Investigation of manual chest compression in CPR on the dialysis chair

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Abstract

Background: Heart failure is the leading cause of death in dialysis patients. Cardiac arrest due to hypotension may also occur during dialysis therapy. If cardiac arrest is elicited, manual chest compressions (MCC) should be started as soon as possible. However, if MCC is applied during the patient is being treated on the dialysis chair, the backrest of the dialysis chair is horizontal to the floor and there is no support between the backrest and the floor, so that will shake and become unstable.

Methods: we investigated whether a round chair is effective for supporting the dialysis chair for MCC. Four adult males performed MCC on three dialysis chairs using a manikin. MCC was performed with 2 sets (1 set was 100 times per minute) per person, with or without a round chair. A total of 4,800 times were performed by four executors.

Results: When the chair was not used as a stabilizer, the mean value of fluctuation range were 20.8 ± 8.1 mm, 18.7 ± 5.5 mm, and 12.8 ± 1.8 mm, respectively. When the chair was used, the mean value of fluctuation range were 6.1 ± 1.1 mm, 7.5 ± 2.1 mm, and 1.0 ± 0 mm, decreasing by 70%, 59%, and 92%.

Conclusion: MCC with the stool under the backrest as a stabilizer was effective for dialysis chairs.

Background

The number of dialysis patients has increased almost every year to more than 330,000 in Japan. Japan (at 2,599 patients per million general population) placed the second largest prevalence of treated end-stage renal disease [1]. Heart failure is the 24% leading cause of death, accounting for 27.8% of all deaths and 3.8% of myocardial infarctions combined. It is reported that heart failure is also the second leading cause of death within the year of introduction of dialysis patients in 2017, accounting for 20.8% [2]. There are also reports of approximately 5% sudden cardiac death [3]. In hemodialysis therapy, treatment is generally performed for 4 to 5 hours on a dialysis bed or medical chair (hereinafter, referred to as “dialysis chair”).

During treatment, it may cause a hypotension associated with the removal of water and may induce cardiac arrest. For cardiopulmonary resuscitation (CPR), manual chest compressions (MCC) and defibrillation must be started as soon as possible. According to American Heart Association (AHA) guideline 2015, effective chest compressions are delivered by pushing hard and fast, causing the chest wall to return after each push, minimizing interruptions in chest compressions. In addition, it is recommended that chest compressions in adults be performed at a depth of 5 cm or more and 6 cm or less, from 100 to 120 times per minute [4]. Therefore, to maximize the effectiveness of MCC, the patient should be placed supine on a firm, stable plane.[2] Patients on dialysis beds can be treated by placing a resuscitation board just under the chest. However, when a dialysis chair is used for treatment, even if the backrest tilted horizontally to the floor and the resuscitation board is laid, there is no stable support between a backrest of the dialysis chair and the floor. Therefore, it is presumed that the backrest shakes and becomes unstable when MCC is applied. Although there is a report [5] verifying the usefulness of

MMC on a dental chair and a report [6] that MCC can be effectively performed, there is no report on dialysis chairs.

The objective of this study was to evaluate whether the effectiveness of using a round chair as a stabilizer between the backrest and the floor in different types of dialysis chairs.

Methods

Materials

Three different type of dialysis chairs Model 1(CM2-020-I®; TACHI-S&P.LTD, Tokyo, Japan), Model 2(Ipsia Tre®; Okamura, Co., Kanagawa, Japan), Model 3(SD-5500; Okamura, Co., Kanagawa, Japan) and the manikin for CPR training (Ambu® man model C torso, Ambu A/S, Ballerup, Denmark) were used in the study.

MCC executors

MCC were performed by four health care providers who completed AHA-certified Basic Life Support course in this study; executor 1: 46 years-old man, 171cm, 60kg. executor 2: 27 years-old man, 169cm, 80kg. executor 3: 21 years-old man, 175cm, 67kg. executor 4: 41 years-old man, 168cm, 62kg.

Manikin installation method and measuring the vertical displacements of the backrest

A manikin for CPR was placed on the backrest of the dialysis chair, which was tilted horizontally. The head was placed on the headrest of the dialysis chair and the chest of the CPR manikin was placed horizontally using a level device (Z -340; Hozan Co., Osaka, Japan) (Figure 1A). To measure the vertical displacements of the backrest, a metal pointer was attached horizontally to the backrest of the dialysis chair, and the position was just below the MCC portion (Figure 1B).

Comparison of MCC implementation methods and measurements

For each dialysis chair, MCC was performed with 2 sets (1 set was 100 times per minute) per person, with or without a round chair. A total of 4,800 times were performed by four executors. The compressions were located in the middle of the chest and in the lower half of the sternum according to the European Resuscitation Council Guidelines for Resuscitation (2015) and the 2015 AHA Guidelines. The speed was adjusted to the sound by setting the metronome at 100 times/minute. The depth of MCC was always between 3.5 cm and 5 cm. The indicator attached to the mannequin (Figure 2A) is green at compression depths of 3.5 cm to 5 cm and red at compression depths of less than 3.5 cm and more than 5 cm. When performing MCC, the executor confirmed that the depth of compression reached the specified value, and made sure to perform compression assistance. The vertical displacements of the backrest were captured by a camcorder (GZ-E180; JVCKENWOOD Co., Kanagawa, Japan) and the video data were transferred to a computer (Model 1631; Microsoft Co., WA, USA). Using the scale of the measure shown in the image as a reference, we measured the difference in the position of the indicator between when the pressure was applied and released to measure the width of movement of the backrest. (Figure 2B). Those that did not reach the specified value were excluded.

Chair arrangement to stabilize dialysis chair.

In order to verify the stability when a stool was placed between the dialysis chair and the floor as a support, the backrest and the chair were placed horizontally in close contact (Figure 3). The chair was placed just below the MCC area of the manikin.

Statistical Analysis

For each dialysis chair, the vertical displacements of the backrest were compared between with and without a stool. In addition, comparisons for all enforcements and by executors were performed. The normality of each data group was tested with the Shapiro-Wilk test (with the function shapiro.test) for the vertical displacements of the dialysis chair backrest during MCC ($p < 0.05$). The Kruskal-Wallis test was used to test for differences between the data groups, considering that the data groups were not normally distributed. The Steel-Dwass test was used as a post hoc test ($p < 0.05$). For statistical analysis, programming language R (version 3.4. 3; The Comprehensive R Archive Network, USA) and Excel statistics 2012 for Windows (R) [Social Information Service Co., Ltd.] were used.

Results

The vertical displacements of the backrest during MCC were measured 4,800 times with or without a round chair. 17 out of 4,800 were excluded because they did not meet the criteria, and a total of 4,783 trials were compared. Table 1 shows the vertical displacements with (hereinafter, referred to as “fix”) or without a round chair (hereinafter, referred to as “free”) for Model 1. The vertical displacements of the backrest of “fix” was lower than the vertical displacements of “free” in all executors ($p < 0.01$). In the executor 4, the mean value of the vertical displacements of the backrest decreased by 77.7% in “fix” compared with “free”. Table 2 shows the vertical displacements of Model 2 without or with a stool. The vertical displacements of the backrest of fix was lower than the vertical displacements of “free” in all executors ($p < 0.01$). Table 3 shows the vertical displacements of Model 3. Particularly, the vertical displacements of fix were significantly lower than the fluctuation range of “free” in all executors ($p < 0.01$). Table 4 shows the vertical displacements between without and with a stool for all dialysis chairs. The vertical displacements of “fix” were significantly decreased compared with “free” in all dialysis chairs ($p < 0.01$). The decrease rate was 70.9% for Model 1, 59.8% for Model 2, and 92.2% for Model 3, indicating improved stability for all dialysis chairs. However, the vertical displacements were different for each dialysis chair regardless of whether there was the stool or not. For Model 3, the vertical displacements of the backrest were 12.8 ± 1.8 mm in “free” and 1.0 ± 0 mm in “fix”. The mean value of the vertical displacements in “fix” decreased by 92% compared with the case in “free”. In the comparison by the executors, the vertical displacements of the backrest were significantly lower with the stool than without the one, and the stability during MCC was improved in all the executors.

Discussion

During dialysis, a most common complication was cardiopulmonary arrest. It was caused during dialysis treatment about 70%, post-dialysis 21%, and pre-dialysis 10% [7]. In addition, according to a statistical survey by the Japanese Society for Dialysis Therapy, the rate of cardiopulmonary arrest during dialysis treatment was not reported, but heart failure was the leading cause of death, accounting for 27.2% [8].

MCC requires the patient to lie supine on a firm, stable plane, and the rescuer to stand beside the patient's chest and initiate as soon as possible. However, during dialysis treatment, it is not easy to carry the patient from the dialysis chair to the floor because the patient's devices are connected by a blood circuit and the length of that is not sufficient. Therefore, MCC is performed on the dialysis bed or chair. If the patient being treated on the dialysis bed has a cardiopulmonary arrest, a certain level of stable MCC can be performed by laying a resuscitation board on the bed. However, when performing treatment in a dialysis chair, there is no support between the backrest of the dialysis chair and the floor, so that a large vertical displacement occurs when the patient's chest is compressed, making it difficult to perform stable MCC. Also, in the case of MCC on a dental chair, similarly to a dialysis chair, there is no support between the backrest and the floor, so that when MCC is applied, the backrest shakes and becomes unstable. In order to improve the situation, the effectiveness of using a round chair as a support directly below MCC's area between the backrest of the dental chair and the floor has been reported[4)], and this method is recommended in ERC Guideline 2015 [9].

In this study, using the same method as in the report[4)], we verified three types of dialysis chairs, with and without a round chair as a support. As a result, the vertical displacements when using a round chair was significantly reduced in all dialysis chairs compared to when the chair was not used. In Model 1 and Model 2, the vertical displacements decreased significantly, but the vertical displacements varied. In Model 3, there was no variation in the vertical displacements among all the executors. It could be said that placing a stool under the backrest as a stabilizer and performing MCC is effective regardless of the model. it is useful to use a stool as a support for MCC on a dialysis chair with a reclining function.

However, dialysis chairs are often used in a sitting position and can be operated by patients themselves. The dental chairs are intended for treatment in a supine position and not operated by the patients themselves. In addition, during a dialysis treatment, the patient will spend a typical treatment time of 4 hours on the dialysis chair. Therefore, the chairs are made in consideration of comfort and relaxing of use, and many of them have backrest with high cushioning property. The purpose of both chairs is a treatment similarly, but there are characteristics according to the use, and the thickness, hardness, and structure are different. For chairs with high cushioning properties, it is necessary to consider the use of a stool for stabilizer as necessary.

Conclusions

MCC with the stool under the backrest as a stabilizer was effective for dialysis chairs.

Declarations

Ethics approval and consent to participate

All procedures performed in studies performing on a manikin model. This article does not contain any studies with human participants or animals performed by any of the authors. For this type of study formal consent is not required. We consulted the IRB at Kyushu university, which confirmed that no formal written waiver for ethics approval was required, because of the design of the study.

Consent for publication

Not applicable.

Availability of date and materials

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

Competing interests

All authors have no conflict of interest.

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Author Contributions:

T. I., Y.K. and T.Y. designed the study; T.I., Y.K., T.H., T.T., K.D., and T.Y. carried out experiments; Y.K. and T.H. analyzed the data; T.I. and Y.K. made the figures; Y.K., T.H. and T.Y. drafted and revised the paper; all authors approved the final version of the manuscript.

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Not applicable.

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Tables

Table 1
The displacements without or with a stool for Model 1.

Model 1	free		fix		p value	Decrease Rate(%)
	mean	SD	mean	SD		
executor 1	12.9	0.9	6.3	0.6	< 0.01	51.0
executor 2	20.1	9.1	5.2	1.1	< 0.01	74.3
executor 3	21.7	6.9	6.4	1.3	< 0.01	70.6
executor 4	28.7	1.9	6.4	0.6	< 0.01	77.7

(free: without a stool, fix: with a stool)

Table 2
The displacements without or with a stool for Model 2.

Model 2	free		fix		p value	Decrease Rate(%)
	mean	SD	mean	SD		
executor 1	16.9	1.5	4.6	1.4	< 0.01	73.0
executor 2	18.3	3.1	7.0	0.0	< 0.01	61.7
executor 3	18.3	5.7	8.5	0.5	< 0.01	53.4
executor 4	21.5	8.2	10.1	0.3	< 0.01	53.2

(free: without a stool, fix: with a stool)

Table 3

The displacements without or with a stool for Model 3.

Model 3	free		fix		p value	Decrease
	mean	SD	mean	SD		Rate(%)
executor 1	15.0	0.9	1.0	0.0	< 0.01	93.3
executor 2	11.3	1.6	1.0	0.0	< 0.01	91.2
executor 3	12.3	0.9	1.0	0.0	< 0.01	91.9
executor 4	12.6	1.4	1.0	0.0	< 0.01	92.1

(free: without a stool, fix: with a stool)

Table 4

The vertical displacements between with and without a stool for all dialysis chairs.

	free		fix		p value	Decrease
	Mean	SD	Mean	SD		Rate（%）
Model 1	20.8	8.1	6.1	1.1	< 0.01	70.9
Model 2	18.7	5.5	7.5	2.2	< 0.01	59.8
Model 3	12.8	1.8	1.0	0.0	< 0.01	92.2

(free: without a stool, fix: with a stool)

Figures

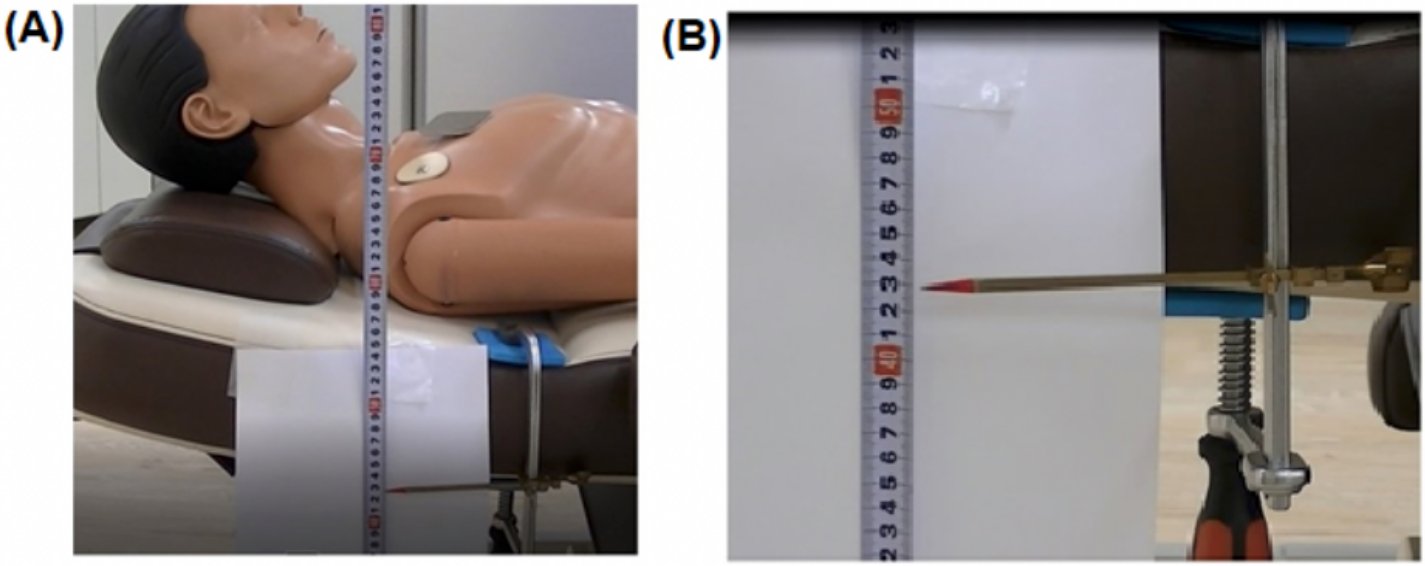

Figure 1

(A) The placement of manikin and guides for measuring the vertical displacements of the backrest. (B) An enlarged view of the pointer attached to the backrest.

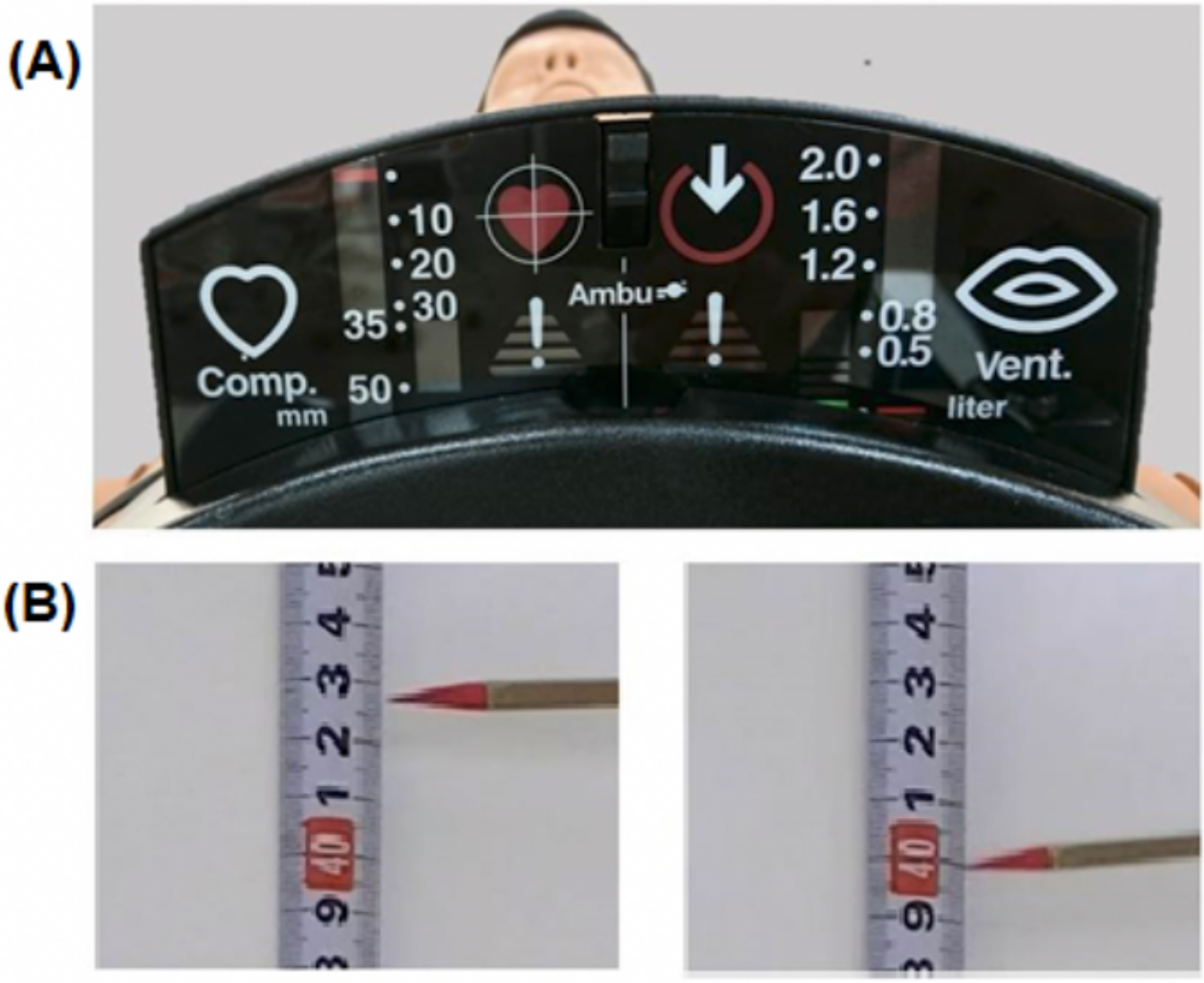

Figure 2

Compression depth indicator on manikin (A) and pointer taken with a camcorder (B).

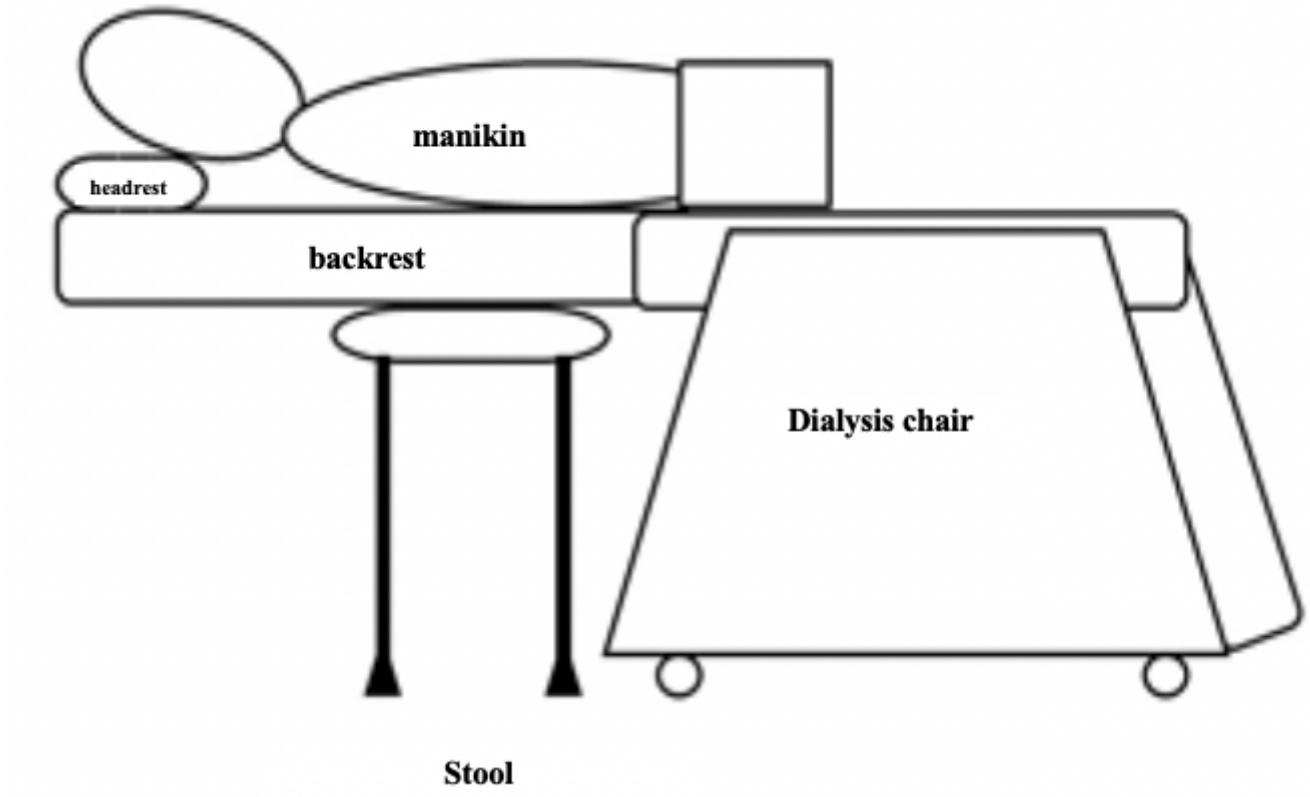

Figure 3

The layout of a dialysis chair and a stool.