~ Signa Vitae

ORIGINAL RESEARCH

Repeated participation in the cadaver-based educational seminar for trauma surgery (C-BEST) could maintain training effects: skill retention at a 2-year follow-up

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Abstract

Although the effectiveness of cadaver surgical training has been clarified, the decline in training effects over time has become a problem. This study examined whether repeated participation in cadaver-based educational seminar for trauma surgery (C-BEST) could suppress the decline in training effects. Basic and advanced C-BEST have pelvic package (PP) and fasciotomy of the lower extremity (FLE) as common training skills. For participants of these skills twice each, we examined the changes in a 10-point self-assessment of confidence levels (SACL) at six time points: (1) before the seminar of basic C-BEST, (2) immediately after basic C-BEST, (3) half a year after basic C-BEST, (4) before advanced C-BEST, (5) immediately after advanced C-BEST, and (6) half a year after advanced C-BEST. Data were collected from 28 basic C-BESTs and 5 advanced C-BESTs conducted from January 2013 to January 2020. Statistical analysis was performed by comparing SACL results from seminar evaluations at the six points, with significance at $P < 0.05$. A total of 60 participants were enrolled (postgraduate year, 16.5 ± 5.7). The interval between basic and advanced C-BEST was 27.1 ± 6.9 months. In PP, the SACL did not decrease at all six points. In FLE, SACL did not decrease at all six points, had a greater increase before versus immediately after advanced C-BEST, and did not decrease thereafter ($P < 0.05$). After participants retook the seminar, FLE-like procedures, which are unfamiliar to nonorthopedic surgeons, had increased and maintained self-evaluation values, whereas PP-like procedures, which are familiar to abdominal surgeons, had maintained high self-evaluation values. Therefore, repeated seminar participation could maintain the effects of cadaver training.

Keywords

Cadaver-based educational seminar for trauma surgery (C-BEST); Skill retention; Repeated participation; 2-year follow-up; Self-assessment of confidence levels; Pelvic package; Fasciotomy of the lower extremity

1. Introduction

Recently, cadaver surgical training has spread in each specialized area, and its educational effects have been clarified. This application extends to radiological training, infiltration techniques for general practitioners, and combined with virtual reality simulation training [1–4]. A facility has set up a large-scale skills center to conduct core skills workshops for surgical training and has reported its usefulness [5].

However, the decline in training effects over time has become a problem. We previously reported that cadaver-based educational seminar for trauma surgery (C-BEST) and advanced C-BEST were useful for trauma surgery training. Furthermore, we highlighted the issue that the self-assessment of confidence levels (SACL) at half a year after the seminar

decreased compared with SACL immediately after the seminar [6, 7]. Regarding this issue, we also speculated that repeated participation in seminars would prevent the decline because other simulation seminars reported that repeated participation could maintain the skills. To verify this assumption, we focused on the idea that basic and advanced C-BEST have pelvic package (PP) and fasciotomy of the lower extremity (FLE) as common training skills. For participants who took these skills twice each, we examined whether repeated participation in the seminar could suppress the decline in training effects.

2. Methods

2.1 Setting

(A) Basic C-BEST Time Schedule

AM

9:00-10:20 [80 min]
Preparation
Offering a silent prayer

10:20–10:40 [20 min]
【Basic technique】
1) Cricothyroidotomy
2) Chest tube insertion

10:40–13:00 [140 min]
【Thoracic trauma】
3) Pericardial window technique
4) Left anterior thoracotomy
     and aortic clamp
5) Bilateral anterior thoracotomy
     (clam shell)
6) Pulmonary hilar clamp
7) Pulmonary injury
8) Atrial injury
9) Ventricular injury

PM

14:00–15:30 [90 min]
【Vascular trauma】
10) Exposure of femoral vessels
11) Exposure of neck vessels
12) Vascular repair (direct suture, patch repair,
     end-to-end anastomosis, and shunting)
15:30–17:00 [90 min]
【Abdominal and 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
     (Cattell-Braasch maneuver)
18) Nephrectomy
19) Abdominal damage control technique
20) **Pelvic package**
17:00–17:30 [30 min]
【Injuries to the extremities】
21) **Fasciotomy of the lower extremity**
17:30
     Offering a silent prayer and placing of body in coffin
     Answering questionnaires

(B) Advanced C-BEST Time Schedule

AM

9:00–10:20 [80 min]
Preparation
Offering a silent prayer

10:20–11:50 [90 min]
【Lung trauma】
1) Pneumonectomy
2) Lobectomy

PM

12:50–14:20 [90 min]
【Liver trauma】
3) Suture with omental flaps
4) Resectional debridement
5) Hepatectomy
6) Hepatic vascular exclusion

14:20–15:50 [90 min]
【Abdominal aortic trauma】
7) Repair of abdominal aortic injury
8) Graft replacement for
     abdominal aortic injury (aneurysm)

15:50–17:20 [90 min]
【Trauma of pelvis and extremity】
9) External fixation for pelvic fracture
10) **Pelvic package**
11) **Fasciotomy of the lower extremity**

17:20
     Offering a silent prayer and placing of body in coffin
     Answering questionnaires

F I G U R E 1. C-BEST Time Schedule. (A) Time schedule for the 1-day basic cadaver-based educational seminar for trauma surgery, (B) Time schedule for the 1-day advanced cadaver-based educational seminar for trauma surgery. min, minutes.
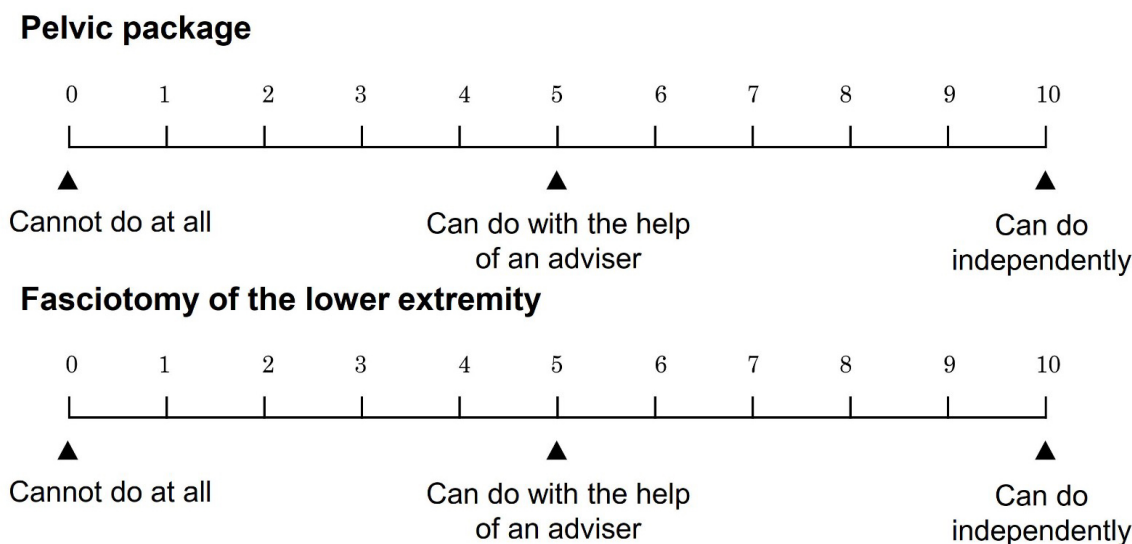
2.1.1 Basic C-BEST

We held a 1-day C-BEST (a total of 38 times) from January 2013 to March 2018, with each session using 2–3 cadavers embalmed using a formalin solution.

A total of 375 participants were recruited on the basis of the following three criteria. First, they need to 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,

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, then do you have confidence to independently perform these techniques in case of an emergency?

Pelvic package

0	1	2	3	4	5	6	7	8	9	10

▲ Cannot do at all   ▲ Can do with the help of an adviser   ▲ Can do independently

Fasciotomy of the lower extremity

0	1	2	3	4	5	6	7	8	9	10

▲ Cannot do at all   ▲ Can do with the help of an adviser   ▲ Can do independently

FIGURE 2. Example of a self-assessment of the confidence levels of the "pelvic package" and the "fasciotomy of the lower extremity" covered in basic and advanced cadaver-based educational seminar for trauma surgery explained through self-assessment examples.

participants with <10 postgraduate years (PGYs) who were recommended by the councilors of the society from the websites of the annual meetings of the Japanese Association for Acute Medicine were considered. Third, they were recruited on the recommendations of C-BEST instructors.

The participants were asked to conduct 21 surgical skills on the cadavers as shown in Fig. 1A. Briefly, in the morning, they first practiced two basic techniques. Thereafter, in terms of thoracic trauma, they practiced their skills related to the heart and lungs, and in the afternoon, they practiced femoral and neck vascular exposure and repairs, followed by skills related to abdominal and pelvic trauma. Finally, they practiced FLE, which is related to extremity trauma. Additionally, we conducted a mini-lecture using a slide presentation before each section to confirm what the participants were expected to do. The groups divided by a cadaver comprised 4–5 participants, and 1–2 dedicated instructors were assigned to each group. Subsequently, the participants proceeded to each session according to the directions and advice of the instructor, and all participants performed their skills for equal learning opportunities.

Moreover, the participants answered the questionnaires, including the SACL for these 21 surgical skills. This was measured using a 10-point visual analog scale (0 points, cannot do at all; 5 points, can do with the help of an adviser; and 10 points, can do independently) and an evaluation of the contents before, immediately after, and at half a year after the seminar. The participants were also asked to answer the questionnaires via e-mail (Fig. 2).

2.1.2 Advanced C-BEST

Among the 375 participants in basic C-BEST, we sent an invitation of advanced C-BEST via e-mail to the senior surgeons (defined as a holder of surgical board certification) who responded to the questionnaire at half a year after basic C-BEST. Subsequently, 62 participants (as a result, selected from 28 times basic C-BEST) who wished to participate attended in 5 times advanced C-BEST held from September 2015 to January 2020. In advanced C-BEST, each session involved 2–3 cadavers embalmed using the saturated salt solution (SSS) method.

The participants were further asked to perform 11 surgical skills on the cadavers as shown in Fig. 1B. Briefly, in the morning, they practiced lung resection-related skills, and in the afternoon, they practiced hepatectomy-related skills, followed by skills related to the repair of abdominal aorta. Finally, they practiced external fixation for pelvic fracture, PP, and FLE, which is related to the extremity trauma. Additionally, we conducted a mini-lecture by specialists (a thoracic surgeon, a liver trauma surgeon, a cardiovascular surgeon, and an orthopedic trauma surgeon) using a slide presentation before each section to confirm what the participants were expected to do. The groups divided by a cadaver comprised 4–6 participants, and 1–2 dedicated instructors were assigned to each group. Thereafter, the participants proceeded to each session according to the directions and advice of the instructor,

and all participants performed their skills to provide equal learning opportunities.

As with the basic seminar, the participants answered the questionnaires including the SACL for these 11 surgical skills. This was measured using a 10-point visual analog scale and an evaluation of the contents before, immediately after, and at half a year after the seminar. The participants were also asked to answer the questionnaires via e-mail (Fig. 2).

2.1.3 Changes in the SACL of PP and FLE between basic and advanced C-BEST

In basic C-BEST, the participants were asked about the 10-point SACL at three time points: before the seminar of basic C-BEST (BS-b), immediately after basic C-BEST (AS-b), and at half a year after basic C-BEST (HS-b). Similarly, in advanced C-BEST, the participants were asked about the 10-point SACL at three time points: before advanced C-BEST (BS-a), immediately after advanced C-BEST (AS-a), and at half a year after advanced C-BEST (HS-a). Thus, we examined the changes in the SACL of PP and FLE as common training skills at six time points: (1) BS-b, (2) AS-b, (3) HS-b, (4) BS-a, (5) AS-a, and (6) HS-a. Fig. 3 shows the training scene of PP and FLE. We conducted the survey in a format similar to the Delphi method, which repeats the questionnaire survey to the participants, although we did not present the obtained results.

2.2 Statistical analysis

The Shapiro–Wilk test was used for all statistical tests to determine whether variables were normally distributed using SPSS Statistics Ver. 27 (IBM Japan, Tokyo, Japan). Data were expressed as mean $\pm$ 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

Of the 62 participants, 2 did not respond to the questionnaire at three time points in advanced C-BEST (response rate, 97%). Consequently, 60 participants were enrolled (PGY, 16.5 $\pm$ 5.7). Participants were recruited from 34 hospitals and 18 universities. The interval between basic and advanced C-BEST was 27.1 $\pm$ 6.9 months. Table 1 displays participant information, including their board certification.

Data were not normally distributed according to the Shapiro–Wilk test; thus, we used the Friedman test as a nonparametric method for statistical analysis.

The changes in SACL in PP are shown in Table 2. In the statistical analyses of PP, BS-b versus AS-b was increased ($P < 0.001$), AS-b versus HS-b was not changed (not decreased), HS-b versus BS-a was not changed, BS-a versus AS-a was not changed, and AS-a versus HS-a was not changed.

Table 3 shows the changes in SACL in FLE. In the statistical analyses of FLE, BS-b versus AS-b was increased ($P < 0.001$), AS-b versus HS-b was not changed, HS-b versus BS-a was not changed, BS-a versus AS-a was increased ($P < 0.001$), and AS-a versus HS-a was not changed.

We also included a free-response question via e-mail assess-

TABLE 1. Participants' information.

|	(n = 60)
PGY (years)	16.5 $\pm$ 5.7
Gender, n (%)	
Female	2 (3)
Male	58 (97)
Workplace, n (%)	
Emergency center	42 (70)
Nonemergency center	18 (30)
Period from taking basic C-BEST to advanced C-BEST (month)	27.1 $\pm$ 6.9
Board certified fellow, n	
Emergency medicine	44
General surgery	56
Gastroenterological surgery	19
Trauma surgery	7
Hepato-biliary-pancreatic surgery	2
Cardiovascular surgery	2
Burn	2
Intensive care	11
Gastroenterological endoscopy	3
Cumulative total number	146
Board certified trainer, n	
Emergency medicine	9
General surgery	9
Gastroenterological surgery	10
Hepato-biliary-pancreatic surgery	1
Cumulative total number	29

PGY, postgraduate year.

ing whether the participants practiced skills in their clinical work at HS-b, BS-a, and HS-a. Table 4 presents the cumulative number of practiced skills. Throughout the three time points, FLE (cumulative number, 12) was more performed than PP (cumulative number, 8). Some participants responded: "If surgeons have experience in abdominal surgery, then PP can be performed without any resistance once they have experienced it by cadaver training" or "I used to consult with an orthopedic surgeon about procedures, such as FLE; however, after attending the seminar, I was able to do it on my own".

4. Discussion

The present study comprised 60 senior surgeons. The interval between basic and advanced C-BEST was approximately 2 years. In PP, the SACL did not decrease at all six points. In FLE, SACL did not decrease at all six points, increased at BS-a versus AS-a, and did not decrease thereafter. Cumulatively, 12 FLEs and 8 PPs were performed during participants' clinical work at HS-b, BS-a, and HS-a.

We previously reported that basic and advanced C-BEST
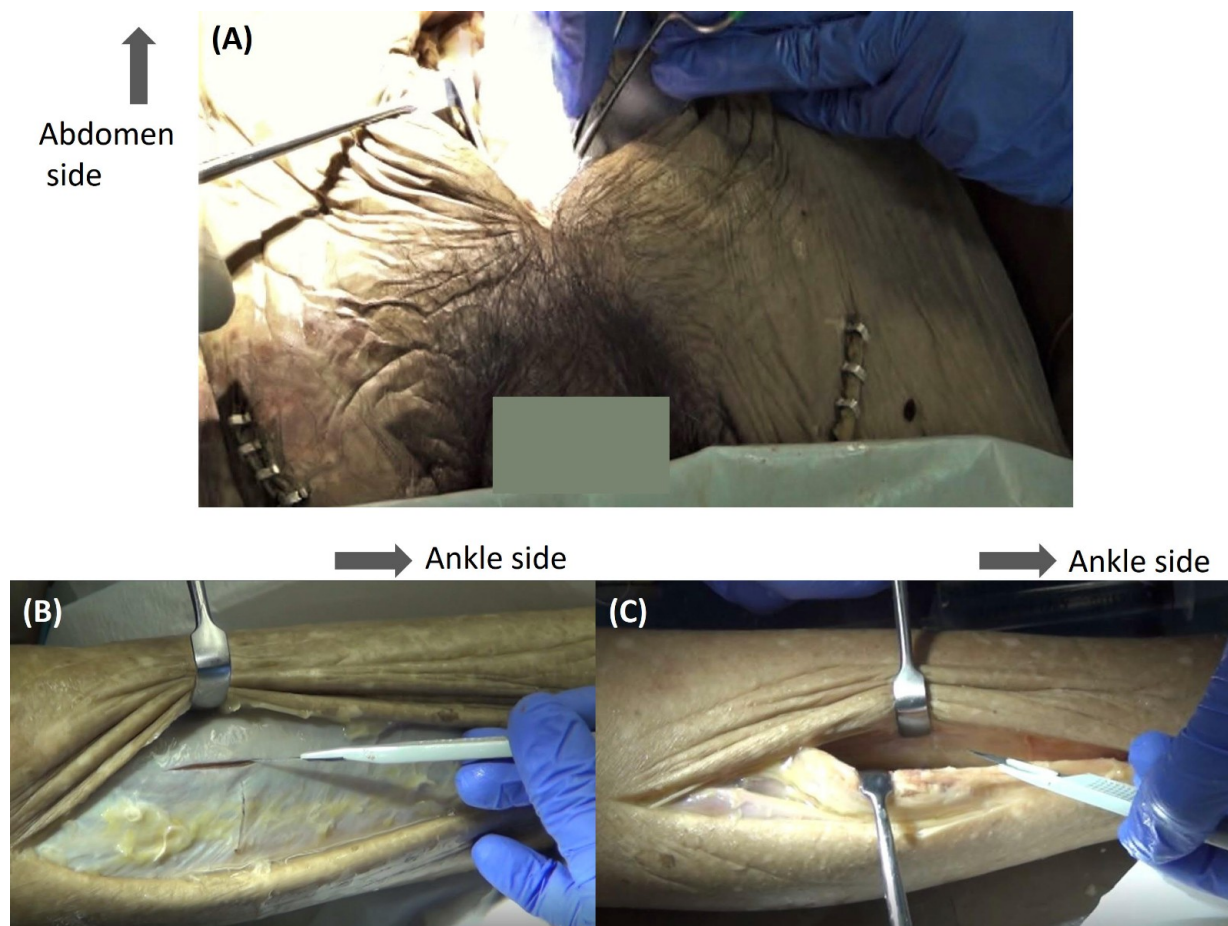
FIGURE 3. Procedure of the pelvic package and fasciotomy of the lower extremity. (A) Procedure of the pelvic package with gauze in advanced cadaver-based educational seminar for trauma surgery (C-BEST) using cadavers embalmed using the saturated salt solution (SSS) method, (B) procedure of the opening of an anterior compartment with a knife in the fasciotomy of the lower extremity (FLE) in advanced C-BEST using cadavers embalmed using the SSS method, (C) procedure of the opening of a deep posterior compartment with a knife in FLE in advanced C-BEST using cadavers embalmed using the SSS method. These pictures were taken during advanced C-BEST held in September 2015.

TABLE 2. Results of the self-assessment of the confidence levels at six time points of the pelvic package in 60 participants.

n = 60	SACL score (average ± standard deviation)					
	BS-b	AS-b	HS-b	BS-a	AS-a	HS-a
Pelvic package	6.5 ± 2.4	8.4 ± 1.8	8.7 ± 1.6	8.1 ± 2.1	8.9 ± 1.6	9.0 ± 1.4
Statistical significance		BS-b vs AS-b $p < 0.001$	AS-b vs HS-b ns	HS-b vs BS-a ns	BS-a vs AS-a ns	AS-a vs HS-a ns	

Six time points: before the seminar of basic cadaver-based educational seminar for trauma surgery (C-BEST) (BS-b), immediately after basic C-BEST (AS-b), half a year after basic C-BEST (HS-b), before advanced C-BEST (BS-a), immediately after advanced C-BEST (AS-a), and half a year after advanced C-BEST (HS-a).
The questionnaires were answered by the participants, which included a self-assessment of confidence levels (0 points, cannot do at all; 5 points, can do with the help of an adviser; and 10 points, can do independently). P-values < 0.05 (analyzed by the Friedman test, a nonparametric method) were considered statistically significant.
ns >0.05 (not significant).

were useful for trauma surgery training [6, 7]. Nonetheless, the issue was that SACL at half a year after the seminar was decreased compared with SACL immediately after the seminar. The issue of the decline in the cadaver training effect

T A B L E 3. Results of the self-assessment of the confidence levels at six time points of the fasciotomy of the lower extremity in 60 participants.

n = 60	SACL score (average ± standard deviation)					
	BS-b	AS-b	HS-b	BS-a	AS-a	HS-a
Fasciotomy of the lower extremity	5.3 ± 2.8	7.0 ± 2.0	6.8 ± 2.0	6.1 ± 2.2	7.9 ± 1.9	7.2 ± 2.0
Statistical significance		BS-b vs AS-b p < 0.001	AS-b vs HS-b ns	HS-b vs BS-a ns	BS-a vs AS-a p < 0.001	AS-a vs HS-a ns	

Six time points: before the seminar of basic cadaver-based educational seminar for trauma surgery (C-BEST) (BS-b), immediately after basic C-BEST (AS-b), half a year after basic C-BEST (HS-b), before advanced C-BEST (BS-a), immediately after advanced C-BEST (AS-a), and half a year after advanced C-BEST (HS-a).
The questionnaires were answered by the participants, which included a self-assessment of confidence levels (0 points, cannot do at all; 5 points, can do with the help of an adviser; and 10 points, can do independently). P-values < 0.05 (analyzed by the Friedman test, a nonparametric method) were considered statistically significant.
ns >0.05 (not significant).

T A B L E 4. Skills the 60 participants practiced half a year after basic cadaver-based educational seminar for trauma surgery (C-BEST) (HS-b), before advanced C-BEST (BS-a), and half a year after advanced C-BEST (HS-a).

	Cumulative number, n			
	HS-b	BS-a	HS-a	Total
Pelvic packing	5	2	1	8
Fasciotomy of the lower extremity	3	2	7	12
Total	8	4	8	20

over time has been reported by several studies. Mackenzie *et al*. [8] evaluated extremity vascular exposure and FLE procedures in fresh cadavers for 38 surgical residents of average 14 months after taking the cadaver ASSET course and 10 experts practicing traumatologists of average 16 months after. They further evaluated the same procedures for 38 PGY 3–6 residents of average 14 months after taking the cadaver ASSET course, 35 practicing surgeons of average 30 months after, and 10 experts practicing traumatologists of average 46 months after [9]. They concluded that, in both studies, skill decreases were associated with interval procedure performance, and not time since taking the seminar [8, 9]. Conversely, there is also a report that the skills were maintained. Gunst *et al*. [10] held their original 1-day trauma surgery course using fresh cadavers. The five-point Likert scale of the 18 participants (6 trauma fellows and 12 surgical chief residents) significantly increased immediately after the course compared with that before the course and did not decrease several months after (average, 6 months). However, the number of participants in this report was small, and no follow-up report was issued. The evidence of skill retention has also been reviewed as lacking [11]. In our study, we did not study a control group in which no additional training was performed during the interval of approximately 2 years. However, if no training was done, we suppose that the SACL would decrease after 2 years, as reported by others.

Certainly, the best way to retain the skills acquired in the seminar training is to practice the procedures in the clinical work. Nevertheless, unlike the routine surgery procedure,

the trauma surgery procedure cannot always be experienced. Hence, as a realistic countermeasure, the training will be repeatedly taken. Although many reports have suggested the usefulness of repeated attendance, few studies have actually verified it. Bruwaene *et al*. [12] performed a retention test after 5 months for 39 medical students divided into four groups of laparoscopic simulation training: (1) no additional training, (2) mass training with one instructor after 2.5 months, (3) five times training a month by a box trainer without an instructor, and (4) five times training a month by a virtual trainer without an instructor. The procedure was maintained in (3), followed by (2) more than in other groups. Moit *et al*. [13] conducted training using the "da Vinci" skill simulator from 2017 as robotic surgery training for the general surgery residency program. The program consisted of Phase 1 of training for PGY 1–2 and Phase 2 of PGY 3–5 refresh training every 6 months. Thereafter, the training evaluations of the six residents surveyed improved with each training.

To verify the assumption that "Repeated participation in the seminar can suppress the decline in cadaver training effects", we focused on the idea that basic and advanced C-BEST have PP and FLE as common training procedures. We reintroduced the skills of PP and FLE in advanced C-BEST for the reason that the participants and instructors of orthopedic surgeons have commented the lack of practical procedures because these musculoskeletal procedures were performed on formalin-fixed cadavers in basic C-BEST. In that respect, we could use cadavers embalmed using the SSS method in advanced C-BEST. Cadavers embalmed using the SSS method were first devel-
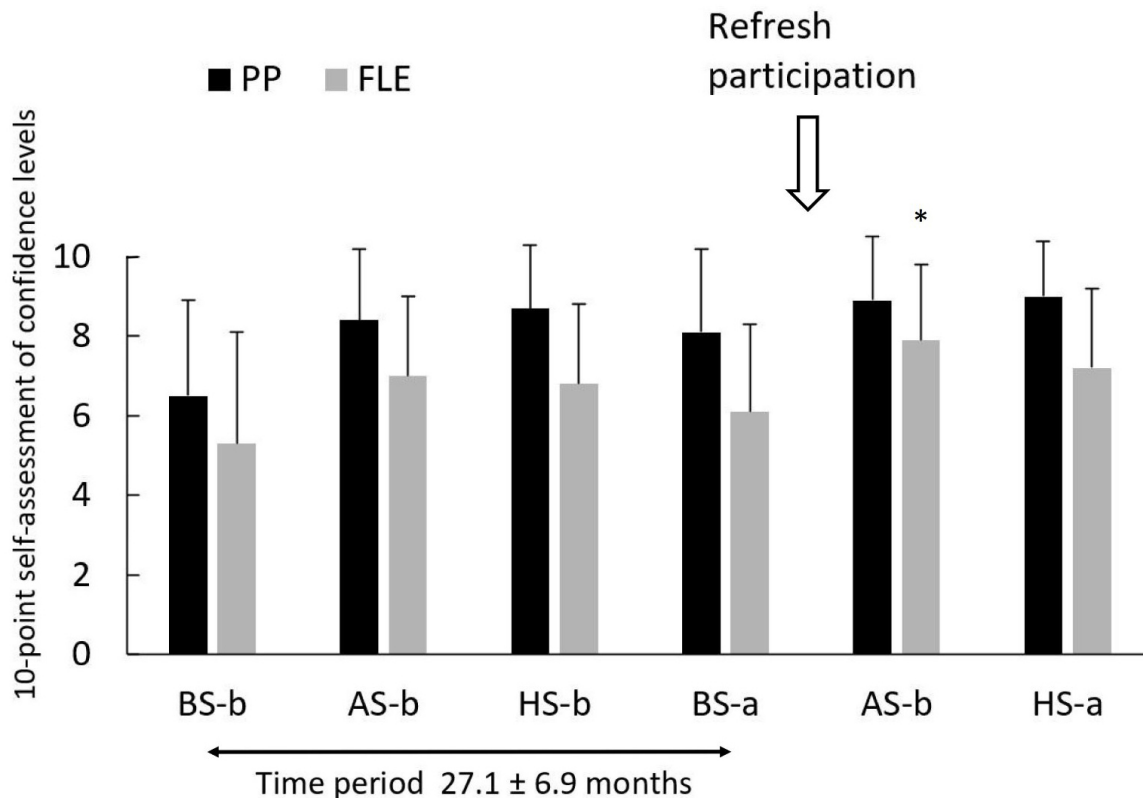
FIGURE 4. Changes in the 10-point self-assessment of confidence levels at six time points of the "pelvic package" and the "fasciotomy of the lower extremity".

PP, pelvic package; FLE, fasciotomy of the lower extremity.

Six time points: before the seminar of basic cadaver-based educational seminar for trauma surgery (C-BEST) (BS-b), immediately after basic C-BEST (AS-b), half a year after basic C-BEST (HS-b), before advanced C-BEST (BS-a), immediately after advanced C-BEST (AS-a), and half a year after advanced C-BEST (HS-a).

Data are expressed as mean $\pm$ SD, with n = 60 participants. * $P < 0.001$ versus BS-a in FLE.

oped by Coleman and Kogan [14], and we introduced it into cadaver surgical training to obtain a realistic feel [7, 15, 16]. It has also been reported that the cadavers embalmed using the SSS method are suitable for surgical training in the field of orthopedics dealing with the musculoskeletal system [17, 18].

The participants of this study were all senior surgeons who have surgical board certification, and the SACL was retained for PP and FLE, even at half a year after basic C-BEST. Furthermore, approximately 2 years (27.1 $\pm$ 6.9 months) after the first course, before taking advanced C-BEST, the SACL of PP and FLE were retained. However, although the SACL of PP was maintained at a high score, the SACL of FLE was not high. This may be because most of the participants were abdominal surgeons who would be familiar with PP because it involves incising the abdomen, but not with FLE, an orthopedic procedure. When the procedure was retaken, that is, refreshed participation [19], during this period of low self-confidence in FLE, the SACL of FLE significantly increased and was retained at half a year after. Meanwhile, PP maintained high self-evaluation values after retaking the seminar (Fig. 4). However, this result was from the senior surgeons and may be different if residents or physicians were the target. We would like to encourage the participants of various categories to retake C-BEST. We also believe that similar studies should

be conducted on participants in other categories to verify these results.

This good result may have been influenced by the fact that the training was conducted with cadavers embalmed using the SSS method. Cadaver training involves the handling of cadavers. In the cadaver fixation method, in addition to our SSS method, there is a report using N-vinyl-2-pyrrolidone [20], and there is also a report of creating a perfusion model by cannulating the cadaver's blood vessels [21–25]. In this way, cadaver training using a model closer to the living body may change the training effect of the participants and the result of their skills maintenance.

The confidence of these acquired skills was also confirmed in the practical example report in the free-response question obtained from them. This question was asked at HS-b, BS-a, and HS-a. Although the trauma surgery procedure cannot be experienced regularly, the most performed procedure was FLE (cumulative number, 7), which was answered half a year after the refresh participation (HS-a) (Table 4). The report from a gastroenterological surgeon at PGY 12 was impressive. While working at a regional hospital, he encountered a patient who showed lower leg compartment syndrome due to fractures of the lower leg by a motorcycle fall accident. The hospital had only an orthopedic resident who had no experience with FLE

at that time. He took the lead in performing FLE with the orthopedic resident and then transferred the patient to a higher hospital. The patient was discharged without after-effects.

This study has a few limitations. First, the number of participants was small. Second, the evaluation items were only self-evaluation points with no objective index. Third, the participants evaluated were only senior surgeons. Lastly, there was no control group assessed for self-evaluation after approximately 2 years without refresh training. These limit the applicability of our results. Further studies with more participants, an objective evaluation index, various category participants, and a control group must address these limitations.

5. Conclusions

After participants retook the seminar, FLE-like procedures, which are unfamiliar to nonorthopedic surgeons, had increased and maintained self-evaluation values, whereas PP-like procedures, which are familiar to abdominal surgeons, had maintained high self-evaluation values. Therefore, repeated seminar participation could maintain the effects of cadaver training. This study is unprecedented as it investigated how reparticipation in cadaver training affects the retention of training effects over approximately 2 years.

AUTHOR CONTRIBUTIONS

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

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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