum by 5 cm is about 500 N [6,7]. A large vertical displacement of the backrest might decrease efficacy of ECC\(^7\). In addition, the vertical displacement increases labor efforts as additional power to push down is required. In these situation, ECC may cause more fatigue especially for rescuers in the light body weights group [9].

In this study, our method significantly reduced the displacement of a backrest against ECC in all dental chairs. A stool was placed under a backrest of a dental chair according as our previous study [4]. During ECC in the dental chair, the displacement of the backrest seemed to be mainly caused by stool movements and cushions or seat-pads-softness. A
stool moved just a little in every ECC (Figure 4). The support efficiency of a stool were different, maybe as the backrest of some dental chairs has an outer-shell shape with curving line. #2 and #8 dental chairs have a flat outer-shape relatively. therefore, the stool supported the backrest of dental chair firmly (Fig.5A). In this situation, about 85% decrease in the displacement of a backrest against ECC by the stool. In #1 dental chair, the shape has a steep curve. Consequently, the stool contacted to the backrest at a smaller point where the ECC’s force concentrates on (Fig.5B). In these situations, the reduction rate is smaller than that of #2 (85%), although, it also significantly decreased the vertical displacement by ECC.

Limitations of the study should be mentioned. First, this study was performed on a manikin model, which cannot be extrapolated to a human faithfully. Second, the stool was set a particular position where was just under the area for ECC. Third, this study did not consider the effect of the cushion-pad of the backrest. If the present study highlights the limitations of the stool using stabilizer, further studies should be conducted to evaluate other position of the stabilizer. where is more effectively. And, the usefulness of other types of stabilizers remains to be verified. However, no studies to date have demonstrated a significant reduce deflective movements on several types of a dental chair. The technique is very easily and helpful method, and must use at time of CPR on a dental chair.

Conclusion

Our method could significantly reduce the vertical displacement of dental chairs by ECC, and it is convenient and useful when sudden CPR is required. We have only to recline the backrest to horizontal position, place the stool below the back rest and down the chair to contact with the stool firmly.
Declarations

Compliance with Ethical Standards

Conflict of Interest: Awata N declares that he has no conflict of interest. Hitosugi T declares that he has no conflict of interest. Miki Y declares that he has no conflict of interest. Kawakubo Y declares that he has no conflict of interest. Yokoyama T declares that he has no conflict of interest.

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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

References

1. Hitosugi T, Tsukamoto M, Hirokawa J, Yokoyama T (2018) In dental office, supine abdominal thrust is recommended as an effective relief for asphyxia due to aspiration. Am J Emerg Med 36:1301

2. Fujino H, Yokoyama T, Yoshida K, Suwa K (2010) Using a stool for stabilization of a dental chair when CPR is required. Resuscitation 81: 502

3. Truhlář A, Deakin CD, Soar J, Khalifa GEA, Alfonzo A, Bierens JJLM, Brattebø G, Brugger H, Dunning J, Hunyadi-Antic´evic´ S, Koster RW, Lockey DJ, Lott C, Paal P, Gavin D. Perkins GD, Sandroni C, Thies KC, Zideman DA, Jerry P. Nolan JP (2015) Cardiac arrest in special circumstances section Collaborators. European Resuscitation Council Guidelines for Resuscitation 2015: Section 4. Cardiac arrest in special circumstances. Resuscitation 95: 148-201

4. Monsieurs KG, Nolan JP, Bossaert LL, et al (2015) European Resuscitation Council
Guidelines for Resuscitation 2015 Section 1. Executive summary. Resuscitation 2015; 95: 1-80.

5. Kleinman ME, Brennan EE, Goldberger ZD, et al Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 132: 414-35

6. Chi CH, Tsou JY, Su FC (2008) Effects of rescuer position on the kinematics of cardiopulmonary resuscitation (CPR) and the force of delivered compressions. Resuscitation 76: 69-75

7. Chi C, Tsou J, Su F (2010) Effects of compression-to-ventilation ratio on compression force and rescuer fatigue during cardiopulmonary resuscitation. Am J Emerg Med 28:1016-23

8. Tomlinson AE, Nysaether J, Kramer-Johansen J, et al (2007) Compression force-depth relationship during out-of-hospital cardiopulmonary resuscitation. Resuscitation 72: 364-70

9. Hasegawa T, Daikoku R, Saito S, et al (2014) Relationship between weight of rescuer and quality of chest compression during cardiopulmonary resuscitation. J Physiol Anthropol 33: 16-23

Figures
Figure 1

Setup of the manikin for measuring chest compression depth and movement of the backrest. Placement of the round stool as a stabilizer. The edge of the seating surface of the round stool was set to touch the backrest vertically under the area or chest compressions (A). The hand position for the chest compressions was a center of the manikin’s chest (B: Red ellipse).

Figure 2

The displacement of the point P on the lower surface of the backrest (vertically under the area for external cardiac compression) was fixed a vertical-measurement instrument. The instrument was attached a metal indicator (A, B). Chest compression depth was measured by the measurement equipment (skill-reporter®). The equipment glow green when chest compression depth was 3.8 to 5.0 cm, and red when 5.1 to 6.0 cm (C).

Figure 3

Effect of the stool (stabilizer) on the vertical movements of the backrest caused by external cardiac compression. Results are expressed as mean ± standard deviation. Asterisks represent significant differences (**P<0.01).

(#: Number of Dental chair)

Figure 4

A position of a stool as a stabilizer with a dental chair for ECC.
Figure 5

A contact area of a stool with a backrest of a dental chair. An outer-shell shape of backrest has curving line, a contact area gets narrow. Power of ECC concentrate on the area. A stool could not sustain the power and moves laterally.