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The effect of practice on performance in a laparoscopic simulator

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Abstract

Background: Laparoscopic skill was measured objectively in a simulator. Seven tasks were scored in terms of precision and speed. These tasks included transferring, cutting, clip+divide, placement of a ligating loop, mesh placement+fixation, and suturing with intracorporeal and extracorporeal knot.

Methods: After baseline evaluation, 12 surgical residents were randomized to either five weekly practice sessions (Group A) or no practice (Group B). Each group was then retested. Performance scores were compared for baseline versus final test, and improvement (baseline to final) for Group A versus Group B. Group A residents had a total of seven repetitions of each task (baseline, five practices, final). Linear regression analysis was used to test for the correlation between score and repetition number.

Results: Group A showed significant improvement in their scores (baseline to final) for each task and for the total score (sum of all tasks) ($p < 0.05$). Group B showed significant improvement in four of seven tasks and for the total score. The magnitude of improvement of Group A versus Group B residents was significantly greater for four of seven tasks (peg transfer, placement of ligating loop, and both suturing skills) and for the total score. The final total score for Group A was 219 ± 14% of baseline ($p < 0.0001$), whereas Group B was only 162 ± 35% of baseline ($p = 0.07$) and not statistically significant. For Group A residents, there was a highly significant correlation between trial number and performance score ($p < 0.05$) for each individual task and for the total score.

Conclusions: Laparoscopic skill can be measured objectively in a simulator, and performance improves progressively with practice. These skills can be incorporated into the training and evaluation of residents in laparoscopic surgery.

Key words: Laparoscopy — Laparoscopic training — Simulation — Education

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Laparoscopic surgery requires ambidexterity, eye-hand coordination, and depth perception. In addition, the surgeon must learn how to operate using new instruments. Many methods have been proposed for training and credentialing. An opportunity for training in laparoscopy outside the operating room would allow the trainee to acquire these skills in an inexpensive and relaxed environment. Structured teaching permits a thorough understanding of the principles of surgery and lays a foundation for the development of more difficult operative tasks [3].

The MISTELS program (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills) has been used previously to evaluate residents across all years of training, laparoscopic surgeons, and nonlaparoscopic surgeons [1]. The aim was to standardize the teaching and evaluation of basic laparoscopic skills. The tasks performed in the simulator were scored objectively. A significant correlation was demonstrated between level of training and performance for most exercises.

The purpose of the present study was to evaluate the effect of structured practice of basic laparoscopic skills in a laparoscopic simulator and to compare the performance of mid-level residents who had weekly practice sessions to those who had no practice.

Materials and methods

The effect of practice on performance of laparoscopic tasks was evaluated in 12 general surgery residents at the PGY3 level. These 12 residents in their research year had no significant clinical exposure during the study period. After baseline laparoscopic skill evaluation in a simulator, the 12 surgical residents were randomized to one of two groups. Group A had five weekly practice sessions; Group B had no practice sessions. All residents were then retested 7 weeks later. The baseline session, practice sessions, and final session each involved performance of seven laparoscopic tasks, which were measured objectively in a simulator. Each of the seven tasks was evaluated for both precision and speed.

The seven standardized exericses that were used ranged from basic to more advanced laparoscopic skills. Some of the exercises were designed to develop laparoscopic coordination skills, some emphasized the use of certain laparoscopic instruments, and some involved particular laparoscopic techniques. These exericses have been described in detail previously [1].

The simulator consists of a laparoscopic trainer box measuring 40 × 30 × 19.5 cm (USSC Laptrainer, United States Surgical Corporation, Norwalk, CT, USA) covered by an opaque membrane. Two 12-mm trocars

(USSC Surgiport, United States Surgical Corporation) were placed according to standard protocol through the membrane at convenient working angles on either side of the 10-mm zero-degree laparoscope (USSC Surgiview, United States Surgical Corporation). Four alligator clips within the simulator were used to suspend materials for certain exercises. The laparoscope and camera (Storz endoscope; telecam) were mounted on a stand at a fixed focal length. This enabled the examinee to work independently. The optical system consists of the laparoscope, camera, light source, and video monitor (Sony Trinitron 19 in). The video monitor was placed in line with the operator.

Performance of each task was scored for both precision of performance and speed. For each exercise a timing score was calculated by subtracting the time to complete the exercise from a preset cutoff time (timing score = cutoff time (sec)—time to complete the exercise (sec)). This system rewards faster performance with higher scores. If the time to complete the exercise surpassed the preset cutoff time, a timing score of 0 (zero) was given, because no negative values were assigned. Precision of performance was also scored objectively by calculating a penalty score for each exercise. Finally, a score was calculated for each exercise by subtracting the penalty from the timing score (score = timing score—penalty score). Thus, the more accurately and quicker a task was completed, the higher the score.

A 20-min introductory video demonstrating proper performance of all exercises was shown to each candidate prior to testing. The tasks were as follows:

Task 1: Pegboard patterns

The operator was required to lift each of six pegs from a pegboard with the left hand, transfer it to the right hand, and place it on another pegboard. This procedure was then reversed. The cutoff time was 300 sec. A penalty was calculated as the percentage of pegs that could not be transferred as a result of being dropped outside the field of view.

Task 2: Pattern cutting

This task required a 4-cm diameter premarked circular pattern to be cut out of a 10 × 10 cm piece of gauze suspended between alligator clips. The examinee used a grasper in one hand and placed the material under tension while cutting with endoscopic scissors that were held in the other hand. The cutoff time was 300 sec. A penalty was determined by calculating the percentage area of deviation from a perfect circle.

Task 3: Clip application

This task involved placing two hemostatic clips on a tubular foam structure at premarked positions 3 cm apart, then cutting on a mark halfway between the clips. Cutoff time was 120 sec. The penalty score was calculated by measuring in millimeters the deviation of the clip or cut from the predrawn lines. A penalty score of 50 points was given for any clip not placed securely or completely across the tube.

Task 4: Placement of ligating loop

This task involved the accurate placement and tightening of a commercially available pretied slip knot (USSC Surgitie, United States Surgical Corporation) on a foam tubular appendage. The procedure involved backloading the ligating loop into a reducer, stabilizing the appendage, accurately and securely seating the knot, and cutting the excess suture. Cutoff time was 180 sec. The penalty score was calculated by measuring the distance in millimeters of the loop away from the premarked position. A 50-point penalty was given for any insecure or failed knot.

Task 5: Mesh placement over a defect

This task required a 5-cm diameter mesh to be placed over a previously created 4-cm circular defect in a foam model, then secured with staples. An allowance of four staples was used to secure the mesh. Cutoff time was 420 sec. A penalty score of 25 points was given for each insecure staple, and 10 points were given for each extra staple used, to a maximum of six. If the mesh was misplaced, thus leaving an area of defect, the percentage of defect was calculated and added to the penalty score.

Tasks 6 and 7: Intracorporeal and extracorporeal knots

A simple suture was placed through premarked points in a longitudinally slit Penrose drain. The suture was then tied using either an intracorporeal knot (task 6) or an extracorporeal knot with the aid of a knot pusher (task 7). Cutoff time was 600 sec for the intracorporeal knot and 420 sec for the extracorporeal knot. A penalty score was calculated to reflect the accuracy and security of the suture. The penalty score was based on the total distance in millimeters of deviation from the premarked points that the suture was placed and the gap in millimeters if the suture failed to approximate the slit. Additional penalty points were given based on the security of the knot (0 points for a secure knot, 10 for a slipping knot, and 20 for a knot that came apart).

Statistics

Baseline to final test scores were compared for each exercise by paired t-test for Group A and Group B. Student's t-test was used to compare the difference between baseline and final performance scores of Group A to Group B. $p < 0.05$ was considered significant. Linear regression analysis was used to test for correlation between score and repetition number for Group A.

Results

Group A, who had weekly practice sessions, showed significant improvement for all tasks and for the total score (sum of all seven tasks). Group B showed significant improvement in four of seven tasks (tasks 1, 4, 5, and 7) and for the total score. The magnitude of improvement was significantly greater for Group A versus Group B residents for four of seven tasks (1, 4, 6, and 7) and for the total score (Table 1).

The final total score for Group A was 219 ± 14% of basleine ($p < 0.0001$), whereas Group B's score was only 162 ± 35% of baseline ($p = 0.07$) and not statistically significant.

Group A residents had a total of seven repetitions of each task (baseline, five practice sessions, final). Total performance scores improved with repetition (Fig. 1). Linear regression analysis demonstrated a highly significant correlation between score and trial number for all tasks and for the total score. (Table 2) (Fig. 2)

Discussion

Surgical technical progress in residency training is expected to improve with increased training and the repetition of certain procedures. Traditionally logbook analysis helps to identify gaps in experience and may allow the resident to make up for them [5]. Simulation training enables practice to continue outside the realm of the operating room. The airline industry, which also relies on technical performance, requires pilot trainees to undergo exhaustive drills on flight

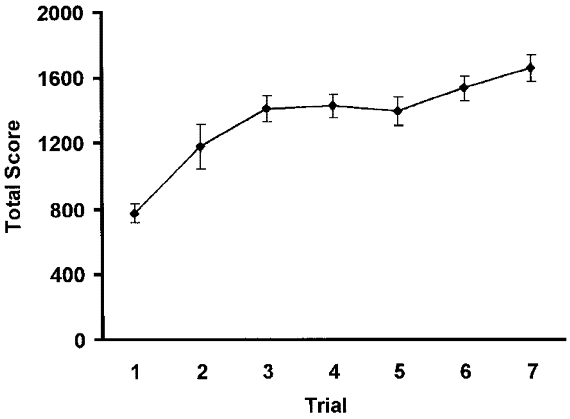

Fig. 1. Total score (mean±SEM) for trials 1–7 for Group A.

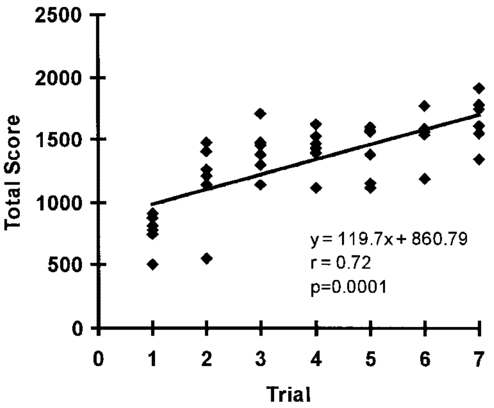

Fig. 2. Correlation of trial number with total score (sum of all scores) for Group A (correlation coefficient $r = 0.72$, $p = 0.0001$).

Table 1. Baseline and final scores (mean ± SEM) for Group A (with practice) and Group B (no practice)

Task	1	2	3	4	5	6	7	Total score
Gp A								
Baseline	146 ± 13	120 ± 29	68 ± 11	43 ± 15	121 ± 25	159 ± 29	118 ± 13	775 ± 60
Final	208 ± 7[a,b]	203 ± 20[a]	127 ± 24[a]	133 ± 7[a,b]	257 ± 31[a]	426 ± 19[a,b]	304 ± 10[a,b]	1658 ± 82[a,b]
Gp B								
Basline	161 ± 12	141 ± 33	82 ± 7	57 ± 17	126 ± 30	211 ± 49	146 ± 28	923 ± 130
Final	182 ± 14[a]	180 ± 20	100 ± 19	99 ± 8[a]	247 ± 23[a]	285 ± 58	221 ± 18[a]	1313 ± 87[a]

[a] Final score superior to baseline score within each group $p < 0.05$
[b] Improvement of Group A over Group B $p < 0.05$

Table 2. Correlation of trial number with performance scores for Group A

Task	1	2	3	4	5	6	7	Total score
r	0.59	0.43	0.51	0.61	0.43	0.65	0.61	0.72
p	0.001	0.004	0.001	0.001	0.004	0.001	0.001	0.001

simulators to perfect their skills prior to embarking on real flights [2]. One may question why the philosophy should be different for surgical trainees.

The evolution of laparoscopic surgical training has progressed from training practicing surgeons to training residents at a progressively junior level. Thus, laparoscopic training must be tailored to train junior level residents effectively and efficiently. Melvin et al. taught laparoscopic knot tying and suturing to junior residents in a laparoscopic trainer by progressing from an open box with direct vision to a laparoscopic camera [4]. Rosser et al. developed standardized drills and evaluated the performance of an intracorporeal suture before and after training with the drills, using time alone as an endpoint [7]. By contrast, in this study a variety of skills were used for training and evaluation; furthermore, the outcomes value not only speed but also precision.

A simulator enables trainees to continue their training and enhance the performance of a technique or the use of a new instrument. It allows them to practice at the convenience of their schedules. In addition, it avoids the possibility that residents will be limited to performance of a particular technique (e.g., laparoscopic suturing) by lack of opportunity in the operating room. Comprehensive curricula can be organized to include didactic sessions, simulator practice, and animal lab training. Most trainees regard these lessons as important and vital to their training when they are learning a radically new procedure [8].

The aim of this study was to evaluate the effect of repetition on the performance in a simulator of tasks that are inherent to laparoscopic procedures. The performance of these operative tasks in such a model provides a safe environment to learn and evaluate laparoscopic skills rather than isolated psychomotor skills. Because these tasks are modeled after fundamental laparoscopic procedures, they have face validity, in contrast to tasks involving isolated psychomotor skills.

It is evident by linear regression analysis that the group with weekly practice sessions showed a significant correlation between trial number and performance scores in each individual task and for the total score. By the seventh trial, there still was no plateau of performance scores for any of the tasks. We are planning further studies to determine the number of repetitions required for the scores to plateau.

When we compared the residents with practice sessions to those with none, we found that the residents who practiced showed improvement in all the tasks. The group with no practice showed improvement only in the transferring (pegboard), placement of ligating loop, mesh placement, and extracorporeal suturing tasks (tasks 1, 4, 5, and 7). These residents showed no significant improvement in tasks such as cutting, clipping, and intracorporeal suturing. A task such as intracorporeal suturing requires practice; it is a technique that most residents only acquire after persistent repetition. The magnitude of improvement of Group A compared to Group B residents was significantly greater for both suturing exercises, transferring, placement of the ligating loop, and the total score.

The goal of a training program is to enhance technical skills that will persist over the long term. These programs should aim to accelerate the learning process in the operating room, ultimately resulting in more efficient and precise performance of laparoscopic operations.

In conclusion, the effect of practice on performance varies with the complexity of the task to be performed. As surgeons, we aim to perfect our skill. Traditionally our training in technical skills has focused on apprenticeship; however, we now need to study more innovative ways of improving our skills and learning to use new instrumentation. Simulation training allows the resident to learn and practice in an environment that complements the operating room. Objective evaluation through standardized testing can provide valuable feedback and suggest the need for remedial sessions when scores fail to meet standards [6].

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