Validation of a Structured Training and Assessment Curriculum for Technical Skill Acquisition in Minimally Invasive Surgery

A Randomized Controlled Trial

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Objective: To develop and validate an ex vivo comprehensive curriculum for a basic laparoscopic procedure.

Background: Although simulators have been well validated as tools to teach technical skills, their integration into comprehensive curricula is lacking. Moreover, neither the effect of ex vivo training on learning curves in the operating room (OR), nor the effect on nontechnical proficiency has been investigated.

Methods: This randomized single-blinded prospective trial allocated 20 surgical trainees to a structured training and assessment curriculum (STAC) group or conventional residency training. The STAC consisted of case-based learning, proficiency-based virtual reality training, laparoscopic box training, and OR participation. After completion of the intervention, all participants performed 5 sequential laparoscopic cholecystectomies in the OR. The primary outcome measure was the difference in technical performance between the 2 groups during the first laparoscopic cholecystectomy. Secondary outcome measures included differences with respect to learning curves in the OR, technical proficiency of each sequential laparoscopic cholecystectomy, and nontechnical skills.

Results: Residents in the STAC group outperformed residents in the conventional group in the first ($P = 0.004$), second ($P = 0.036$), third ($P = 0.021$), and fourth ($P = 0.023$) laparoscopic cholecystectomies. The conventional group demonstrated a significant learning curve in the OR ($P = 0.015$) in contrast to the STAC group ($P = 0.032$). Residents in the STAC group also had significantly higher nontechnical skills ($P = 0.027$).

Conclusions: Participating in the STAC shifted the learning curve for a basic laparoscopic procedure from the operating room into the simulation laboratory. STAC-trained residents had superior technical proficiency in the OR and nontechnical skills compared with conventionally trained residents. (The study registration ID is NCT01560494.)

Keywords: curriculum, laparoscopy, medical education, simulation, technical skills

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The unique skill set required for performing laparoscopic surgery is well suited for training in a simulated, laboratory setting. A range of simulated models have been developed and validated for laparoscopic surgery, including laparoscopic box trainers and virtual reality simulators. Several randomized controlled trials and systematic reviews have demonstrated that the technical skills learned on these simulators transfer to the operating room.[1–6] Currently, however, the integration of these simulated models into formal residency training curricula is lagging. This may be due to the fact that acquiring and maintaining simulators requires a significant financial and time commitment.[7] In addition, although many studies examining the effectiveness of simulators are well designed, as a group they are heterogeneous with different simulators being used, with a variety of settings, and a variety of training strategies. Moreover, these studies primarily focus on the psychomotor aspect of technical skill training, even though it has been shown that cognitive training is equally as important as psychomotor training in the process of learning a surgical procedure and maintaining safe practice.[8–11] It is therefore necessary for the current focus in educational research to shift from validating simulators to developing and validating comprehensive evidence-based curricula to teach surgical procedures in their entirety.

The Fundamentals of Laparoscopic Surgery curriculum is probably the most well-described and validated comprehensive curriculum for basic laparoscopic training in the literature. This curriculum consists of both a cognitive training component to teach the essentials of basic laparoscopy, and training on a laparoscopic box trainer.[12] Using an animal model, it has been shown that skills learned on the Fundamentals of Laparoscopic Surgery system transfer to the operating room (OR), and are durable for at least 5 months.[13–15] Although there is strong evidence for the validity of the Fundamentals of Laparoscopic Surgery curriculum, it is limited to teaching basic generic laparoscopic skills. Learning surgical procedures in their entirety is more complex than learning components of laparoscopic tasks, yet few curricula have been described for entire minimally invasive surgical procedures.[16,17] The curricula that have been described have yet to demonstrate transfer to the real world of surgical operations and have as well, by in large, not incorporated the cognitive competent of skill learning.[16,17]

The purpose of this study was to develop and validate a comprehensive curriculum for a basic laparoscopic procedure (laparoscopic cholecystectomy). Specifically, this study has 2 aims: first, to assess the effect of participation in a structured comprehensive curriculum on technical performance and learning curves in the OR as compared with conventional residency training, and second, to investigate whether curricular participation can affect the development of nontechnical skills. We hypothesize that a comprehensive ex vivo training curriculum for basic laparoscopy will result in residents having improved technical performance in the OR and a shorter learning curve when compared with conventionally trained residents. We also hypothesize that a comprehensive curriculum will result in a gain of cognitive skills, as measured by a postoperative simulated crisis scenario designed to measure nontechnical proficiency.

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METHODS

Study Design

This study was a randomized single-blinded prospective trial conducted at a tertiary care academic center (Figs. 1, 2). The appropriate institutional review boards approved the study and written informed consent was obtained from all participants.

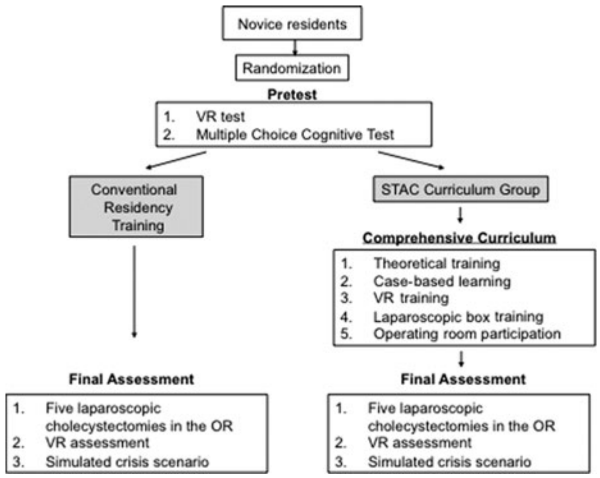

FIGURE 1. Study flow diagram.

Participants

Participants included postgraduate year 1 and postgraduate year 2 general surgery residents. All participants were required to be novice laparoscopists [completed <10 basic laparoscopic procedures (laparoscopic cholecystectomy or appendectomy) as the primary surgeon].

The residents were randomized using a closed envelope technique into 1 of 2 groups: the structured training and assessment curriculum (STAC) group (intervention group), or conventional residency training (control group).

Initial Assessment

After randomization, the operative experience, cognitive knowledge, and technical proficiency of all study participants was assessed. Operative experience was assessed using a brief questionnaire. All participants completed a multiple-choice test designed to assess their cognitive knowledge related to basic laparoscopy. Finally, all residents performed 2 tasks (clipping, and lifting and grasping on the medium level) on the LapSim virtual reality simulator (Surgical Science, Gothenburg, Sweden) to assess their baseline laparoscopic proficiency.

Intervention

Residents randomized into the intervention group completed the STAC in its entirety. This curriculum consisted of 5 components: theoretical preparation, case-based learning, proficiency-based virtual reality training, laparoscopic box training, and OR participation.

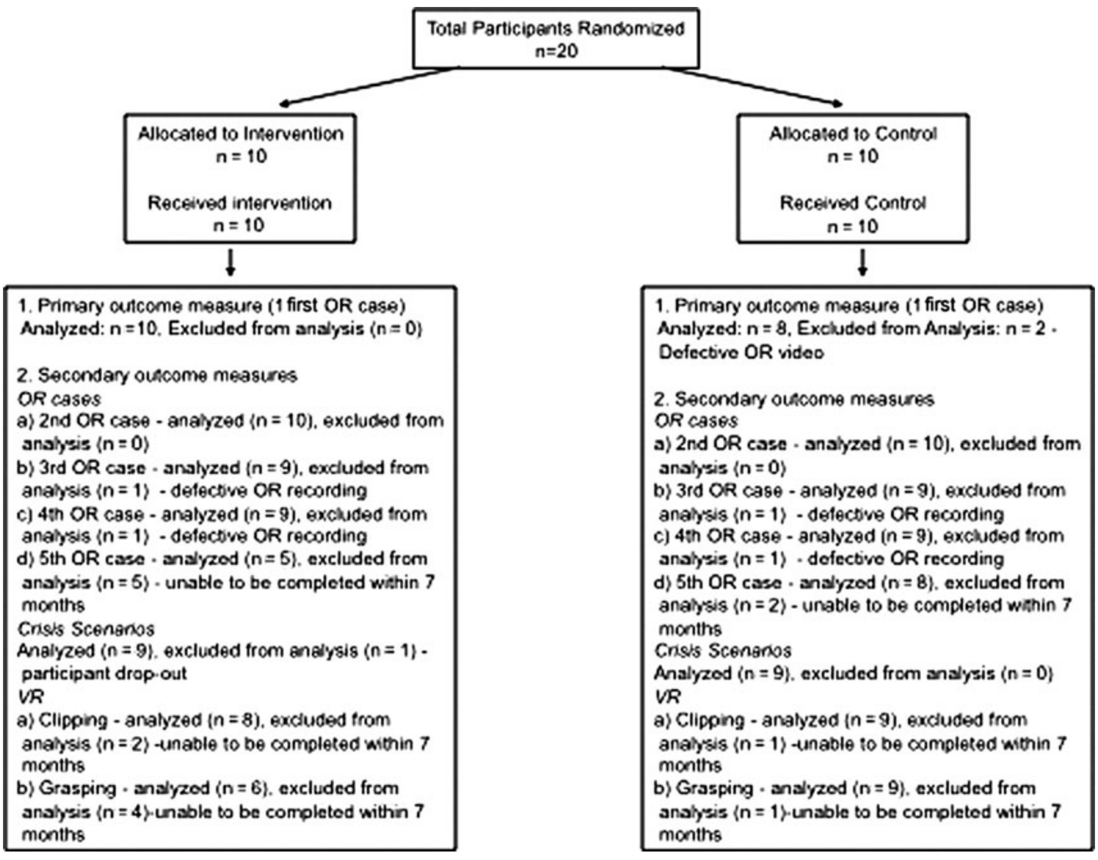

FIGURE 2. CONSORT diagram.

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Theoretical Training

During the first week after randomization, residents in the intervention group were provided with a standardized package of theoretical information relating to basic laparoscopy and laparoscopic cholecystectomy. This information was obtained from the American College of Surgery Principles and Practice Textbook and Sabiston Textbook of Surgery.[18–21] Residents were instructed to read this material.

Case-Based Learning

Residents in the intervention group participated in a 1-hour one-on-one interactive learning session with a minimally invasive surgical fellowship-trained staff surgeon. During this teaching session, a set of instructional operative videos was viewed and used as a starting point for discussion of proper operative steps/technique, relevant anatomy, possible complications, and management of possible complications.

Virtual Reality Training

All residents in the intervention group completed a longitudinal technical skills training session on the LapSim virtual reality simulator. Residents completed the following basic tasks twice on the easy level and twice on the "medium level": Camera Navigation, Instrument Handling, Coordination, Grasping, Cutting, Precision and Speed. They then completed the following tasks twice on the "medium level": Lifting and Grasping and Clip Applying. Finally, they completed the "Gallbladder Dissection" task and the "Laparoscopic Cholecystectomy" task twice on the "medium level." The levels of difficulty for each task were predetermined on the basis of the data from Aggarwal and colleagues.[22] Passing proficiency scores were previously validated.[22] Residents trained until they reached proficiency on each task. Residents adhered to a distributed practice schedule. The distributed schedule was purposeful, as there is evidence to show that a period of reflection after practice improves learning retention.[23] They practiced on the simulator for no more than an hour at a time, no more than 2 sessions per day (separated by half an hour), and a maximum of 2 sessions per week.

Laparoscopic Box Training

Residents in the intervention group performed the technical skills portion of the Fundamentals of Laparoscopic Surgery curriculum in a laparoscopic box trainer until predefined expert proficiency criteria were reached. Practice attempts were supervised by a minimally invasive surgical fellowship-trained surgeon. Residents were required to adhere to the same distributed practice schedule as described for the virtual reality portion of the curriculum.

Operating Room Participation

During the STAC, each resident in the intervention group was required to either observe or assist with a minimum of 5 laparoscopic cholecystectomies in the OR. The purpose of this was to allow the residents to become familiar with the operative technique and procedure flow for laparoscopic cholecystectomy.

Final Assessment

At the end of the curriculum-training period, the technical skills of all study participants were assessed on the virtual reality simulator and in the OR, and their nontechnical skills were assessed in a simulated crisis scenario. All participants were aware of what the final assessment parameters were at the outset of the study. All final assessment parameters were recorded within a 6-month period from the intervention.

Proficiency on the Virtual Reality Simulator

All participants completed 2 tasks on the "hard level" (Clipping, and Lifting and Grasping) twice on the virtual reality simulator.

Proficiency in the OR

Learning curves and technical proficiency in the OR were assessed. All study participants completed 5 laparoscopic cholecystectomies in the OR as the primary surgeon. These cases were video recorded through the laparoscopic camera. A member of the study team was present during each of the cases to facilitate the recording and to document any potential takeovers by the faculty member. The videos were evaluated by an individual experienced in video assessment who rated the videos using 2 previously validated tools: the modified Objective Structured Assessment of Technical Skill global rating scale and a procedure-specific rating scale for laparoscopic cholecystectomy.[4,24] The evaluators were blinded to the randomization of the study participants. The rater was provided with the takeover information from the OR. The rater was instructed to assess only the parts of the case that were performed by the study participant. A case was rated only if the study participant performed more than 50% of the case (subjective assessment of the rater).

Nontechnical Skills

All study participants participated in a simulated postoperative crisis management scenario. Residents were randomized into 1 of the 3 scenarios (postoperative sepsis, postoperative pulmonary embolism, and postoperative hemorrhage). The study participants participated in these scenarios with an actor who played the role of a nurse. The actor only responded when prompted by the participant, and would then provide test results, imaging, and other relevant information. The scenarios were video recorded and evaluated by a blinded reviewer. The evaluator rated nontechnical performance of the residents using the previously validated Ottawa Global Rating Scale for nontechnical skills.[25,26]

Outcome Measures

The primary outcome measure was the difference in the technical performance of the first laparoscopic cholecystectomy in the OR between the 2 groups. Secondary outcome measures included the difference in learning curves in the OR between the curricular-trained and conventionally trained residents, the difference in technical performance between each sequential laparoscopic cholecystectomy in the OR, the difference in performance on the virtual reality simulator, and a difference in performance in nontechnical skills.

Sample Size Calculation

A power calculation was performed to assess the number of participants required in the control and intervention groups. Previous work using Objective Structured Assessment of Technical Skill to assess technical differences between trained and untrained novices showed an effect size of 1.3.[27] For the purposes of this study, this difference in performance was deemed to be the minimum relevant difference required to differentiate between these 2 groups. Using an α of 0.05 and a power of 0.80, the minimum number of participants in each group was 9.

Statistical Analysis

Descriptive statistics were calculated. Data are reported as medians (interquartile ranges). Variables were not normally distributed (as assessed with Q-Q plots) therefore differences between the control and intervention groups on the virtual reality simulator, multiple-choice test, postoperative crisis scenarios, and laparoscopic cholecystecomies in the OR were assessed using the Mann-Whitney test.

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Difference in learning curves between the 2 groups was assessed using Friedman test. All statistical analyses were performed using SPSS Version 18.0 (SPSS Inc, Chicago, IL). $P < 0.05$ was considered statistically significant.

RESULTS

Participant Demographics and Laparoscopic Experience

Twenty residents were included in the study (16 postgraduate year 1s and 4 postgraduate year 2s; 13 males and 7 females). Most had limited laparoscopic experience. The majority (13/20) had performed no laparoscopic cases as the primary surgeon, although most (15/20) had observed at least one laparoscopic case in the OR (Table 1).

Initial Assessment

Cognitive Knowledge

The STAC group and the conventionally trained group had similar cognitive knowledge relating to basic laparoscopy at the beginning of the study as evidenced by median scores on the multiple choice test [STAC 16.5 (21–31), conventional 18.5 (16–22); $P = 0.343$].

Virtual Reality Simulator

There were no statistically significant differences between groups with respect to time, economy of motion parameters or error score on the virtual reality simulator at the outset of the study (Table 2).

TABLE 1. Demographics of Study Participants

	Conventionally Trained Group	Curriculum Group	Overall
Postgraduate year level			
Postgraduate year1	9	7	16
Postgraduate year2	1	3	4
Sex			
Male	6	7	13
Female	4	3	7
No. laparoscopic cases as the primary surgeon			
0	7	6	13
1–5	2		2
5–10	1	1	2
10–15		1	1
15–20			
20–30			
30–40		1	1
>40			
No. laparoscopic cases observed			
0	3	1	4
1–5	2	3	5
5–10	1		1
10–15		2	2
15–20	2		2
20–30	1	1	2
30–40			
>40	1	2	3

One participant in the STAC group did not complete the "No. laparoscopic cases as the primary surgeon" and "No. laparoscopic cases observed" questions.

STAC Training

All residents in the STAC group completed the theoretical training, case-based learning, laparoscopic box training, and OR participation components of the curriculum. With the exception of the Cholecystectomy task and the Lifting and Grasping task all residents trained to proficiency on all tasks on the virtual reality simulator. One resident did not complete the Lifting and Grasping task, 1 resident did not complete the first trial of the Cholecystectomy task, and 2 residents did not complete the second trial of this task. Although most tasks on the virtual reality simulator required a median of 1 or 2 attempts by the group to pass, the Lifting and Grasping task, Gallbladder Dissection task, and Laparoscopic Cholecystectomy task required a significantly higher number of practice attempts to pass (Table 3).

Final Assessment

Laparoscopic Cholecystectomy in the OR

Residents in the STAC group outperformed residents in the conventional group in the first ($P = 0.004$), second ($P = 0.036$), third ($P = 0.021$), and fourth ($P = 0.023$) laparoscopic cholecystectomy performed in the OR as measured using the modified Objective Structured Assessment of Technical Skill global rating scale (Fig. 3). There was no significant difference in score between the 2 groups of residents for the fifth procedure ($P = 0.065$). The learning curve of the STAC group, in the OR, was flat (Friedman = 0.320), that is, there was no significant improvement in scores between their first and fifth operation, whereas the conventionally trained group showed a significant learning curve in the OR (Friedman = 0.015) with a significant degree of learning occurring between the first and second laparoscopic cholecystectomy ($P = 0.005$).

Postoperative Crisis Scenario Management

Residents in the STAC group outperformed the conventionally trained residents: nontechnical skill scores [30 (28–37) vs 26 (22–30), $P = 0.027$].

TABLE 2. Preintervention Assessment on the Virtual Reality Simulator

LapSim Task	Conventional	STAC	P
Clipping—trial 1			
Median time, s	166 (99–227)	331 (97–194)	0.45
Median path length, m	2.8 (2.0–3.9)	1.9 (1.6–3.2)	0.26
Median angular path, °	517 (357–822)	458 (294–682)	0.33
Number errors	2 (1–3)	2 (0–2)	0.48
Clipping—trial 2			
Median time, s	101 (77–139)	146 (103–161)	0.12
Median path length, m	1.89 (1.50–2.24)	2.56 (1.56–3.87)	0.12
Median angular path, °	381 (246–404)	418 (238–774)	0.37
Number errors	2 (1–2)	1 (0.75–2.5)	0.80
Grasping—trial 1			
Median time, s	77 (64–81)	69 (65–75)	0.29
Median path length, m	3.5 (3.3–3.6)	3.4 (3.1–3.5)	0.54
Median angular path, °	767 (723–912)	755 (660–818)	0.36
Number errors	2 (2–3)	4.5 (2.5–6.2)	0.09
Grasping—trial 2			
Median time, s	65 (63–76)	64 (53–71)	0.56
Median path length, m	3.42 (3.19–3.75)	3.34 (2.94–4.01)	0.70
Median angular path, °	754 (708–914)	727 (649–873)	0.38
Number errors	7 (3–8)	6 (1–10.5)	0.77

Data are reported as medians (interquartile ranges).

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TABLE 3. Number of Trials to Pass the Virtual Reality Training Portion of the Curriculum

Task	Level	No. Trials to Pass Median (Interquartile Range)
Camera Navigation	Easy—trial 1	2 (1–2)
	Easy—trial 2	1 (1–1.25)
	Medium—trial 1	1 (1–1.25)
	Medium—trial 2	1 (1–1.25)
Instrument Handling	Easy—trial 1	1 (1–1)
	Easy—trial 2	1 (1–1)
	Medium—trial 1	1 (1–1)
	Medium—trial 2	1 (1–1)
Coordination	Easy—trial 1	1.5 (1–2.5)
	Easy—trial 2	1.5 (1–2.25)
	Medium—trial 1	1 (1–1)
	Medium—trial 2	1 (1–1)
Grasping	Easy—trial 1	1 (1–1)
	Easy—trial 2	1 (1–1)
	Medium—trial 1	1 (1–1)
	Medium—trial 2	1 (1–1)
Cutting	Easy—trial 1	1 (1–1.5)
	Easy—trial 2	1 (1–1)
	Medium—trial 1	1 (1–2)
	Medium—trial 2	1 (1–2.25)
Precision and Speed	Easy—trial 1	1 (1–1)
	Easy—trial 2	1 (1–1)
	Medium—trial 1	2 (1–2)
	Medium—trial 2	1 (1–1)
Lifting and Grasping	Medium—trial 1	10 (6–19.5)
	Medium—trial 2	7 (1.5–15)
Clipping	Medium—trial 1	2 (1–3.5)
	Medium—trial 2	1 (1–1)
Gallbladder Dissection	Medium—trial 1	5 (4.5–14)
	Medium—trial 2	9 (4–14)
Laparoscopic Cholecystectomy	Medium—trial 1	9 (2.5–9.5)
	Medium—trial 2	7.5 (4–8.75)

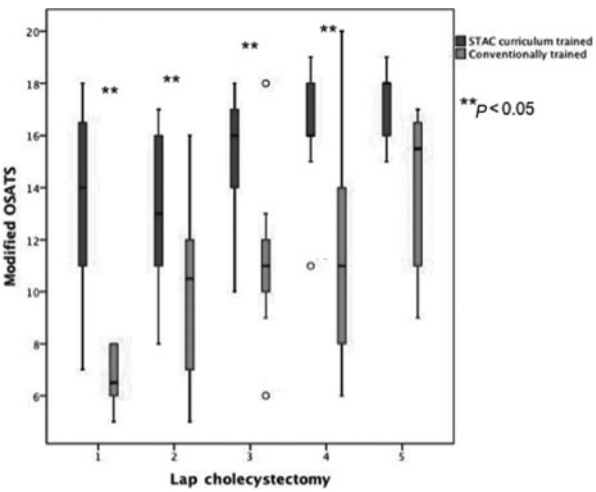

FIGURE 3. Performance of the STAC-trained residents in the OR compared with the conventionally trained residents. Horizontal bars, boxes, and whiskers represent the median, interquartile range, and range respectively.

Virtual Reality Simulator

On the clipping task, there was a significant difference between the STAC group and the conventional group with respect to error score ($P = 0.01$), but not time or economy of movement parameters. The STAC group outperformed the conventional group on the grasping task with respect to time ($P = 0.02$), path length $P < 0.01$), and angular path ($P < 0.01$), but not error score (Table 4).

DISCUSSION

This prospective randomized single-blinded controlled trial describes and assesses a comprehensive training curriculum for laparoscopic cholecystectomy. The curriculum consists of both psychomotor and cognitive training components, adheres to current standards of proficiency-based training, and was structured to be consistent with current frameworks for curricular design.[28,29] Residents who participated in the curriculum surmounted the early portion of the learning curve during ex vivo training, and outperformed conventionally trained residents in both the OR and during a simulated crisis scenario.

This study was designed to assess the effect of the curriculum on the technical performance of 5 sequential laparoscopic cholecystectomies in the OR. Although several curricula for laparoscopic skills have been described in the literature, to our knowledge, this is the first study to have investigated the effects of the curriculum on learning curves in a real clinical situation.[16,17,22,30–32] Our data show that training using this comprehensive curriculum for laparoscopic cholecystectomy effectively transitions the learning curve for this procedure outside the OR to a safe simulated environment. This finding is consistent with studies comparing simulation trained and untrained residents that have shown that the effects of training persist beyond the first case either in the OR, or on a porcine model.[33,34] We hypothesize that these findings have implications for patient safety in the OR, and provide further evidence underlining the necessity of challenging conventional methods of surgical training, leading to implementing evidence-based ex vivo curricula within surgical residency training programs. Although this study was underpowered to examine differences in adverse events in the OR, more work with a much larger sample size of participants and patients could further delineate and describe specific differences in adverse events in the OR between comprehensive curricular-trained residents and conventionally trained residents.

It is of note that the control group, as a standard of training practice at our institution, has participated in current reasonably comprehensive general surgical curriculum provided to all residents.

TABLE 4. Postintervention Assessment on the Virtual Reality Simulator

LapSim Task	Conventional	STAC	P
Clipping			
Median time, s	100 (80–100)	97 (77–100)	0.72
Median path length, m	1.70 (1.49–1.91)	2.07 (1.34–2.46)	0.37
Median angular path, °	287 (224–364)	282 (178–347)	0.42
Number errors	2 (2–3)	1 (0–2)	0.01
Grasping			
Median time, s	56 (47–65)	45 (38–54)	0.02
Median path length, m	3.33 (2.87–3.52)	2.43 (2.26–2.50)	<0.01
Median angular path, °	750 (659–779)	569 (541–605)	<0.01
Number errors	3 (1–5)	2 (1–6)	0.82

Trials 1 and 2 on the virtual reality simulator were averaged for analysis. Highlighted cells represent significant differences in performance in the curriculum-trained and conventionally trained groups. Data are reported as medians (interquartile ranges).

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This curriculum consists of weekly technical skill instruction (for the postgraduate year 1s) and weekly didactic teaching sessions (for the postgraduate year 1s and postgraduate year 2s). On the basis of the results of this study we would suggest that the STAC provides an *additional* technical and cognitive benefit to trainees, who are already receiving a baseline amount of ex vivo surgical instruction.

To our knowledge, this is the first study that has demonstrated a comprehensive ex vivo training curriculum can positively impact nontechnical skills. The cognitive training component of the STAC consisted of information relating to how to perform a laparoscopic cholecystectomy, and information relating to the management of potential intraoperative and postoperative complications. It can be therefore postulated that during the simulated crisis scenario, curricular-trained residents had a better cognitive map of how to manage the postoperative complications compared with conventionally trained residents, and were therefore able to devote more attention and energy to nontechnical competencies such as team management, communication, and situational awareness. This is supported by the theory of attention of Gallagher et al.[35] Gallagher et al[35] state that both experts and novices have finite attentional resources. What differentiates an expert from a novice, however, is the degree to which an expert has automated particular components of task execution, thus freeing more attentional resources away from the task at hand. Although in its original articulation, the theory of Gallagher et al[35] referred to the execution of a motor task, the theory could possibly be applied to this situation—the execution of a cognitive task. This finding is particularly interesting because it has been shown that nontechnical skills such as communication, and teamwork are essential in enhancing patient safety and reducing the number of errors in the OR.[36,37] This, in conjunction with the improved technical performance of the curricular-trained group in the OR, indicates that the curriculum effectively contributes to the 2 essential components of surgical expertise, technical proficiency and cognitive knowledge.

This curriculum was created in a systematic manner using the theoretical framework established by Aggarwal and colleagues.[28] This framework advocates 5 critical elements for curriculum design: task deconstruction, creation of an evaluation tool, developing a comprehensive curriculum, assessing whether the learning achieved transfers to a real environment, and establishing tools for credentialing.[28] Using the previously developed and validated procedure-specific tool for laparoscopic cholecystectomy, we ensured that our curriculum delivered all psychomotor and technical components related to performing this minimally invasive surgical procedure. Although Aggarwal et al[28] advocate creating an evaluation tool for the procedure, in this case, the modified Objective Structured Assessment of Technical Skill tool has been previously shown to be valid and reliable in the context of blinded OR assessment of laparoscopic cholecystectomy; thus, we elected not to create an evaluation tool de novo.[4] The final curriculum we developed is comprehensive in that it incorporates both psychomotor training and cognitive training. The cognitive training elements were comprehensive and included providing theoretical information, watching videos of the procedure with a staff physician, and assisting during 5 laparoscopic cholecystectomies in the OR. These elements together were designed so that trainees could develop a cognitive map of the procedure. We hypothesize that this, in combination with the psychomotor skills that they acquired during the virtual reality proficiency-based training and the laparoscopic box training, allowed the trainees to have the skills to plan and execute the operation, which was reflected by their improved performance in the OR compared with conventionally trained residents. Adhering to this theoretical framework for curricular design, we believe, resulted in the deliberate, evidence-based creation and validation of a curriculum, which in turn can facilitate its incorporation in a meaningful fashion into surgical residency programs.

A potential limitation in this study is the dropout rate. Indeed, we were unable to record 5 laparoscopic cholecystecomies for all study participants. As indicated, 8 residents in the control group and 5 residents in the intervention group had a fifth procedure recorded. This was due to logistical factors in the study rather than participant dropout. We had predetermined that we would limit case recording to 6 months after curriculum. This period of time was chosen because it has been shown that technical skills learned on a virtual reality simulator can be retained from 5 to 7 months.[15,38] The logistics of recording a total of 100 laparoscopic cholecystectomies were quite significant and in certain cases it was impossible to acquire all the case recordings within 6 months after the intervention. We believe that our inability to completely capture a fifth operation for all trainees resulted in the lack of statistically significant differences between the performances on the fifth cholecystectomy between the 2 groups. Future research involving multiple centers with a larger pool of potential study participants and OR cases could further clarify the duration of the difference in technical proficiency between the curricular-trained group and the conventionally trained group.

This randomized controlled study has the potential to significantly alter our current methods of training surgical residents and has significant implications for patient safety and team dynamics in the OR. Ultimately, we plan on implementing curricula such as the STAC and other systematic evidence-based curricula developed by our group for other surgical procedures as part of the mandatory educational component of the residency training program at our institution. Future directions for research include investigating whether the nontechnical skills gained by the curricular-trained residents persist in a real clinical environment. In addition, further investigations pertaining to the cost effectiveness of this ex vivo training program, and the time investment required for participation, would further substantiate the implementation of this type of curriculum into surgical residency training programs.

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