



Development of a systematic telesimulation curriculum for laparoscopic inguinal hernia repair

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Abstract

Purpose Telesimulation, whereby learners telecommunicate and use simulator resources to receive education at an off-site location, has been used to educate surgical trainees about how to perform basic surgical procedures. However, it has not yet been used for advanced surgical procedures. We aimed to develop a telesimulation curriculum to teach a common laparoscopic procedure called transabdominal preperitoneal (TAPP) repair and to explore the feasibility of its use.

Methods Learning objectives were created to develop a telesimulation curriculum that included didactic telelecture and telesimulation training. Pre-tests and post-tests to assess the didactic materials were developed and assessed among surgeons with various experiences. We assessed the feasibility of the telelecture and telesimulation separately. Pre-tests, post-tests, and questionnaires were used to assess the telelectures. We created a TAPP repair telesimulation system and checked for problems during training. Trainees were assessed to determine their skill improvement using previously published assessment tools and questionnaires.

Results A didactic telelecture was developed based on the learning objectives using an expert consensus and pilot-tested among five participants. After the lecture, their test scores improved and they expressed positive opinions about the usefulness of telelectures. The TAPP repair telesimulation training was pilot-tested among three trainees. No technical problems occurred during training. All trainees improved their skills after the telesimulation training and agreed that the training was useful for learning the TAPP repair procedure.

Conclusions We systematically developed a telesimulation curriculum for the TAPP repair procedure and demonstrated its feasibility among learners.

Keywords Telesimulation · Surgical education · Transabdominal preperitoneal repair · Laparoscopic inguinal hernia repair · Curriculum development

Introduction

During the past few decades, simulation training has become a necessary part of surgical training [1]. However, one of the limitations regarding the access to simulation training for trainees globally was that it had to be performed at a site, where both the simulator and proctor were present. Even before the coronavirus disease 2019 (COVID-19) pandemic, few researchers have investigated the feasibility of telesimulation, whereby a trainee in a remote location could receive simulation training by an instructor in a different location using the Internet as a means to eradicate the geographical barriers involved in simulation training [2, 3]. Recently, the COVID-19 pandemic forced educators worldwide to change

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their training style from onsite to online; therefore, telesimulation is rapidly gaining attention [4, 5].

Although telesimulation training has shown promising results, it has been used mainly for the training of basic surgical skills [6, 7] instead of advanced procedures. Onsite training of surgical novices to perform laparoscopic inguinal hernia repair (LIHR), which is a common surgical procedure for surgical residents, has been accomplished using a few simulators [8, 9]. However, the feasibility of using these simulators in a remote environment and the curriculum regarding how to use them in a telesimulation environment are lacking.

A curriculum for remote education systems for LIHR training has been developed and the effects have been assessed [10–12]. However, it mainly focused on training by providing feedback based on the recorded performance in the operating room and lacked real-time skill training. Based on these findings, our hypothesis was that a remote training curriculum of LIHR to improve the knowledge and skills for novice trainees was feasible. The objective of this study was to develop a telesimulation curriculum to remotely teach the transabdominal preperitoneal (TAPP) repair procedure to trainees and performed a pilot study to explore the feasibility of such training as a first step before assessing its usefulness.

Methods

Ethical issues

This study was approved by the Institutional Review Board (IRB) of the Faculty of Medicine and Graduate School of Medicine at Hokkaido University (IRB no. 20–037). All participants of the pilot study were informed about the study objective, and written consent was obtained.

Development of the telesimulation curriculum

The curriculum was divided into didactic lectures for novices to acquire the necessary knowledge of inguinal hernia and telesimulation training to improve the skills of the trainees. These were developed separately and pilot-tested among the study participants to assess their feasibility. This telesimulation curriculum was performed using Zoom™ software (Zoom Video Communications), thereby allowing participants to share materials and communicate with an instructor online and see each other's performance in real time.

Development of didactic materials

Learning objectives for inguinal hernia in general, including epidemiology and surgical treatment, and for LIHR

were first created based on textbook information, international guidelines for groin hernia [13], and the discussions of researchers, which included members with experience of more than 500 inguinal hernia repair procedures and 30 scientific articles in the field of surgical education and inguinal hernia repair. The didactic materials were created in accordance with these learning objectives and included the content of the TAPP repair checklist [11], previously known assessment tools for LIHR, and surgical procedures. Educational slides and videos from nationally recognized inguinal hernia were collected for each of these learning objectives. Surgical videos of rare complications were collected from the presenters of such complications in national meetings after getting permission from the patient and the surgeon. The anonymity of both the patients and the institute from where such video was received was maintained in the didactic materials. Ways to avoid such complications were also discussed with the presenter and other experts and was included in the didactic materials. The didactic materials were finalized after being reviewed individually by 4 nationally recognized hernia experts who had the experience of more than 500 hernia repairs and more than 30 published articles in the field of inguinal hernia.

Cognitive tests to assess the knowledge of inguinal hernia repair

Two sets of questions, test A and test B, were developed based on the learning objectives. One was used as a pre-test and the other was used as a post-test. They were used to assess the participants' knowledge of inguinal hernia repair before and a few weeks after the didactic telelecture. Participants were given the didactic materials and were able to study them. To assess the test validity, surgeons with various experiences with hernia surgery completed both sets of tests. Surgeons with no experience with inguinal hernia repair comprised the novice group. Those with experience with fewer than 100 hernia cases comprised the intermediate group. Those with experience with more than 100 hernia cases comprised the experienced group. The differences in the scores for both sets of questions between groups were compared. The scores of test A and test B were compared to check the differences in each group. Internal consistency of both the tests were also calculated.

Development of a telesimulation system

We used previously developed LIHR simulators that improved the LIHR skills as the simulation and operating room settings [8]. An instruction video was created to show the steps involved in preparing the simulator and given to the trainees along with the simulator. For this feasibility study, the participants at different locations in the same building

were connected to the instructor using their smartphones and Zoom. The trainees were, however, required to prepare the simulator themselves after watching the video and receiving support from the researcher who guided them with verbal instructions via Zoom. The researcher was ready to physically help the trainee during the setup or training process in case the remote instructions were not enough. The simulator was connected to a monitor via a camcorder. Participants performed the TAPP repair procedure while watching the image displayed on the monitor. The smartphone camera captured an image of the simulator and relayed it to the instructor. The instructor also had the same simulator that was connected to the web camera so that the trainees could see how they performed the procedure (Fig. 1).

Trainees underwent one-on-one training via telesimulation with an instructor. All the training was done by the same instructor. Because we assessed how the novice trainees understood the TAPP repair procedures and whether they were performed properly, trainees first tried to perform TAPP repair procedures by themselves. When they had difficulties performing, they could receive feedback, step-by-step instructions, and demonstrations from the instructor to complete the TAPP repair procedure. As part of “reflective



Fig. 1 Telesimulation training setting. A camcorder was connected to a monitor and showed the transabdominal preperitoneal repair simulator. The trainee's smartphone shows an instructor's image of the procedure and allowed the trainee to communicate with the instructor via Zoom™ during training. The instructor was able to see the trainee's performance in real time

practice,” reflection was one of the important elements of the improvement of surgical skills; therefore, during the first TAPP repair procedures, they were able to reflect on their abilities after their performance [14]. Based on a study that analyzed the TAPP repair procedure performed by novice surgeons, the instructions were mainly focused on the traction of the peritoneum, layer of dissection, instrument handling, and tissue handling, because they were considered essential steps in the process of acquiring skills [15].

Pilot test of didactic materials

The didactic materials were later assessed by the trainees. The participants' baseline knowledge of inguinal hernia repair was also assessed using test A as a pre-test. They were then provided with the PowerPoint slide of the didactic material and later received one-on-one 1 h live telelecture about various aspects of the inguinal hernia and communicated interactively about the newly developed didactic materials. All the telelecture was conducted by the same instructor. The participants involved in this pilot study assessed the usefulness of the materials, the amount of information, and their understanding of various aspects of the materials by completing a questionnaire. The participants were again assessed using with test B as the post-test 1 month after the lecture.

Pilot test for telesimulation

A pilot test was conducted among a different set of trainees with no experience with the TAPP repair procedure to assess the feasibility of the TAPP repair telesimulation. After setting up the simulator, the trainees performed the procedure in the simulator receiving instructions from the instructor whenever they could not proceed. Video recording of this procedure was later assessed as a pre-test. If trainees needed a demonstration, then it was determined that they did not understand the step. For this pilot study, time limits were not set and trainees were required to finish the full procedure in the simulator with the help of instructions from the instructor via Zoom. Immediately, after the first procedure, the trainees performed a TAPP repair procedure again after the training session using the simulator without assistance from the instructor, and the performance was assessed as a post-test. Two raters blindly assessed the video recording of the training session and the post-test using two previously published assessment tools for LIHR: the Global Operative Assessment of Laparoscopic Skills–Groin Hernia (GOALS-GH) [16] and the TAPP repair checklist [11]. Items that could not be evaluated using the simulator, such as trocar insertion and bleeding, were excluded, resulting in a total score of 20 for both assessment tools. The operative time

was set as 1 h based on the time required by experienced surgeons to perform the procedure using the simulator.

During the pilot test, we estimated the delays in communication and network problems. Trainees answered a questionnaire about their self-confidence during each step of the TAPP repair procedure before and after completing the telesimulation training program and about the usefulness of the telesimulation setup. The total cost of the one training session for telesimulation was also calculated.

Statistical analysis

All data were presented as medians and interquartile ranges (IQRs). The scores of test A and test B of the groups of participants were compared using the Kruskal–Wallis test. Differences between scores within the same group were compared using the Wilcoxon signed-rank test for each test. Internal consistencies of test A and test B were calculated using Cronbach's alpha. A statistical analysis of the pre-test and post-test knowledge scores was performed using the Wilcoxon rank test. Two-tailed $p < 0.05$ was considered statistically significant for all analyses. All statistical analyses were performed using SPSS Statistics version 26 (IBM, New York, NY, USA).

Results

Development of didactic materials

Fifteen learning objectives were created based on the opinions of researchers. They comprised topics, such as epidemiology, anatomy, surgical treatment, complications, and troubleshooting of adult inguinal hernia (Table 1). Video clips and educational slides were also collected from experienced surgeons and incorporated into didactic materials to explain the procedure. The materials were finalized after a consensus was reached by four nationally recognized hernia experts.

Tests to assess the knowledge of inguinal hernia repair

We created two test sets, test A and test B, each with 15 questions based on the learning objectives. Twenty-seven participants of various experience completed both tests (Table 2). Difference between the scores of the novice, intermediate and experience groups showed statistical significance for both test A ($p = 0.004$) and test B ($p = 0.001$), and the two sets of scores of each group were comparable (Fig. 2). Internal consistencies were 0.79 for test A and 0.82 for test B.

Table 1 Learning objectives for LIHR

	No	Objectives
Epidemiology	1	Understand adult hernia morbidity
	2	Explain hernia risk factors
	3	Understand the physical findings of hernia and how to diagnose it
Anatomy	4	Understand the anatomy required for LIHR and point to the spermatic vessels, testicular arterioles, inferior abdominal wall arterioles, pubic bone, Cooper's ligament, ilio-pubic tract, and medial umbilical folds
	5	Demonstrate the site of prolapse of indirect hernia
	6	Demonstrate the site of prolapse of direct hernia and the location of the Hesselbach triangle
	7	Demonstrate the site of prolapse of obturator hernia and that of femoral hernia
	8	Demonstrate the location of and explain the myopectineal orifice (MPO)
	9	Demonstrate contraindications to tacking during LIHR and indicate the triangle of doom, the triangle of pain, and the corona mortis
Surgical treatment	10	Explain treatment methods and the indications for surgery, explain follow-up methods
	11	Explain hernia surgical options for primary inguinal hernia
	12	Describe the characteristics of open inguinal hernia surgery and laparoscopic inguinal hernia surgery
	13	Explain the surgical options for recurrent inguinal hernia
	14	Understand the mesh types and appropriate mesh sizes
Complications and troubleshooting	15	Understand intraoperative troubleshooting and explain postoperative complications

LIHR: laparoscopic inguinal hernia repair

Table 2 Participants who completed the two tests about knowledge of inguinal hernia

	Novice (N = 10)	Intermediate (N = 9)	Experienced (N = 8)
PGY	1 (1–2)	7 (6–7)	20.5 (16–31)
Total number of inguinal hernia repairs	0	50 (7–101)	760 (350–2025)
Number of LIHRs	0	40 (5–51)	560 (150–1225)
Number of open inguinal hernia repairs	0	15 (2–50)	250 (100–800)
Score of test A	5 (5–6)	10 (9–12)	12.5 (11.5–14)
Score of test B	4 (3–6.25)	11 (8–11)	11 (9.75–13)

All data are presented as median (interquartile range)

LIHR laparoscopic inguinal hernia repair, PGY postgraduate year

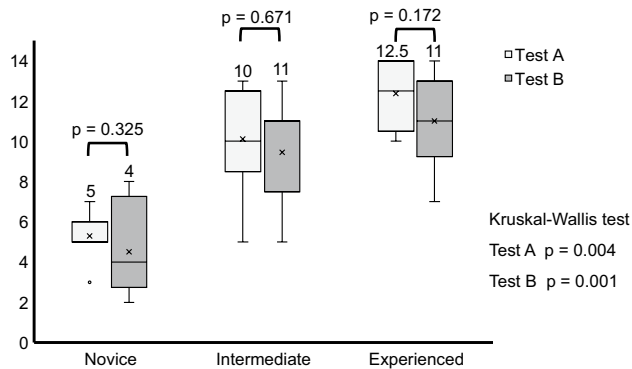


Fig. 2 Validation of two tests regarding the knowledge of inguinal hernia (total of 15 points). Surgeons with no experience with inguinal hernia repair were separated into the novice group. Those with experience with fewer than 100 cases were separated into the intermediate group. Those with experience with more than 100 cases were separated into the experienced group

Educational efficacy of didactic materials

Five novice residents with experience with fewer than one TAPP repair procedure from four institutes attended the telelecture using didactic materials. All participants thought the telelecture was easy to understand, and that the length of the telelecture session was adequate. They agreed that the didactic materials were useful for learning about adult inguinal hernia, and that telelecture with the materials needed to be added to the telesimulation curriculum. Four of the five residents improved their knowledge test scores. The median score of the participants improved from 8 (IQR, 7–9) to 11 (IQR, 9–11) ($p = 0.07$).

Feasibility of telesimulation

Three novice participants with no experience with the TAPP repair procedure were recruited for this pilot study of telesimulation training. Participants could access and use the Zoom telecommunication platform comfortably. With the help of an instruction video, they could prepare the simulator themselves without any trouble. Though the instructor was

in the same building for troubleshooting, their onsite help was not needed during the whole process. Because of communication latency, the instructor thought that the sessions should be paused when correcting the performance of the novice. However, there were no technical issues or telecommunication malfunctions. The instructor was able to easily provide verbal and visual guidance to the trainees.

Educational efficacy of telesimulation

The trainees required a median of 96 min (IQR, 88–145 min) to complete the training session. All trainees improved their performance scores of all video assessments after training (Table 3). Although there was no improvement in the confidence score of one trainee, two trainees experienced a slight improvement in the confidence scores of almost all steps of the procedure. All trainees strongly agreed that TAPP repair telesimulation training is useful for the assessment and training of the TAPP repair procedure. The total cost was 1,993 United States (US) dollars (1 US dollar was converted to 135 yen). A set of simulators cost 1,426 US dollars, but the cost of perishable items used in one training was 94 US dollars.

Discussion

During this study, we systematically developed a comprehensive telesimulation curriculum for the TAPP repair procedure that included a telelecture of didactic materials and remote skills training using a simulator. We conducted a separate pilot study and concluded that the telelecture of didactic materials and skills training using telesimulation were feasible for teaching how to perform the TAPP repair procedure and providing education about inguinal hernia. A systematic curriculum including comprehensive knowledge of inguinal hernia and skills training is expected to have better educational effects that conform with clinical practice.

During this study, we created a comprehensive TAPP repair curriculum that included not only skills training but also a lecture of didactic materials that comprised epidemiology and troubleshooting information that trainees might

Table 3 GOALS-GH and TAPP checklist scores

		Trainee 1		Trainee 2		Trainee 3	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
GOALS-GH score	Rater 1	8	15	4	7	5	14
	Rater 2	4	11	4	7	4	11
TAPP checklist score	Rater 1	6	14	1	5	3	14
	Rater 2	4	11	1	4	2	12
Self-confidence scores							
Peritoneum incision		3	4	1	2	1	1
Dissection space creation		3	4	1	2	1	1
Hernia sac reduction		3	4	1	1	1	1
Extent of dissection		3	4	1	1	1	1
Mesh deployment		3	3	2	2	1	1
Peritoneum suturing		3	3	1	1	1	1
Overall		3	4	1	2	1	1

GOALS-GH scores: minimum, 4points; maximum, 20 points

TAPP checklist scores: minimum, 0points; maximum, 20 points

The trainees' self-confidence scores are based on a scale of 1 to 5 points

GOALS-GH Global Operative Assessment of Laparoscopic Skills–Groin Hernia, *TAPP* transabdominal preperitoneal repair

not know. We systematically developed this curriculum based on the objectives of novices and assessed it using previously published skills assessment tools and newly created tests. The newly developed tests showed significant differences based on experience; therefore, they could be used to assess knowledge.

Information regarding both knowledge of inguinal hernia and how to perform surgery for inguinal hernia has become available via webinars and YouTube™; however, there have been no academic reports of a comprehensive curriculum that combines both. Previously reported curricula were focused on skills training alone [8, 10, 12]. Future studies of the effectiveness of a comprehensive curriculum for novices should be conducted among a sufficient sample size.

Simulation training has become an important part of surgical training because of the increasing demand for surgical training outside the operating room. Multiple simulators have been shown to improve surgical skills. Zendejas [9] demonstrated that the use of a hernia simulator also improved patient outcomes. During the COVID-19 pandemic, educators worldwide were forced to find methods that enabled them to continue training while remaining socially distanced and keeping the risk of infection low. Before the pandemic, telesimulation was a tool mainly used to connect trainers in the developed world to trainees in the developing world; when the pandemic occurred, however, it suddenly gained great interest [3]. Since the pandemic began, surgical educators have used telesimulation mainly to conduct patient consultations, handoff training, or simulation training of basic skills [17, 18]. Recently, the feasibility of conducting telesimulations for more specific curricula,

such as Fundamental Use of Surgical Energy™ (FUSE) and advanced laparoscopic suturing, has been demonstrated [19, 20]. Our study showed the feasibility of replicating these successes with more advanced procedures, such as the TAPP repair procedure. Although it was necessary to take some measures such as stopping trainees from performing a procedure, TAPP repair telesimulation training was conducted smoothly. The only objective of this study was to determine the feasibility of advanced telesimulation training; therefore, the trainees and the instructor were in the same building. Further research involving a larger remote scale and larger sample size is necessary.

Telesimulation training is not a fad that will disappear after the COVID-19 pandemic has subsided. Telesimulation eliminates various barriers to education. McCoy et al. [2] listed several advantages of telesimulation; for example, both the trainee and trainer can be in different locations and are not bound by geographical borders. This provides access to a larger pool of trainees and trainers. Having access to the training materials at their locations can also enable trainees to practice independently between telesimulation sessions. An effective training curriculum can reduce the workload of the faculty. Carter et al. [18] were able to perform telesimulation training with 50% of the faculty needed for in-person training. These studies demonstrated that telesimulation is a more cost-effective, more accessible, and more efficient training system than onsite training. During this study, the cost of the simulator was high, but we expect that the simulator prices will decrease as more people use them. During this study, the training was provided free of cost; however, in the future, participation fees should be required to offset costs.

The participants in our pilot study required a median of 96 min to complete the training and experienced a moderate improvement in skills. The participants in this study were laparoscopic novices who had undergone only one training session. Annabelle et al. [21] demonstrated that the surgical volume was significantly associated with the increase in resident confidence. As Kurashima et al. [8] demonstrated, competency-based simulation training and multiple simulation training, including skills assessment and feedback, are necessary for trainees to acquire skills and improve their operative confidence.

This study had limitations. First, this was a pilot study. Although we have shown the feasibility of a telesimulation curriculum for training novice participants, the efficacy of this system has not yet been tested. This was beyond the scope of the current study. This study was conducted in different rooms in the same building in Japan, where the Internet connection is relatively stable. However, its feasibility in other countries where Internet access varies remains unclear. Because the speed and connectivity of the Internet have been improving globally every year, our study allows for the possibility of connecting trainees and trainers everywhere to improve their surgical skills.

Although the pilot phase of our study showed the feasibility of the telesimulation curriculum for the TAPP repair procedure, further studies should investigate its educational impact and feasibility worldwide.

Conclusions

We systematically developed a telesimulation curriculum for the TAPP repair procedure and demonstrated its feasibility for training novices.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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