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# Educational system based on the TAPP checklist improves the performance of novices: a multicenter randomized trial

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**Abstract**

*Background* Despite recent developments in surgical education, obstacles including inadequate budget, limited human resources, and a scarcity of time have limited its widespread adoption. To provide systematic training for laparoscopic inguinal hernia repair, we had previously developed and validated a checklist to evaluate the recorded performance of transabdominal preperitoneal (TAPP) repair. We had also developed an educational system that included didactic materials based on the TAPP checklist and incorporated remote evaluation and feedback system. The aim of this study was to evaluate the educational impact of the TAPP education system on novice surgeons.

*Methods* Residents and surgeons from participating hospitals, who had performed 0 or 1 TAPP procedure, were randomly assigned to the intervention group (IG), who trained using this new educational tool, and the control group (CG), who trained using the conventional system. Their surgical videos were rated by blinded raters. All participants performed their first case prior to randomization. The primary outcome was improvement of TAPP checklist score from the first to the third case.

*Results* Eighteen participants from 9 institutes were recruited for this study. Seven participants in the IG and 5 participants in the CG were included in the final analysis. The participants in the IG demonstrated significant improvement in their TAPP performance ($p = 0.044$) from their first case to their third case, whereas their counterparts in the CG failed to make any significant progress during the same period ($p = 0.581$).

*Conclusion* The new TAPP educational system was effective in improving the TAPP performance of novice surgeons.

**Keywords** Surgical education · Laparoscopic inguinal hernia repair · Transabdominal preperitoneal (TAPP) repair · Assessment and feedback · Remote education

The introduction of laparoscopic surgery has triggered a paradigm shift in the field of surgical education [1]. From the traditional apprentice model, where trainees were supposed to watch and learn from their mentors, surgical education has become more evidence-based. Importance of assessment, feedback, and simulation training has been established [1]. For laparoscopic inguinal hernia repair (LIHR), 2 groups in North America have developed simulation-based curriculums and have demonstrated their educational benefits [2, 3]. Interest in this paradigm shift has also been noted in other parts of the world [4, 5]. Recently, a group in Japan developed a new simulator for LIHR [6]. However, even in developed countries, surgeon educators face various obstacles such as lack of adequate budget and limited human resources and time to train residents outside of the operation room [7]. Moreover, for many developing countries, simulation training is simply too expensive. As such, despite the advances in

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the field of simulation training, the majority of the trainees around the world are still being trained using the traditional apprentice model [8–11]. This training model, however, has a long learning curve of at least 60 cases [12, 13].

We had earlier developed an assessment tool for the evaluation of the recorded performance of LIHR [14]. We also developed educational tools for the training of LIHR based on this evaluation tool. We then developed an educational system that incorporated these educational tools and remote assessment and feedback using the transabdominal preperitoneal (TAPP) checklist. In the pilot study, this educational system was highly appreciated by the trainees.

The objective of the current study was to examine the educational value of this new educational system as compared with that of the traditional education system among novice surgeons via a multicenter randomized controlled trial.

## Materials and methods

### Ethical issues

The institutional review board (IRB) of the Faculty of Medicine at Hokkaido University approved this study (Med 014-0055). Individual IRB approval was also obtained from each participating hospital. The participants were additionally asked to obtain written informed consent from the patients after informing them that the surgical video of their procedure would be evaluated by experts outside the hospital. The instructors in each institute had full right to determine whether the participants were ready to perform the TAPP procedure, and to take over the procedure if they felt that the participants were having trouble during the procedure or if they felt that there was a possibility that the patient might be at harm. They were allowed to continue with their normal clinical duties and other surgeries during the study period.

### Participants

General surgery residents and general surgeons from participating hospitals, who had performed one or less TAPP procedure, were recruited for this study from April 2015 to March 2016. The study was designed as a prospective randomized controlled trial (RCT) in accordance with the CONSORT statement (Fig. 1). The participants were individually given an explanation about this trial and only the participants who provided written informed consent were included in this study.

### Randomization

Background information on all participants was collected. The participants were randomly assigned to either an intervention group (IG) or a control group (CG) such that p value between the background data in both groups was $>0.4$. The participants, however, were not notified of their grouping until they submitted their first TAPP procedure video.

When more than one individual from the same institute participated in the study at the same time, participants in the IG were asked not to share their education tools with the participants in the other group or the participants who were yet to be notified of their grouping status. The instructors in charge of the first case and the ones for the CG trainees were also separated from the ones who were in charge of the IG trainees during the study period.

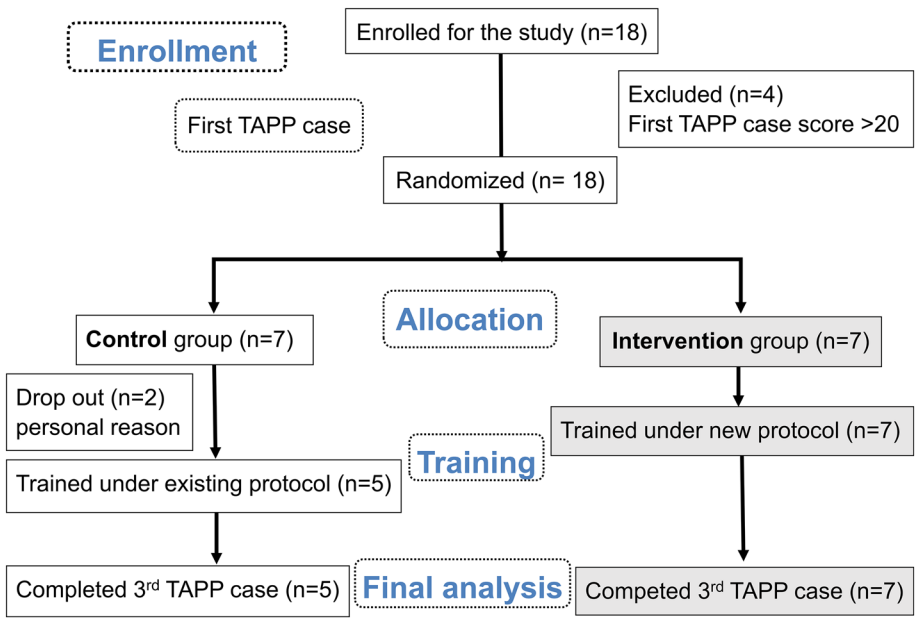


**Fig. 1** The CONSORT statement

### Case selection

The participating institutes were requested to select male patients with primary indirect hernia, PL2, characterized according to European Hernia Society guidelines for the inclusion in the study [15]. The participants were barred from performing surgery on recurrent or incarcerated hernias during the study period.

### Assessment of TAPP procedure

The TAPP procedures in this study were assessed using the TAPP checklist (Fig. 2). This assessment tool had been previously developed and had shown good inter-rater reliability and the scores correlated with the experience of the surgeon [14]. All participants were asked to send the surgical video of their TAPP procedure and a short note indicating

**TAPP Checklist**

Operator/DVDno :

Evaluator :

(Yes =1, No=0)

| | Topics | Explanation | |
|---|---|---|---|
| **Trochar Insertion** | | | |
| **1** | View | Trochar is inserted under visualization | |
| **2** | Position | Trochar is properly located | |
| **Incision of peritoneum** | | | |
| **3** | Starting point | First incision is made in an appropriate location on the lateral to inguinal canal | |
| **Creation of Dissection Space** | | | |
| **4** | Start of Dissection | After the incision, the proper layer is found and dissection is started | |
| **5** | Layer of Dissection | The proper dissection layer is maintained | |
| **6** | Traction | Traction is changed according to the direction of the dissection | |
| Parietalization | | | |
| **7** | Safe Dissection | Recognizes and safely dissects Spermatic chord and vessels | |
| **Reduction of Hernia Sac** | | | |
| **8** | Reduction | Properly reduces the hernia sac. Hernia sac is completely reduced in direct hernia. | |
| **Extent of Dissection (Following Structures can be visualized)** | | | |
| **9** | Medial | Pubic Symphysis, Cooper ligament, Rectus Muscle | |
| **10** | Ventral | Rectus muscle, Inferior epigastric vessels, transverse muscle | |
| **11** | Lateral | Dissection of lateral triangle up to Superior Iliac spine | |
| **12** | Dorsal | Spermatic vessels and spermatic chord | |
| **Mesh Deployment** | | | |
| **13** | Size | Proper mesh size is selected | |
| **14** | Position | Mesh is placed properly | |
| **15** | Stretching | Mesh is stretched properly | |
| **16** | Fixation | Mesh is fixed properly | |
| **Suturing of the Peritoneum** | | | |
| **17** | Needle movement | Proper Suture Bite and Pitch and proper needle handling | |
| **18** | Final appearance | No tear in peritoneum, no slacking of suture and no mesh visible | |
| **Overall** | | | |
| **19** | Energy Device | No electric damage done to surrounding organs | |
| **20** | Bleeding | No bleeding requiring hemostatic procedure | |
| **21** | Instrument handling | Bimanual Dexterity, able to grab the peritoneum finely | |
| **22** | Tissue handling | Tissues are handled gently | |
| **23** | Flow of procedure | Overall flow of procedure is smooth | |
| **24** | Operation Time | Operation time is within 90 Mins | |
| | | **Total** | |

**Comment** :

**Fig. 2** The TAPP checklist. Previously published by Poudel et al. [14]

the portions where the instructor had taken over, to the researchers. The participants were requested to perform further TAPP procedures only with the researcher's approval. Digital copies of these videos were then randomly rated by one of the 3 video raters, who had earlier been trained as raters, using the TAPP checklist. The raters were blinded to the identity, institute, and grouping of the participants.

### Exclusion criteria

Participants were excluded from the study if their first TAPP video checklist score exceeded 20. Participants who had already performed more than 1 TAPP procedure were also excluded from the study.

### Training of the intervention group

The participants and their instructors were notified regarding which group they had been assigned to, after they submitted the video of their first case. The participants and the instructors in the IG were provided with the TAPP educational video and the TAPP checklist explanation sheet. They were briefed on how to use the TAPP checklist, the TAPP checklist explanation sheet, and the TAPP educational video. The participants were then provided with the assessment sheet of their first procedure by the video raters, and were asked to review the educational video and their procedure. They were also asked to practice the intracorporeal suture in the dry box.

The operators' criteria were set for the trainees in the IG, to check their level of technical skill and cognitive knowledge before the trainees were allowed to perform their next TAPP procedure. The technical aspect of the criteria was being able to complete 3 intracorporeal suture knots, including a square knot, within 2 min in a dry box. The time was based on the study by Scott et al. [16] which set the proficiency benchmark for passing FLS. For the test of the cognitive knowledge, a set of multiple choice questions on TAPP procedure had been earlier developed. The questions were related to basic inguinal hernia anatomy and the surgical process of the TAPP procedure. This was piloted among minimally invasive surgeons experienced in the TAPP procedure. Based on the pilot study, participants in the IG were required to obtain full marks on this test to pass this criterion. The trainees were required to pass both these criteria before they were assigned their second TAPP case.

The instructors were instructed to use the TAPP checklist to evaluate their trainees after the procedure. They were also encouraged to use the same terms used in the educational video when giving feedback to the trainees. During the study, the blinded video rater rated the videos using the TAPP checklist, and those assessments were sent back to the participants to help them with their next procedure. The participants were asked to share the TAPP checklist assessment and feedback they received from the video raters with their instructors in their hospital.

### Training of the control group

The participants and the instructors of the CG continued with their regular training and performed the TAPP procedure as per their individual hospital's criteria. They were asked to submit a video of each procedure. Following the completion of the study, they were provided with the TAPP checklist, the TAPP checklist explanation sheet, and the TAPP educational video, along with the assessment sheets of their previous surgical procedures.

### Outcome

The primary outcome of this study was an improvement in a trainee's TAPP checklist score from the first TAPP case to the third TAPP case. The total TAPP checklist scores of the third TAPP case between both groups were also compared. To investigate into the different aspects of the TAPP procedure where this educational tool might have an impact, we also checked the scores of the different subsections. Subsections, incision of the peritoneum, creation of dissection space, parietalization, and reduction of hernia sac were grouped together as dissection of the preperitoneal space. The secondary outcome of this study was the difference in the score and the improvement from Case 1 to Case 3 in each subsection of the TAPP checklist.

The scores given by the blinded video raters were used in all analyses in this study. If the video provided contained a portion of procedure that was not recoded, then that portion of the procedure was not scored and was handled as missing data for the purpose of scoring the total score and the scores for the unrecorded subsections. The scores of the recorded sections were, however, used for the analysis of the subsections.

### Statistical analysis

Based on our previous data, a post-training increase in the TAPP checklist score to 20 in the IG was considered significant. To demonstrate a significant difference between the two groups with an alpha error of 0.05 and a beta error of 0.20, the analysis indicated a need for a minimum of 5 participants in each group.

A Wilcoxon signed-rank test was done to compare the checklist scores between TAPP Case 1 and TAPP Case 3 of the same individual. A Mann–Whitney $U$ test was used to compare the data between the two groups. Data are presented as median (interquartile range).

$p < 0.05$ (two-tailed) was considered significant in all analyses. All statistical analyses were done using SPSS version 17 (IBM Co., Armonk, NY, USA).

## Results

### Demographics

Eighteen participants from 9 institutes were recruited for this study. Four participants were excluded from the study, as they met the exclusion criteria. Two participants from the CG dropped out of the study due to their personal reasons. Ultimately, 7 participants from the IG and 5 participants in the CG completed the study and were included in the final analysis. There was no difference between the backgrounds of the participants (Table 1).

### Primary outcome

From their first case to their third case, the participants in the IG demonstrated a significantly improved score, from 11.0 (9.0–15.0) to 21.5 (20.3–22.5) ($p = 0.044$). The participants in the CG, however, did not show a significant improvement in their performance ($p = 0.581$) (Table 2). In their

**Table 1** Backgrounds of the participants

| | Control group ($n = 5$) | Intervention group ($n = 7$) | $p$ |
|---|---|---|---|
| Post graduate year (year) | 4 (3.0–5) | 3 (3–8) | 0.930 |
| Number of TAPP cases as assistant (cases) | 6 (5–19) | 8 (4–15) | 0.870 |
| Laparoscopic surgery experience as surgeon (cases) | 6 (1–40) | 24 (8–38) | 0.222 |
| Number cases in the institute last year (cases) | 60 (44–62) | 50 (48–60) | 0.282 |
| TAPP experience of the instructor (cases) | 50 (34–144) | 50 (18–138) | 0.805 |

Data are presented as median (interquartile range)

**Table 2** TAPP checklist scores of the participants

| | Control group | Intervention group | $p$ |
|---|---|---|---|
| TAPP 1 total score [24] | 15 (13–18) | 11 (9–15) | 0.164 |
| TAPP 3 total score [24] | 16 (12.5–20.5) | 21.5 (20.3–22.5) | 0.081 |
| $p$ | 0.581 | **0.044*** | |
| TAPP 1 trocar score [2] | 2 (1.5–2) | 2 (1–2) | 0.428 |
| TAPP 3 trocar score [2] | 2.0 (2–2) | 2.0 (2–2) | 1.000 |
| $p$ | 0.317 | 0.157 | |
| TAPP 1 dissection score [6] | 4 (3–4.5) | 3 (2–4) | 0.391 |
| TAPP 3 dissection score [6] | 4 (4–5) | 6 (5.8–6) | **0.019*** |
| $p$ | 0.276 | **0.044*** | |
| TAPP 1 extent of dissection score [4] | 2.0 (1.0–3.0) | 2.0 (1.0–3.0) | 0.863 |
| TAPP 3 extent of dissection score [4] | 2.0 (1.0–4.0) | 4.0 (4.0–4.0) | **0.025*** |
| $p$ | 0.705 | **0.017*** | |
| TAPP 1 mesh score [4] | 4.0 (2.5–4.0) | 3.0 (1.0–4.0) | 0.233 |
| TAPP 3 mesh score [4] | 3.0 (2.0–4.0) | 4.0 (4.0–4.0) | 0.080 |
| $p$ | 0. 414 | 0.066 | |
| TAPP 1 suture score [2] | 2.0 (1.5–2.0) | 2.0 (2.0–2.0) | 0.901 |
| TAPP 3 suture score [2] | 2.0 (2.0–2.0) | 2.0 (2.0–2.0) | 1.000 |
| $p$ | 0.317 | 0.317 | |
| TAPP 1 overall score [6] | 3.0 (1.5–3.5) | 1.0 (1.0–2.0) | 0.173 |
| TAPP 3 overall score [6] | 2.0 (1.5–4.5) | 3.0 (3.0–4.0) | 0.318 |
| $p$ | 0.854 | 0.125 | |

Data are presented as median (interquartile range)

Maximum total possible score in each section is written inside []. $p$ values in the column represent the difference between the score of the control group and the intervention group. $p$ values in the rows represent the difference between the scores of the first TAPP case and the third TAPP case. * and bold letters are used to denote the difference that is statistically significant

third case, the participants of the IG tended to outscore their counterparts in the CG (Table 2).

### Secondary outcome

In the analysis of different subdivisions of the procedure, the participants in the IG showed significant improvement in important aspects of the TAPP procedure, specifically in the subsections "dissection of the preperitoneal space" ($p=0.044$) and "extent of dissection" ($p=0.017$). They also showed the tendency of improvement in the "mesh deployment" section ($p=0.066$). The participants in the CG, however, did not show significant improvement in any aspect of TAPP procedure (Table 2).

There were no post-operative complications in any of the cases completed by the participants.

## Discussion

In this study, novice surgeons trained using the newly developed TAPP educational system showed significant improvement in their performance in the short span of 3 cases. Regarding the important aspects of the procedure, the trainees who trained under this educational system, despite being from various institutes, outperformed their counterparts who were exposed to traditional training method that existed in their hospital.

In order to make it easily accessible to institutes in a variety of settings, the only technical skills training offered in this educational system was intracorporeal suturing in box trainers. Despite this, the trainees in IG made significant improvement in their performance. We believe that the assessments and the formative feedback provided to the trainees using a detailed checklist have helped the novices in identifying their weakness. The educational video provided to them had technical tips on how to overcome various difficulties during the procedures. They were encouraged to focus their training and study in those areas. This may have led the novices to initiating deliberate practice of the areas of their weakness. Deliberate practice has been attributed to better performances in the field of games, music, and sports [17]. Recently, several studies have looked into its implication on the field of surgical education [18–21]. Hashimoto et al. [19] demonstrated that the quality of the performance of the novices undergoing deliberate practice was higher in simulation training. Other studies have also demonstrated the effectiveness of deliberate practice [18, 21, 22]. Deliberate practice could be the reason why the trainees in the IG demonstrated such significant improvement in their performance in our study.

The novice users who were trained with this new educational tool also made significant progress in the following important aspects of the procedure: dissection of the preperitoneal space, extent of dissection, and mesh deployment. Most of the participants from the both groups scored nearly full marks in items that were relatively easy, such as the insertion of trocar, and the ones that required purely technical skill, such as that of suturing of the peritoneal flap. However, in the items in which both technical skills and cognitive skills were necessary, such as the dissection of the preperitoneal space and extent of dissection, the difference between the IG and CG was evident. In the subsection of extent of dissection, all participants in the IG scored full marks in their third case. An earlier study by Kurashima et al. [2] on totally extraperitoneal (TEP) repair showed a similar trend, with the educational effect most evident in the creation of preperitoneal space and the reduction of hernia sac. These steps are actually the most important steps in the TAPP and are directly related to patient outcomes such as relapse, hemorrhage, and hernia neuropathy [23].

This study was conducted in multiple institutes with a number of instructors from each institute supervising the trainees. While the hospitals where the trainees trained and the TAPP experience of the instructors in both groups were well matched, it was not possible to measure the level of the instructors as an educator. The educational impact of this educational tool was based both on the feedback the trainees received from the video raters as well as their own supervisors in their respective hospitals. The trainees who are fortunate to have a good educator that provides them assessment and meaningful feedback may make similar progress without the use of the system we have developed. However, as evident by the wide range of scores of the respective third cases of the participants in the CG, there is a disparity in the progress made by participants who were solely dependent on the training provided by the instructors in their institutes. Meanwhile, the scores of participants in the IG are spread in a narrower range. In the current setting, where we cannot control the level of the instructors in each institute, using the educational system that we developed can have a positive impact in the training of trainees in a variety of settings.

Simulator training is considered to be gold standard for the training for surgical skill [1]. In this study, we were able to demonstrate that a considerable educational impact was made on the novice surgeons without the use of simulation. Ideally, we would have to demonstrate the educational impact of this educational tool by comparing it with established simulator training. However, as mentioned earlier, this educational system has been developed for settings in which simulator training is not feasible. We have demonstrated that even in these settings, using a systematic approach to the training of surgical skills was superior to the use of traditional training methods. Moreover, we demonstrated the educational impact of this tool using trainees distributed

within a wide range of institutes. This adds to the generalizability of our educational system, which is one of its strongest points.

The present study has some limitations. First, this study did not demonstrate a difference in patient outcome. Zendejas et al. [3] demonstrated less intraoperative and post-operative complications in procedures completed by trainees who underwent simulation training. Unfortunately, our study was not powered to detect the differences between the complications between the two groups. All participants performed the procedures within controlled environments in which their instructors took over whenever they felt that the trainees did not know what they were doing or were risking patient safety. While this led to a decreased score in the performance of the trainee, it did not necessarily result in complications in the patients. This educational system can be easily implemented in any hospital to train the trainees with LIHR. It has the potential to improve patient outcome by enhancing the quality of the surgery performed by trainees during the early stages of their learning curve. It also has the potential to serve as a template for developing educational tools for other complex surgical procedures.

## Conclusions

The newly developed TAPP educational system was effective in improving the TAPP performance of novice surgeons.

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**Compliance with ethical standards**

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