The evaluation of the correlation between origami crane training and Fundamentals of Laparoscopic Surgery (FLS)

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ABSTRACT

Objective: How does making origami cranes under a dry box affect Fundamentals of Laparoscopic Surgery (FLS) scores in medical students?

Design: Four medical students from Asahikawa Medical University (tertiary hospital) participated. They made origami cranes under a dry box (origami crane training) five days per week for four weeks. The time required to make each origami crane (origami crane time) and degree of completion were evaluated. FLS scores were measured before training and on days 5, 10, 15, and 20. We examined the relationship between “origami crane training” and FLS scores.

Results: At the beginning of the experiment, none of the participants could complete the origami crane, but they were able to complete it in 31\textpm{}7 min on day 20. The Total FLS score was 164\textpm{}48 before the start of training, and 1107\textpm{}112 on day 20. The average scores of the students closely approached the Proficiency Level for the FLS tasks of peg transfer, loop ligation and extracorporeal ligation (103\textpm{}228, 61\textpm{}137, 0\textpm{}259). The change over time in the average of the increase in Total FLS Score (difference from the first time and each week’s score) improved significantly in four weeks (P < 0.01).

Conclusions: Origami crane training improved the medical students’ FLS scores. We thought that origami crane training mainly enhanced hand-eye coordination and bi-hand coordination.

1. Introduction

Mastery of laparoscopic surgical techniques requires improved hand-eye coordination and spatial awareness skills [1]. Dry box (off-the-job) training is an important training tool to improve hand-eye coordination and spatial awareness skills. Suture and ligation training in a dry box is common and important [2]. Other basic techniques (e.g., grasping, lifting, pushing, pulling, pressing, and dissection) are a large part of laparoscopic surgery. However, no routine and effective training methods have been established. Fundamentals of Laparoscopic Surgery (FLS) was developed by the Society of American Gastrointestinal and Endoscopic Surgeons to teach standard cognitive and psychomotor skills to practitioners of laparoscopic surgery. The importance of standardization in training was recognized by the American Board of Surgery (ABS), which in 2008 made passing the FLS a requirement for obtaining certification in general surgery [3, 4]. The FLS consists of five tasks (Peg Transfer, Precision Cutting, Ligation Loop, Suture with Extracorporeal Knot, and Suture with Intracorporeal Knot). For all tasks, both time and accuracy are measured for performance and high scores result from tasks performed efficiently and without error. Each task has its own scoring formula based upon a combination of time and accuracy measures [5, 6]. The performance of the FLS tasks has been shown to be correlated with intraoperative performance on laparoscopic procedures [7, 8]. Creating various shapes with origami is a traditional Japanese culture. The crane, which is one of the most well-known origami forms, is not easy to create due to its complex structure (Figure 1). In recent years, some Japanese laparoscopic trainees have been trained to make origami cranes under a dry box (hereafter referred to as origami crane training). Coordinated movement of both forceps is essential to make an origami crane in a dry box, and it is considered effective for training hand-eye coordination and bi-hand coordination [9]. In the present study, we examined the impact of origami crane training on the FLS scores of medical students.

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The dimensions were measured paper used for the origami crane in this study was white on one side, with various colors on the other side. These participants underwent origami crane training with the task of making one origami crane per day under a laparoscopic dry box (hereafter referred to as origami crane training). The paper used for the origami crane in this study was white on one side, with various colors on the other side. The dimensions were measured 7.5 × 7.5 cm. This paper is a standard paper and is not a traditional one. The perfection of the origami cranes (precision, shape, and lack of scratches) was scored on a 15-point scale, and the experimenters evaluated and scored each other (hereafter referred to as the origami crane score). For the unfinished origami cranes, the score was multiplied by the degree of progress (Figure 1).

The FLS performed five tasks, each scored according to the manual [5, 6]. The FLS tasks were demonstrated by the supervising physician at the beginning of this study and each participant was referred to the FLS training video. After that, each participant did the origami crane training without the supervising physician. The FLS was performed five times before the start of origami crane training (day 0) and at the beginning of each week (day 5, day 10, day 15, day 20). This study was approved by the Asahikawa Medical University Research Ethics Committee (No. 20181). Written informed consent was obtained from the medical students. The results were presented as the mean ± standard deviation of the participants. All analyses were performed using the R software program (version 3.1.2) and the EZR software program [10]. We determined that comparisons over time were necessary to determine improvement in technique. Since the FLS scores were measured weekly, we tested them using repeated measures analysis of variance (ANOVA). It was performed to analyze the change over time in the average of the increase in total FLS score (difference from the first time and each week’s score because minimize individual differences). We thought that this analysis would allow us to determine how much difference there was in the Total FLS Score increase within the origami crane training period, regardless of the individual’s ability. P values of <0.05 were considered to indicate statistical significance. The authors declare no conflicts of interest in association with the present study.

2. Materials and methods

This study is a prospective single-arm cohort study examining the relationship between origami crane training and FLS scores in four Japanese medical students. The study participants were four medical students who had never been trained in surgical techniques for laparoscopic surgery. They were already able to fold the origami crane using their hands. These participants underwent origami crane training five days per week for four weeks. During the period, the students were given the task of making one origami crane per day under a laparoscopic dry box (hereafter referred to as origami crane training). The paper used for the origami crane in this study was white on one side, with various colors on the other side. The dimensions were measured 7.5 × 7.5 cm. This paper is a standard paper and is not a traditional one. The training was directly started using this size of the paper without any other prior training using larger or smaller sizes of the paper. The origami crane training was terminated if the participant could not complete the origami crane in 100 min. The completed origami cranes were mutually evaluated for quality. The process of creating a crane by folding paper and the origami crane score when not completed. (1) For 1–10 folds: multiply score by 0.25. (2) For 11–18 folds: multiply score by 0.5. (3) For 19–30 folds: multiply the score by 0.75. <18 folds: multiply score by 1.0.

Figure 1. The process of creating a “crane” by folding paper and the origami crane score when not completed. (1) For 1–10 folds: multiply score by 0.25. (2) For 11–18 folds: multiply the score by 0.5. (3) For 19–30 folds: multiply the score by 0.75.

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3. Results

The four participants were two males and two females with a median age of 23.5 (22–24) years. All participants were right-handed. Two participants self-reported being good at video games. All participants self-reported being good at driving. Three participants self-reported being dexterous.

Figure 2 shows the crane completion rates in chronological order. The degree of completion increased over time.

Figure 3 shows the change over time in FLS scores: After 4 weeks of training, the average scores of the students reached a level that was close to the Proficiency Level [5] in peg transfer (Figure 4a), ligation loop (Figure 4c), and suture with extracorporeal knot (Figure 4d) (peg transfer, 90% [228/252 points]; ligation loop, 93% [137/147 points]; extracorporeal ligation, 91% [258/284 points]). The average scores of the students for precision cutting (Figure 4b) and suture with intracorporeal knot (Figure 4e) were 155 ± 20 and 329 ± 81 points, respectively (precision cutting, 77% [155/202]; intracorporeal ligation, 67% [329/488]). The Total FLS score was 164 ± 48 before the start of training, 527 ± 151 on day 5, 767 ± 240 on day 10, 822 ± 127 on day 15, and increased to 1107 ± 112 points on day 20 (Figure 4f). The Total FLS scores increased with a decreasing origami crane time, with the average scores of the students identified to be close to the Proficiency Level (1107/1373 points), and both tasks improved over time.

Figure 5 shows the change over time in the average of the increase in Total FLS Score (difference from the first time and each week’s score); there was a significant difference between W1 and W4 (P < 0.01), and Total FLS Score increased significantly in four weeks (P < 0.01).

4. Discussion

In this study we examined the relationship between “origami crane training” and FLS score. The present study showed that origami crane training increased the FLS score. As noted above, FLS training is an indicator of improved laparoscopic technique, and FLS training has been
reported to be associated with a significant increases in surgical scores (Lap-C) [8]. Among the skills, hand-eye coordination and bi-hand coordination are important for laparoscopic procedures [11, 12]. In addition, FLS training is thought to train coordinated movements [13]. Based on the results of this study, in which origami crane training increased FLS scores, it was hypothesized that origami crane training would improve hand-eye coordination and bi-hand coordination.

For each FLS task, the average scores of the students closely approached the Proficiency Level for peg transfer, loop ligation, and suture with extracorporeal knot, while eventually exceeding 90% after the continuation of origami crane training [5]. Laparoscopic and non-laparoscopic surgeons are reported to show significant differences in scores for peg transfer, precision cutting, and suture with intracorporeal knot [1]. In other words, scores for peg transfer, precision cutting, and suture with intracorporeal knot may reflect hand-eye coordination and bi-hand coordination, which are not important in laparotomy. In particular, peg transfer has been employed in VR simulator tasks because it provides training in hand-eye coordination and bi-hand coordination [14, 15]. The high percentages for peg transfer, which reached the Proficiency Level [5], in this study suggested that the origami crane training mainly enhanced hand-eye coordination and bi-hand coordination. Furthermore, there was no significant difference in loop ligation scores, and it was considered that there was no difference between laparoscopic and non-laparoscopic surgeons because the technique is not frequently used [1]. In this study, the average scores of the students closely approached the Proficiency Level for loop ligation and suture with extracorporeal knot [5]. Unlike the other tasks, forceps manipulation is mainly performed with one hand; thus, it is likely that the improvement in forceps manipulation through origami training and hand-eye coordination contributed to the favorable increase in the scores.

On the other hand, the percentages for precision cutting and suture with intracorporeal knot were less likely to reach the Proficiency Level [5]. Hand-eye coordination and bi-hand coordination are also important for precision cutting and intracorporeal ligation, but the operations of “dissection”, “needle movement”, and “ligation” themselves are unique and require practice [3]. Since precision cutting with scissors is an operation experienced in daily life, it was thought that training with origami cranes alone would not be sufficient to improve suturing, especially intracorporeal suturing, and that dedicated training and instruction would be necessary.

The Total FLS Score (difference from the first time and each week’s score) increased significantly over time, and since there was a significant difference between W1 and W4, we thought that four weeks of origami crane training would result in a significant increase in the Total FLS Score. In laparoscopic procedures, it is difficult to improve and judge the
Figure 4. Change in the FLS scores over time. a: FLS scores for peg transfer increased over time. The final percentage of students reaching Proficiency Level was 90%. b: Precision cutting FLS scores increased over time. The final percentage of Proficiency Level was 77%. c: FLS scores for loop ligation showed ups and downs but increased over time. The final percentage of students reaching Proficiency Level was 93%. d: FLS score for suture with extracorporeal knot slightly decreased at week 3 but increased at week 4. The final percentage of students reaching Proficiency Level was 91%. e: FLS scores for suture with intracorporeal knot increased over time. The final percentage of students reaching Proficiency Level was 67%. f: Total FLS scores increased over time. The final percentage of Proficiency Level was 81%.
The present study was associated with some limitations. First, it is not known whether origami crane training is associated with improved clinical skills or outcomes. Second, this study is a prospective single-arm cohort study examining the relationship between origami crane training and the FLS scores in four Japanese medical students. The small number of participants may have caused a selection bias. There are two possible future prospects. First, it is necessary to increase the sample size and see if reproducibility can be obtained. Second, it is necessary to have trainee physicians perform the origami crane training to see if the technique can be improved using simulators and actual surgery.

5. Conclusion

Origami crane training improved the FLS scores, especially in peg transfer and loop ligation, which involve hand-eye coordination and bilateral coordination. In addition, four weeks of origami crane training significantly increased the Total FLS Score. Therefore, we thought that origami crane training is useful as laparoscopic training.

Declarations

Author contribution statement

Tomohiro Takeda: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Tatsuya Shonaka: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Yuki Adachi; Masahide Otani; Mizuho Ohara; Chikayoshi Tani; Kengo Kitza; Kimiharu Hasegawa; Yasuo Sumi: Conceived and designed the experiments.

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Data availability statement

Data included in article/supp. material/referenced in article

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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