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ORIGINAL RESEARCH

The effectiveness of the cadaver-based educational seminar for trauma surgery (C-BEST) for residents

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Abstract

To assess the effectiveness of the cadaver-based educational seminar for trauma surgery (C-BEST) for residents using a 10-point self-assessment of confidence levels (SACL) survey. We collected data, including SACL for 21 surgical skills and an evaluation of the contents before, immediately after, and half a year after the seminar, from 42 seminars conducted between January 2013 and March 2019. On comparing SACL results from evaluations at the three time points using statistical analysis, a p value of <0.05 was obtained. We enrolled 412 participants; of the 52 residents, 47 respondents were included in the study. Improvements in all skills were observed on comparing SACL before and immediately after the seminar (2.2 ± 2.6 vs. 5.3 ± 2.5; $p < 0.001$), but a decrease was observed between immediately after and half a year after the seminar (5.3 ± 2.5 vs. 4.9 ± 2.7; $p < 0.01$). Upon examining the results according to each skill, SACL did not decrease between immediately after and half a year after the seminar ($p > 0.05$). The most performed procedure was left anterior thoracotomy and aortic clamp (n = 13), and the number of residents majoring in surgery increased from 27 to 32 half a year after the seminar. C-BEST boosts more self-confidence of the participating residents immediately after the seminar. Although this effect is not maintained half a year after the seminar, many participants practiced their skills after the seminar. Therefore, C-BEST is useful for residents with little surgical experience; this may also inspire the residents to major in surgery.

Keywords

Cadaver-based educational seminar for trauma surgery (C-BEST); Skill retention; Half a year follow-up; Self-assessment of confidence levels; Residents

1. Introduction

We previously reported the effectiveness of the cadaver-based educational seminar for trauma surgery (C-BEST) in improving the skills and confidence of the participants [1]. In that study, the participants included residents, physicians, and surgeons. Participants across all categories showed increased self-assessment of confidence levels (SACL) immediately after the seminar. However, it was unclear how the seminar would specifically affect residents. Some residents received little surgical training, and their motivation for participating in the seminar might be mere interest rather than practical use. Even if they participated in the seminar, it may not be relevant for practical use in their clinical work. Moreover, despite there being many reports on surgical training using simulators by residents, there are only few reports on trauma surgical training using cadavers and long-term progress. Furthermore, the number of residents majoring in surgery is currently decreasing in Japan; however, it is unclear whether such a seminar will change this. Therefore, we surveyed the residents and analyzed the effectiveness of C-BEST in detail.

2. Methods

2.1 Setting

We conducted 42 sessions of one-day C-BEST from January 2013 to March 2019, with each session using two to three cadavers embalmed in formalin solution.

Participants were recruited using the following criteria. First, they must have board certifications. The councilors of the society recommended them from the websites of the Japanese Association for Acute Medicine, the Japanese Association for the Surgery of Trauma and the Japanese Society for Acute Care Surgery. Second, the participants could not be more than 10 post-graduate year (PGY) and were recommended by the councilors of the society from the websites of the annual meetings of the Japanese Association for Acute Medicine. Third, they had to be recommended by the instructors of C-BEST.

The participants were asked to perform 21 surgical skills on the cadavers as shown in Figs. 1,2. Briefly, they first practiced two basic techniques in the morning. Next, as part of the thoracic trauma section, they practiced surgical skills

AM

9:00-
Preparation
Offering a silent prayer

10:20- 10:40
【Basic technique】
1) Cricothyroidotomy
2) Chest tube insertion

10:40- 13:00
【Thoracic trauma】
3) Pericardial window technique
4) Left anterior thoracotomy & aortic clamp
5) Bilateral anterior thoracotomy (clam shell)
6) Pulmonary hilar clamp
7) Pulmonary injury
8) Atrial injury
9) Ventricular injury

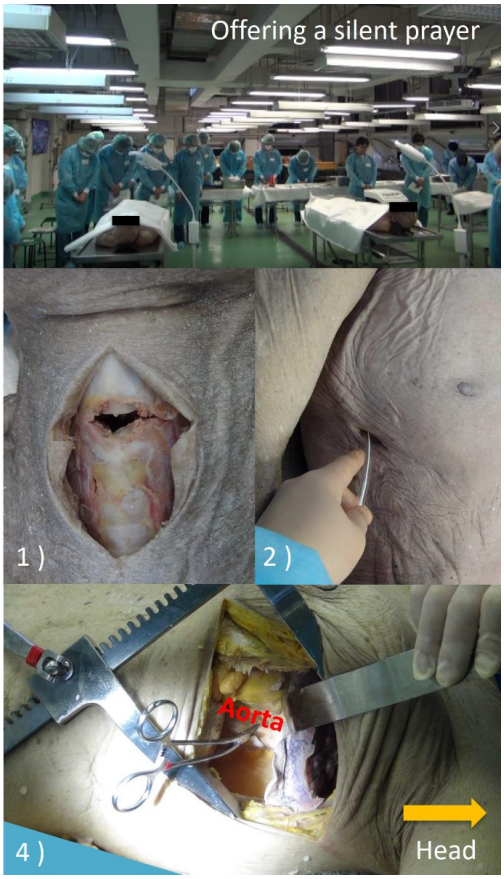

FIGURE 1. Morning schedule for 1-day C-BEST.

related to the heart and lungs. Then, they practiced femoral and neck vascular exposure and repairs followed by skills related to abdominal and pelvic trauma in the afternoon. Finally, they practiced fasciotomy of the lower extremity, which is related to extremity trauma. Additionally, we conducted a mini-lecture using a slide presentation before each section to convey to the participants what they were expected to do. Each cadaver was worked upon by a group of four to five participants with one to two dedicated instructors. The participants proceeded to each session according to the instructors' directions and advice, and all participants performed the procedures and had equal learning opportunities.

Then, the participants filled the questionnaires including SACL for these 21 surgical skills. The questionnaires included a 10-point visual analog scale (0 points, cannot do at all; 5 points, can do with help of an adviser; 10 points, can do independently) and an evaluation of the contents before, immediately after, and half a year after the seminar. The participants were asked to answer the questionnaires via e-mail (Fig. 3).

2.2 Statistical analysis

The Shapiro–Wilk test was performed for all statistical tests to determine the normally distributed variables using SPSS Statistics Ver. 27 (IBM Japan, Tokyo, Japan). Data were expressed as mean ± SD and analyzed using the Friedman test, a nonparametric method, using GraphPad InStat Ver3.0 (GraphPad Software, Inc., CA, USA). A p value of <0.05 indicated statistical significance.

3. Results

We enrolled 412 participants in this study. Of these, 52 were residents not greater than PGY5 in Japan. They were recruited if they met the second and third criteria mentioned above. Every year since 2016, 10 participants have attended the seminar in conjunction with the Annual Meetings of the Japanese Association for Acute Medicine. Accordingly, the number of residents who participated based on this criterion was small.

The responses of 47 participants from 14 hospitals and 9 universities were obtained from the "pre", "post", and "half a year after" questionnaires (response rate, 90.4%). The participants' information is presented in Table 1.

Some data were found not to be normally distributed using the Shapiro–Wilk test; therefore, we used the Friedman test.

SACL improved for all skills between before and immediately after the seminar (2.2 ± 2.6 vs. 5.3 ± 2.5; $p < 0.001$); however, a decrease was observed between immediately after and half a year after the seminar (5.3 ± 2.5 vs. 4.9 ± 2.7; $p < 0.01$). On examining the results according to each skill, SACL did not decrease between immediately after and half a year after the seminar ($p > 0.05$) (Table 2).

We also included a free-response question via e-mail to assess whether the participants practiced the skills in their clinical work half a year after the seminar. The cumulative number of practiced skills is presented in Table 3. The most performed

PM

14:00 — 15:30

【Vascular trauma】

10) Exposure of femoral vessels
11) Exposure of neck vessels
12) Vascular repair (direct suture, patch repair, end-to-end anastomosis, shunting)

15:30 — 17:00

【Abdominal & pelvic trauma】

13) Trauma laparotomy
14) Portal triad clamp (Pringle's maneuver)
15) Liver package
16) Left medial visceral rotation (Mattox maneuver)
17) Right medial visceral rotation (Cattel-Braasch maneuver)
18) Nephrectomy
19) Abdominal damage control technique
20) Pelvic package

17:00 — 17:30

【Injuries to the extremities】

21) Fasciotomy of the lower extremity

17:30 —

Offering a silent prayer & placing of body in coffin
Answering questionnaires

FIGURE 2. Afternoon schedule for 1-day C-BEST.

QUESTION

Do you have any experience in performing the techniques listed below? If you do not have any experience in performing these techniques on your own, do you have confidence to perform these techniques independently in case of an emergency?

3) Pericardial window technique

0 1 2 3 4 5 6 7 8 9 10

▲ cannot do at all
▲ can do with help of an adviser
▲ can do independently

4) Left anterior thoracotomy and aortic clamp

0 1 2 3 4 5 6 7 8 9 10

▲ cannot do at all
▲ can do with help of an adviser
▲ can do independently

FIGURE 3. Example of a self-assessment of confidence levels form for the 21 surgical skills covered in C-BEST explained using examples.

TABLE 1. Participants' details.

		PGY1	PGY2	PGY3	PGY4	PGY5
	n = 47	(n = 1)	(n = 3)	(n = 25)	(n = 9)	(n = 9)
Gender, n						
Female			1	5	2	1
Male		1	3	20	7	8
Workplace, n						
Junior resident		1	4			
Emergency center				24	5	4
Internal medicine				1		
Surgery					3	5
Orthopedics					1	

PGY, post-graduate year.

procedure was left anterior thoracotomy and aortic clamp (n = 13), and the grade in which the procedure was performed most was PGY3 (n = 19). Some participants responded that they could practice skills for the cases in which they had never attempted performing surgery before. Many responded that they would perform the procedures when they encountered cases that required them.

When PGY3–PGY5 participants were asked about the specialized fields they would like as a major in the future in the free-response question half a year after the seminar, 27 and 32 participants responded with "surgery" before and half a year after the seminar, respectively.

4. Discussion

The present study included 47 residents. Improvements in all skills were seen on comparing SACL before and immediately after the seminar; however, a decrease was observed between immediately after the seminar and half a year later. On examining the results according to each skill, SACL did not decrease between immediately after and half a year after the seminar. The procedure performed the most was left anterior thoracotomy and aortic clamp. The number of participants intending to major in surgery increased from 27 to 32 half a year after the seminar.

The efficacy of educating students using cadavers is widely recognized [2, 3] and the use of cadavers for educational purposes is increasingly being applied to the field of surgical training. In Japan, surgical training using cadavers has been officially adapted in universities since the Japan Surgical Society and the Japanese Association of Anatomists announced the Guidelines of Autopsy in the Education and the Study of Clinical Medicine in 2012 [4]. In the field of acute care surgery, the Advanced Surgical Skills for Exposure in Trauma (ASSET) [5] and our C-BEST are conducted for cadaver surgical training in Japan. C-BEST is now held in many universities across Japan, including Tokyo Medical University, Hokkaido University Graduate School of Medicine, Tohoku University Graduate School of Medicine, Ehime University Graduate School of Medicine, and University of Occupational and Environmental Health [1]. C-BEST was conducted 42 times in Tokyo Medical University as of March 2019, and the cumulative total of participants was 412.

Gunst *et al.* [6] reported skill retention after a cadaveric trauma surgery seminar with a median follow-up duration of 6 months. Many other simulation studies [7–10] have reported follow-up results at 6 months or later. Therefore, we used a follow-up period of 6 months for skill retention in our C-BEST study.

We previously reported the following about C-BEST for participants in all categories. First, SACL improved for all skills between before and immediately after the seminar; however, they decreased between immediately after and half a year after the seminar. Second, SACL did not significantly change for all skills between immediately after and half a year after the seminar among highly experienced and experienced group members belonging to an emergency center. Third, several studies on repeat participants of these seminars have found it to be effective for skill retention. Therefore, practicing and participating in C-BEST repeatedly is supposed to be effective for retention of skills in trauma surgery [1]. However, in the above studies, many of the participants were experienced doctors, and it is unclear how these seminars would affect residents. Some residents have little surgical experience, and a point of concern is that even if they participated in the seminar, these skills will not be utilized in future. Therefore, in this study, we focused on the residents and analyzed the effectiveness of C-BEST in detail.

The resident system in Japan is as follows: PGY1 and PGY2 (also called junior residents) are placed in a training hospital and rotate in multiple departments every few months, whereas PGY3–PGY5 select an exclusive department to train in. In this study, SACL improved for all skills between before and immediately after the seminar; however, they decreased between immediately after and half a year after the seminar. When examining these results according to each skill, SACL did not decrease between immediately after and half a year after the seminar. These results were almost the same as those in our previous report. Participating in the seminar repeatedly is supposed to be effective for skill retention, although SACL decreased in all skills half a year after the seminar [1]. Many of the residents surveyed in this study and showed

TABLE 2. Results of the self-assessment of confidence levels for the 21 surgical skills for 47 participants before (BS), after (AS), and half a year after (HS) C-BEST.

		Evaluation (averages ± standard deviations)			Significant differences		
	n = 47	BS	AS	HS	BS vs. AS	BS vs. HS	AS vs. HS
Basic technique							
(1) Cricothyroidotomy		5.7 ± 2.9	8.4 ± 1.9	7.9 ± 2.1	***	***	ns
(2) Chest tube insertion		7.8 ± 2.3	9.1 ± 1.5	9.2 ± 1.4	**	***	ns
Thoracic trauma							
(3) Pericardial window technique		1.9 ± 1.9	5.1 ± 1.7	4.7 ± 1.6	***	***	ns
(4) Left anterior thoracotomy and aortic clamp		2.6 ± 3.0	5.9 ± 2.3	5.9 ± 2.8	***	***	ns
(5) Bilateral anterior thoracotomy (clam shell)		2.0 ± 2.7	5.6 ± 2.4	5.4 ± 2.8	***	***	ns
(6) Pulmonary hilar clamp		1.7 ± 2.3	4.9 ± 2.1	4.9 ± 2.7	***	***	ns
(7) Pulmonary injury		1.5 ± 1.8	4.2 ± 2.1	4.0 ± 2.2	***	***	ns
(8) Atrial injury		1.2 ± 1.6	4.1 ± 2.1	3.4 ± 2.1	***	***	ns
(9) Ventricular injury		1.0 ± 1.3	3.9 ± 2.0	3.6 ± 2.3	***	***	ns
Vascular trauma							
(10) Exposure of femoral vessels		3.0 ± 2.4	6.4 ± 2.1	6.1 ± 2.1	***	***	ns
(11) Exposure of neck vessels		2.0 ± 1.9	5.3 ± 2.2	4.6 ± 1.9	***	***	ns
(12) Vascular repair (direct suture, patch repair, end to end anastomosis, shunting)		1.5 ± 1.6	4.1 ± 1.8	3.9 ± 1.9	***	***	ns
Abdominal and pelvic trauma							
(13) Trauma laparotomy		2.6 ± 2.7	5.8 ± 2.5	5.0 ± 3.0	***	***	ns
(14) Portal triad clamp (Pringle's maneuver)		1.9 ± 2.5	5.3 ± 2.6	4.5 ± 2.9	***	***	ns
(15) Liver package		1.9 ± 2.2	5.5 ± 2.3	5.0 ± 2.4	***	***	ns
(16) Left medial visceral rotation (Mattox maneuver)		0.9 ± 1.3	4.5 ± 2.2	4.1 ± 2.6	***	***	ns
(17) Right medial visceral rotation (Cattel-Braasch maneuver)		0.9 ± 1.4	4.4 ± 2.2	4.0 ± 2.7	***	***	ns
(18) Nephrectomy		0.8 ± 1.2	3.8 ± 1.9	3.4 ± 2.4	***	***	ns
(19) Abdominal damage control technique		1.7 ± 1.9	4.5 ± 1.8	4.3 ± 2.3	***	***	ns
(20) Pelvic package		1.7 ± 1.9	5.6 ± 2.1	5.0 ± 2.4	***	***	ns
Injuries to the extremities							
(21) Fasciotomy of the lower extremity		1.9 ± 1.8	5.1 ± 1.7	4.7 ± 2.0	***	***	ns
Total		2.2 ± 2.6	5.3 ± 2.5	4.9 ± 2.7	***	***	**

Participants answered questionnaires that included a self-assessment of confidence levels form for 21 surgical skills (0 points, cannot do at all; 5 points, can do with help of an adviser; 10 points, can do independently). p values of <0.05 were considered statistically significant.
$*p < 0.05$; $**p < 0.01$; $***p < 0.001$; $ns > 0.05$.

willingness to retake the seminar if given the opportunity.

We only used a 10-point SACL as an evaluation method to evaluate the participants. Many simulation training courses often use the five-point Likert scale (1, having very little confidence and 5, having quite a bit of confidence). However, we ventured to use a 10-point scale for a more detailed analysis. Although some ASSET courses used other evaluation methods that measured the time required to complete skills or adopt complex evaluation methods [11, 12], we do not think that these are suitable for cadaver surgical training because such evaluations disturb the principal objective of our seminar, namely, "Teach clinical anatomy gently and by taking time".

The most performed procedure was left anterior thoracotomy and aortic clamp, and this procedure was performed the highest among PGY3 participants at 36% (according to the free-response question half a year after the seminar), followed by 33% among PGY4 participants. We assume that this is because many participants belonged to the emergency center in which left anterior thoracotomy and aortic clamp were often performed; thus, PGY3 and PGY4 residents treating emergency patients were more likely to be given the opportunity to perform this procedure. The execution rate for any procedure was 76% in PGY3 and 78% in PGY4. With the exception of PGY1 which had only one participant, PGY3 and PGY4 participants had the highest execution rates. However, exposure to trauma surgery cases is unpredictable. Residents with no exposure to trauma cases would not have the opportunity to perform these skills. This was a limitation of the present study. However, residents who encountered cases requiring these skills reported the benefits of attending our seminar.

It is a point of concern that even if the participants feel confident after simulation training, they may not always be able to the procedures at the actual setting. In fact, many of the participants in this study have little surgical experience. Boza *et al*. [13] validated a 16-session advanced laparoscopy simulation training program for PGY1 junior residents compared with general surgeons with no simulation training when performing a stapled jejuno-jejunostomy in the operating room. They assessed the global rating scale and specific rating scale scores, operative time, and the distance traveled by both hands measured using a tracking device. In that study, PGY1 junior residents had significantly better results in all measured outcomes, scoring considerably higher on the global rating scale with a lower operative time compared with general surgeons. They concluded that the advanced laparoscopic skills acquired through a simulated training program in novice surgical residents were successfully translated to the operating room [13]. The results of this study suggest that the confidence of residents educated at C-BEST can be demonstrated in actual surgical scenes. The skills practiced by the participants are presented in Table 3.

Interesting results were also obtained in the free-response question half a year after the seminar. When PGY3–PGY5 participants were asked about the specialized fields they would like to choose as a major in the future, 27 and 32 participants answered "surgery" before and half a year after the seminar, respectively. In other words, after attending the seminar, residents with an interest in surgery increased by 18.5%. Accordingly, it was also suggested that participation in C-BEST inspires residents to take up surgery as a major. Incidentally, Marshall *et al*. [14] reported in their systematic review that surgical experiences during medical school may influence interest in future surgical careers. In recent years, the decreasing number of residents majoring in surgery has become a problem in Japan; thus, attending simulation seminars such as C-BEST might be useful for sparking interest in the field.

Our seminars use formalin-fixed cadavers and therefore the actual feel of the organs, bleeding, or elasticity could not be experienced by the participants. We used these cadavers because they are usually in stock for the anatomy training of medical students and can be used by many participants; moreover, formalin fixing is inexpensive. Thiel's fixed method, which is widely used in surgical training these days, is expensive, and fresh-frozen cadavers are uncommon in Japan. Cadavers embalmed using saturated salt solution (SSS), first developed by Coleman and Kogan [15], were used to considerably solve these problems [16, 17]. In fact, we held three 1-day advanced C-BEST using the cadavers embalmed with SSS from September 2015 to January 2018 [18]. In the future, we plan to introduce these SSS-embalmed cadavers in conventional C-BEST so that participants can undergo more realistic training.

The number of participants included in the present was small, thereby limiting the applicability of these results. Further studies with more participants are warranted to address this limitation.

5. Conclusions

C-BEST enhances the self-confidence of all participating residents immediately after the seminar. Unfortunately, this effect was not maintained half a year after the seminar; however, many participants practiced these skills after participating in the seminar. C-BEST is useful for residents with little surgical experience, and it might also inspire participants to major in surgery.

AUTHOR CONTRIBUTIONS

HH designed the research study. HH, JO, and HS performed the research. JO, SK, and MI provided help and advice on the cadaver training. HH analyzed the data and wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The present study was approved by the institutional review board (IRB) of the faculty of Tokyo Medical University (IRB: SH3412). All study participants provided informed consent.

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TABLE 3. The skills practiced by the participants half a year after C-BEST.

	Cumulative number, n					
	PGY1	PGY2	PGY3	PGY4	PGY5	
n = 47	(n = 1)	(n = 3)	(n = 25)	(n = 9)	(n = 9)	Total
Cricothyroidotomy			4 [16]	1 [11]		5
Chest tube insertion	1 [100]	1 [33]	4 [16]	1 [11]		7
Pericardial window technique		1 [33]		1 [11]		2
Left anterior thoracotomy and aortic clamp			9 [36]	3 [33]	1 [11]	13
Bilateral anterior thoracotomy					2 [22]	2
Exposure of fomoral vessels			1 [4]			1
Exposure of neck vessels				1 [11]		1
Nephrectomy			1 [4]			1
Pelvic package					1 [11]	1
Total	1 [100]	2 [67]	19 [76]	7 [78]	4 [44]	33

PGY, post-graduate year.
Execution rates are defined as the number of procedures performed by each PGY divided by the number of participants from each PGY. These are displayed as percentages in brackets and rounded up to one decimal place.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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