

Use of Collapsible Box Trainer as a Module for Resident Education

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ABSTRACT

Background and Objectives: We sought to determine whether training with a simple collapsible mobile box trainer leads to improved performance of fundamental laparoscopic skills (FLSs) during a 6-month interval versus validated laparoscopic box trainers and virtual-reality trainers, only accessible at a simulation training center.

Methods: With institutional review board approval, 20 first- and second-year general surgery residents were randomized to scheduled training sessions in a surgical simulation laboratory or training in the use of a portable, collapsible Train Anywhere Skill Kit (TASKit) (Ethicon Endo-Surgery Cincinnati, OH, USA) trainer. Training was geared toward the FLS set for a skill assessment examination at a 6-month interval.

Results: The residents who trained with the TASKit performed the peg-transfer, pattern-cut exercise, Endoloop, and intracorporeal knot-tying FLS tasks statistically more efficiently during their 6-month assessment versus their initial evaluation as compared with the group randomized to the simulation laboratory training.

Conclusions: Using a simple collapsible mobile box trainer such as the TASKit can be a cost-effective method of training and preparing residents for FLS tasks considering the current cost associated with virtual and high-definition surgical trainers. This mode of surgical training allows residents to practice in their own time by removing barriers associated with simulation centers.

Key Words: Laparoscopic, Collapsible laparoscopic box trainer, Surgery, Surgical simulation.

INTRODUCTION

With the 80-hour resident work week, it is important to realize that work-hour restrictions limit resident availability for educational endeavors. In fact, some authors have pointed out that the current time constraints may jeopardize the quality of resident training if attention is not redirected from service to education.¹⁻³ Therefore use of surgical skills laboratories on a routine basis has enabled residents to maximize their efficiency and ensure competency in the operating environment.⁴⁻⁶ This method of surgical training has resulted from our current system being challenged by legal and ethical concerns for patient safety, operating room time costs, surgical complications, and work-hour restrictions yet offers the surgical trainee an opportunity to acquire and practice advanced skills in a nonthreatening environment outside of the operating room.

As expected, along with the exponential growth of minimally invasive surgery, a number of laparoscopic surgical simulators have been developed and commercialized to improve surgical performance by surgical trainees of all levels.⁷⁻¹⁰ These virtual-reality surgical simulators were conceived from earlier experiences of inanimate training and aviation simulators. The notion is to create a “realistic” operating environment that offers unlimited laparoscopic practice without detrimental consequences when trainees make mistakes. This has completely revolutionized the surgical concept of “see one, do one, teach one” in the training of surgical residents.¹¹ Furthermore, with the development of haptic virtual simulators based on the science of sensing through touch, these new simulators have provided an immersive environment for surgeons to touch, feel, and manipulate computer-generated 3-dimensional tissues and organs with tool handles used in actual operating theaters. Such simulators have enabled us to standardize the assessment of surgical skills and avert the need for cadavers and animals currently used in training but are very expensive to purchase and maintain and are frequently cost-prohibitive for residency training programs.^{6,7,12}

On the opposite spectrum, simple standardized box trainers, using laparoscopic surgical instruments and equipment, are frequently used to train surgical residents in

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acquiring fundamental laparoscopic skills (FLSs). This allows for a simple, low-cost simulated laparoscopic experience and development and practice of minimally invasive surgical skill sets. These laparoscopic box trainers focus on drills that teach fundamental technical skills by simulating maneuvers uniquely required in laparoscopic surgery, such as ambidexterity, depth perception, hand-eye coordination, controlled movement of instruments, and efficiency of movement. In addition, a well-structured curriculum incorporating simulated laparoscopic surgical training has been shown to improve laparoscopic skill acquisition, which can lead to improved performance in the operating room environment.⁶

Unfortunately, the accessibility of simulation centers to the trainees is often limited by location and work-hour restrictions. Hence we propose to determine whether training with validated laparoscopic box trainers and virtual-reality trainers, only accessible at a simulation training center, is superior to training with a simple collapsible mobile box trainer. More specifically, we aim to decipher whether a simple collapsible mobile box trainer leads to improved performance of FLSs during a 6-month interval.

METHODS

With institutional review board approval, 20 first- and second-year general surgery residents who performed <10 laparoscopic cases as the primary surgeon were equally randomized (10 residents in each arm) to scheduled training sessions at our surgical simulation laboratory or training in the use of a portable, collapsible Train Anywhere Skill Kit (TASKit) (Ethicon Endo-Surgery Cincinnati, OH, USA) trainer. Before randomization, subjects were all trained on appropriate laparoscopic camera skills, instrument handling, object positioning, dissection, ligation, suturing, and intracorporeal and extracorporeal knot tying throughout this study by an experienced laparoscopic surgeon who is a member of the research team. Training was geared toward the FLS set for the assessment examination.

All subjects had a group orientation to the surgical simulation laboratory, which was within our hospital center and housed both laparoscopic box trainers and virtual-reality trainers, as well as TASKit box trainers. The basic FLS tasks required were as follows: peg transfer, pattern cut, ligating loop, and suturing with intracorporeal and extracorporeal knot tying. Each subject performed a single, supervised practice repetition to orient him or her to the computer simulator and laparoscopic box trainer in the surgical simulation laboratory or to the TASKit trainer,

depending on his or her randomization. Subjects were required to perform a minimum of 10 supervised repetitions to ensure that the learning curve for novice surgeons reached a plateau.¹³ The residents who were randomized to receive the TASKit trainer were instructed to use this mode of training on a weekly basis at their leisure. All residents had full access to the surgical simulation laboratory, virtual-reality simulator, and laparoscopic box trainers.

Subject training occurred over a 6-month period, during which a series of FLS tasks were assessed at 0 and 6 months on an FLS-specific training box (**Table 1**). Each subject's performance was captured on DVD, and his or her performance was reviewed by an experienced laparoscopic surgeon blinded to the training status and identity of the subject. Each exercise was scored for time and number of errors. Each error (as outlined in **Table 2**) resulted in 1 penalty point, which was accumulated for each task. A cutoff time was not assigned for each task because the subjects were novice users. A penalty score was applied for errors or lack of precision, as outlined in **Table 2**. The residents were not informed of the time of testing and were blinded to the fact that they were being recorded.

All statistical analyses evaluating the efficacy of the 2 interventions were measured with 95% confidence intervals. Analysis was initiated by evaluating the distribution of all variables by use of means and standard deviations, as well as frequencies and percentages. Bivariate analysis (2-sample *t* tests with the assumption of dissimilar standard deviations) was used to evaluate the efficacy of the training intervention.

RESULTS

Our study group consisted of 13 and 7 first- and second-year surgery residents, respectively. There was little variability between the first- and second-year residents' performance during their initial FLS assessment (time 0), suggesting that both sets of residents were novice to laparoscopic techniques. Seventy percent of the residents who did not receive the TASKit trainer practiced their FLS tasks in the simulation laboratory 3 to 4 times during the study period; the remaining subjects attended the simulation laboratory twice for a similar 2- to 3-hour session. We assumed that each of the TASKit trainer recipients practiced his or her FLS tasks on a weekly basis as instructed and outlined in our study protocol. We did not require the residents to record the amount of time they spent using the TASKit.

Table 1.
FLS Tasks Performed

Task Description	
Task 1: Peg transfer	A series of 6 plastic rings are picked up in turn by a grasping forceps from a pegboard with the surgeon's left-handed grasper, transferred in space to a grasper in the right hand, and then placed around a post on the corresponding right-sided pegboard. After all of the rings are transferred from the left to right, the process is reversed, requiring transfer from the right to left hand.
Task 2: Pattern cut	A 4-inch square gauze is suspended by clips. The surgeon is required to cut a precise circular pattern from the gauze along a premarked 1-mm-wide template.
Task 3: Ligating loop	The trainee must introduce the pretied ligating loop (Endoloop) through one trocar while controlling a tubular structure (foam appendage) using a grasping forceps through the other trocar. The loop is then cinched precisely on a previously marked 1-mm line on the appendage.
Tasks 4: Intracorporeal knot tying	A 12-cm-long No. 2-0 silk suture with a curved needle is introduced through the trocar and positioned properly using the needle holders. A stitch is then placed through target points on either side of a slit in a Penrose drain, and the suture is tied using an intracorporeal (instrument) technique.
Tasks 5: Extracorporeal knot tying	A 120-cm No. 2-0 silk suture with a curved needle is introduced through the trocar and positioned properly using the needle holders. A stitch is then placed through target points on either side of a slit in a Penrose drain, and the suture is tied using an extracorporeal knot-tying technique with the aid of a knot pusher.

Table 2.
Assessed FLS Penalties

FLS Task	Penalty Assessed
Peg transfer	Any object dropped
Pattern cut	Any cuts not within the white channel between the two black circles
Ligating loop	Placement of the loop >1 mm away from the black line
Intracorporeal knot/suture	Missing the black dots by >1 mm, dropping of the needle, instruments outside field of view, or incomplete/loose knots
Extracorporeal knot/suture	Missing the black dots by >1 mm, dropping of the needle, instruments outside field of view, or incomplete/loose knots

During the 6-month assessment, the residents who were randomized to the TASKit group were more efficient in completing their FLS tasks than initially evaluated. The residents who trained with the TASKit performed the peg transfer at a much quicker pace during their 6-month assessment versus their initial evaluation (79 seconds vs 118 seconds, $P = .02$). Neither group had any statistically significant differences between subjects' penalties during their initial evaluation and those during their evaluation at 6 months when performing the peg-transfer task. There was no statistical difference between the residents who were randomized to the TASKit and those who were not with regard to their penalties when performing the peg transfer. However, there was a trend for those who were randomized to the TASKit to perform their peg-transfer task more efficiently at the time of their final evaluation than those who were randomized to practice their FLS

tasks in the simulation laboratory (79 seconds vs 97 seconds, $P = .094$) (**Table 3**).

Similarly, during the pattern-cut exercise, the residents who were randomized to the TASKit group performed this task significantly faster during their 6-month assessment versus their initial attempt (127 seconds vs 171 seconds, $P = .05$). There was also a trend for those who were randomized to the TASKit group to perform their pattern-cut exercises more efficiently (127 seconds vs 159 seconds, $P = .096$). In addition, neither group had any statistically significant differences between their penalties during their initial evaluation and their evaluation at 6 months when performing the pattern-cut task. Lastly, there was no statistical difference between the residents who were randomized to the TASKit arm and those who were not with regard to their penalties when performing the pattern cut (**Table 3**).

Table 3.
Pre- and Post-FLS Training Times and Penalties

	0 mo	6 mo	P Value
Peg-transfer FLS task			
TASKit		n = 10	
Mean time (s)	117.8	78.5	.021
Mean penalties	1.7	1.1	.26
Simulation laboratory			
		n = 10	
Mean time (s)	113.7	96.9	.21
Mean penalties	1	1.7	.19
Pattern-cut FLS task			
TASKit		n = 10	
Mean time (s)	170.7	127.1	.05
Mean penalties	5.2	5.9	.13
Simulation laboratory			
		n = 10	
Mean time (s)	182.2	159.3	.19
Mean penalties	4.7	4.6	.45
Endoloop FLS task			
TASKit		n = 10	
Mean time (s)	91.6	68.4	.015
Mean penalties	0.4	0.3	.33
Simulation laboratory			
		n = 10	
Mean time (s)	74.2	82.2	.28
Mean penalties	0.2	0.3	.29
Extracorporeal knot-tying FLS task			
TASKit		n = 10	
Mean time (s)	236.7	187.1	.20
Mean penalties	2.1	1.7	.23
Simulation laboratory			
		n = 10	
Mean time (s)	178	185.9	.35
Mean penalties	1.7	1.4	.32
Intracorporeal knot-tying FLS task			
TASKit		n = 10	
Mean time (s)	286	213	.049
Mean penalties	4.4	4.4	>.99
Simulation laboratory			
		n = 10	
Mean time (s)	286	287	.97
Mean penalties	3.3	4.1	.30

The group that was randomized to the TASKit training also performed significantly more efficiently with the Endoloop FLS task (68 seconds vs 92 seconds, $P = .015$) and intracorporeal knot tying (213 seconds vs 286 seconds,

$P = .049$) at 6 months when compared with their initial evaluation. There were no statistical differences between the 2 groups with regard to their extracorporeal knot-tying ability. There was a trend for those who were randomized to the TASKit group to perform their intracorporeal knot-tying task more efficiently at the time of their final evaluation than those who were randomized to practice their FLS tasks in the simulation laboratory (213 seconds vs 287 seconds, $P = .05$) (Table 3).

DISCUSSION

The Fundamentals of Laparoscopic Surgery program was developed by members of the Society of American Gastrointestinal and Endoscopic Surgeons as an educational curriculum to represent the fundamental cognitive knowledge and technical skills unique to laparoscopic surgery. These fundamental skill sets cross multiple surgical specialties and are independent of any specific laparoscopic procedure. The ability to use FLSs to assess laparoscopic psychomotor skills has been demonstrated and has led to an FLS certification program that is now required by the American Board of Surgery for residents finishing their general surgery training.

Along with the resident work-hour restrictions and other social/financial constraints that challenge surgical educators, many surgical training programs are looking at new options for providing surgical trainees the opportunity to acquire and practice laparoscopic skills outside of the operating theater. Many studies have validated various laparoscopic simulators, but only one has recently evaluated the effectiveness of home laparoscopic training.¹⁴ Hence we evaluated the use of a simple collapsible mobile box trainer that can be accessed easily without having to travel to a surgical training laboratory as a platform geared toward FLS assessment.

During the study period, we showed that the use of the TASKit as a method for training residents improves their performance of FLSs over a short period. This is likely because of the readily available access and ability to use the mobile laparoscopic trainer with ease and minimal effort. Although we did not require our study participants to record the amount and length of time the TASKit trainer was used, we believe that, on the basis of their performance at 6 months compared with their initial assessment, their exposure and FLS preparation were greater than those in subjects who were not provided the TASKit. In addition, we did not ascertain whether the subjects randomized to the TASKit group had any technical issues with the video imaging or the instruments provided with

the TASKit, and only one rater provided scores to all participants. We appreciate that this noninferiority pilot study might be underpowered because of our sample size but believe that it provides a platform to build on as we find and validate new options for providing surgical residents the opportunity to acquire and practice surgical skill sets outside of the operating room environment. Perhaps a multi-institutional study using this mode of training may help decipher whether this can be a readily available surgical training tool.

Regardless of the modality used to train surgical residents, we strongly affirm that a well-structured curriculum will also improve the residents' FLS performance. Unfortunately, we did not require our study participants to attend the simulation laboratory on a routine basis but rather "encouraged" the surgical trainees to visit the simulation laboratory at their will. Perhaps the difference in the TASKit trainer users would not be so pronounced as compared with the subjects who were randomized to the simulation laboratory arm if the former group was enrolled in a weekly practice session.

Using a simple collapsible mobile box trainer such as the TASKit can be a cost-effective method of training and preparing residents for the FLS tasks considering the current cost of virtual and high-definition surgical trainers. Hence we strongly believe that this mode of surgical training allows residents to practice in their own time by removing barriers associated with simulation centers. We further anticipate that the residents who were randomized to the TASKit training will outperform those who were not during their official FLS testing session.

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