Gynecology and Minimally Invasive Therapy 5 (2016) 112–115

Contents lists available at ScienceDirect

Gynecology and Minimally Invasive Therapy

journal homepage: www.e-gmit.com

Original article

Efficacy of short-term training for acquisition of basic laparoscopic skills

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ARTICLE INFO

Article history:
Received 31 December 2014
Received in revised form
30 January 2015
Accepted 5 June 2015
Available online 26 June 2015

Keywords:
laparoscopic surgery simulator
laparoscopy training
resident teaching
surgical education
virtual reality

ABSTRACT

Objective: To determine whether our newly developed short-term training program contributes to the acquisition of basic laparoscopic surgery skills.
Design: Prospective study (Canadian Task Force Class II).
Setting: University Hospital.
Participants: Four obstetrics-gynecology residents who participated in our 2-month laparoscopic training course.
Interventions: Virtual reality laparoscopic surgery simulator-based assessment of four basic tasks: (1) "camera manipulation"; (2) "eye-hand coordination"; (3) "two-handed maneuvers"; and (4) "cutting," before and after the course.
Measurements and main results: Mean times required to perform the tasks before and after training were compared. The mean times required to perform three of the four tasks (except camera manipulation) were significantly reduced after training. Total instrument path lengths were reduced, especially for instruments used by the dominant hand.
Conclusion: Use of the virtual reality laparoscopic surgery simulator allowed us to objectively assess residents' acquisition of basic laparoscopic skills. We found that residents more readily acquired dominant-hand skills during their 2-month training. We conclude that our training system serves as an effective initial step towards the acquisition of the necessary laparoscopic surgery skills, even though residents do not actually perform surgeries during the training period.
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Introduction

Over the past 10 years, laparoscopic surgery has advanced rapidly, and indications have expanded. Because of the minimal invasiveness, reduced postoperative pain, shorter hospital stay, and improved wound cosmetics, patients tend to choose laparoscopic surgery over open surgery, and surgeons are thus required to learn the necessary skills. Laparoscopic surgery requires that the operator and assistants be adept at using long instruments under the limitation of a two-dimensional image. Acquisition of these laparoscopic skills requires particular training, and the learning curve differs from that of open surgery.[1] Thus, we have developed our own laparoscopic training program to provide initial assistance in the development of the necessary manual dexterity. The program consists of two different courses—basic and advanced. The basic course is a 2-month course designed for obstetrics-gynecology residents and aimed mainly at the management of inpatients. The advanced course is intended for more experienced surgeons, and successful completion of this course is acknowledged by the provision of a certificate of expertise in laparoscopic surgery. Approximately 100 operators and 500 assistants enroll in the advanced course annually.

During their formal training, residents may not acquire adequate skills. To address this issue, we used a virtual reality (VR) simulator to objectively assess the efficacy of our training program, which is directed towards enhancing residents' basic laparoscopic skills.

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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http://dx.doi.org/10.1016/j.gmit.2015.06.001
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Materials and methods

VR simulator

For the objective assessment of residents' basic laparoscopic skills, a LAP Mentor VR simulator (Simbionix USA Corp., Cleveland, OH, USA) was used, and residents performed four basic tasks: (1) "camera manipulation"; (2) eye-hand coordination"; (3) "two-handed maneuvers"; and (4) "cutting" (Figure 1).

Camera manipulation

For the camera manipulation task, residents were presented with a VR observation experience based on a 30° oblique camera view. The task required residents to search for a red dot displayed on the monitor, center the dot in the camera view, and then release the shutter (Figure 1A).

Eye-hand coordination

For the eye-hand coordination task, residents held an instrument with a red tip in one hand and an instrument with a blue tip in the other hand. The monitor displayed a bar with either red or blue dots at the top, and one of the dots flashed on and off. This task required residents to touch the flashing dot using the instrument tip of the corresponding color (Figure 1B).

Two-handed maneuvers

For the two-handed maneuvers task, residents held two pairs of grasping forceps, one in each hand. The monitor displayed blue jelly in which red dots appeared to be embedded. When the jelly was lifted with an instrument, the embedded red dots turned green and could be removed from the jelly with the other instrument. This task required residents to remove the green dots and place them in the designated basket (Figure 1C).

Cutting

For the cutting task, residents held grasping forceps and scissors forceps. The monitor displayed jelly, the bottom surface of which was connected to the "floor" with elastic threads. This task required residents to lift the jelly with the grasping forceps and then cut the connecting threads with the scissors forceps (Figure 1D).

Participants

Four right-handed obstetrics-gynecology residents participated in the basic training course between August 2010 and December 2011. They each had 2 years of experience in general medicine but limited experience in laparoscopic surgery. The residents' performance of each task was assessed with the use of the simulator before and after 2 months of clinical training. During the clinical training period, the residents did not practice on the simulator. Also during training, residents acted as the first or second assistant, not as the operator. The main duties of the first assistant were to pull tissues with forceps and to cut surgical sutures with scissors forceps. The second assistant was responsible for holding the camera. The residents participated in approximately 30 live procedures as the first assistant and in 40 live procedures as the second assistant during the training period.

The operators were four surgeons with > 10 years of experience in laparoscopic surgery and each of the four operators had experience in over 1000 cases.

Assessments and statistical analysis

The time required to complete each task and the instrument path lengths were assessed, both before and after the clinical training. The completion times are expressed as mean ± standard deviation. The completion times before and after training were compared, and differences were analyzed with a paired *t* test, with

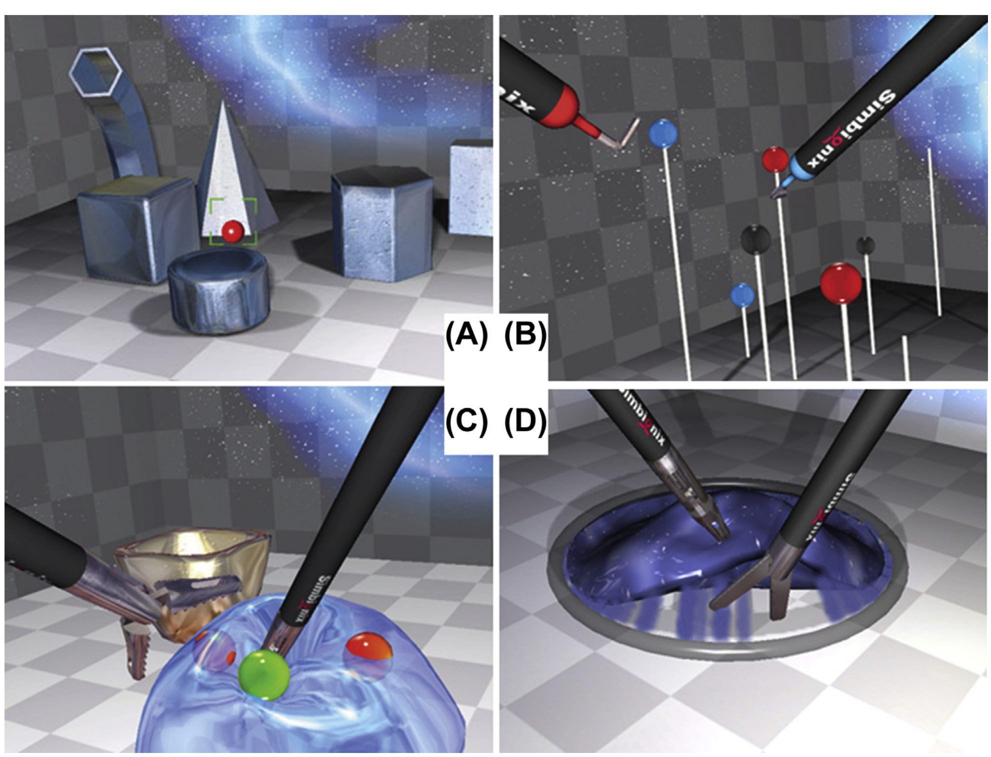

Figure 1. Screen appearance of the basic task modules. (A) Camera manipulation; (B) eye-hand coordination; (C) two-handed maneuvers; and (D) cutting.

$p < 0.05$ considered as statistically significant. Statistical analyses were performed with SPSS version 20 (IBM Software, Tokyo, Japan).

Results

The time required to perform the camera manipulation task was reduced after the clinical training, but the difference did not reach statistical significance (Figure 2A). The other tasks were accomplished significantly more quickly after the training than before the training (Figures 2B–2D).

The camera path length was slightly but not significantly increased after the training (Figure 3). In the eye-hand coordination and two-handed maneuvers tasks, the path lengths of instruments held in the right (dominant) hand were significantly reduced, but there was no significant change for instruments held in the left hand (Figures 4 and 5). For the cutting task, the instrument path lengths were reduced but not significantly so (Figure 6).

Discussion

Use of VR simulation has been reported to effectively improve laparoscopic skills,[2–4] and it has also been used for objective assessment of clinical skills.[5–8] Psychomotor performance on a VR simulator has been shown to correlate with technical skills in the operating room.[9] However, few studies have investigated the duration of clinical experience needed to improve these skills. Our study showed that even a brief, 2-month training course can improve the performance of three of the four fundamental tasks;

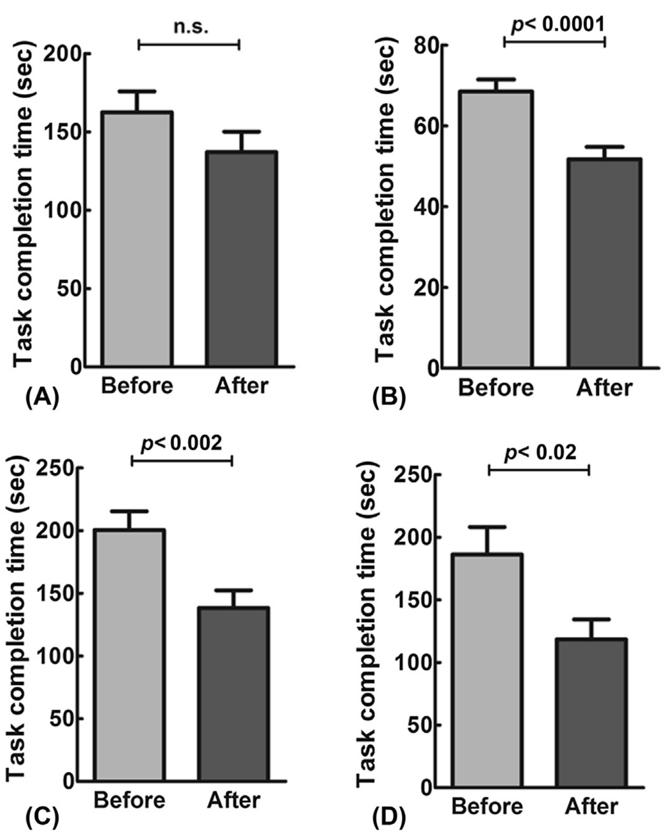

Figure 2. Time required for tasks before versus after training. (A) Camera manipulation, 162.5 ± 37.79 seconds versus 137.0 ± 37.14 seconds, $p = 0.17$; (B) eye-hand co-ordination, 68.5 ± 8.47 seconds versus 51.8 ± 8.62 seconds, $p < 0.001$; (C) two-handed maneuvers, 200.5 ± 42.14 seconds versus 138.3 ± 39.88 seconds, $p < 0.002$; and (D) cutting, 186.3 ± 62.0 seconds versus 118.5 ± 44.74 seconds, $p < 0.02$. n.s. = not significant.

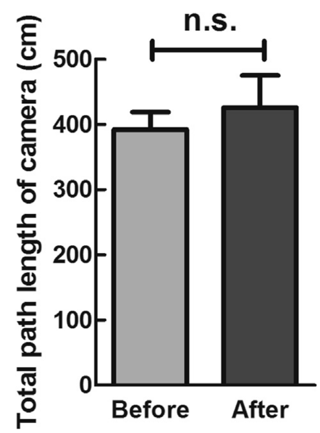

Figure 3. Total camera path length. Before versus after training: 391.9 ± 75.99 cm versus 425.5 ± 139.5 cm, $p = 0.43$. n.s. = not significant.

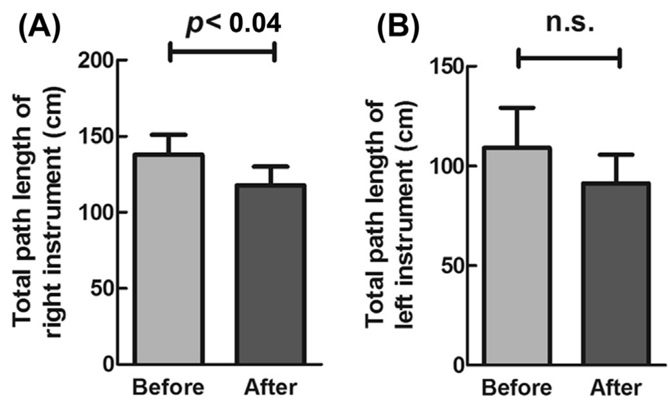

Figure 4. Total instrument path length during the eye-hand coordination task. (A) right hand, 137.8 ± 37.39 cm versus 117.7 ± 34.84 cm, $p < 0.04$; (B) left hand, 109.1 ± 56.85 cm versus 91.2 ± 40.65 cm, $p = 0.16$. n.s. = not significant.

only camera manipulation was not improved. Like us, McDougall et al[10] reported no difference in scores between medical students, residents, fellows, and experienced laparoscopic surgeons for camera manipulation simulated by the LAP Mentor. We speculate that the camera manipulation task is fairly easy, thus explaining why there is no significant difference in performance of this task between residents and laparoscopic specialists.

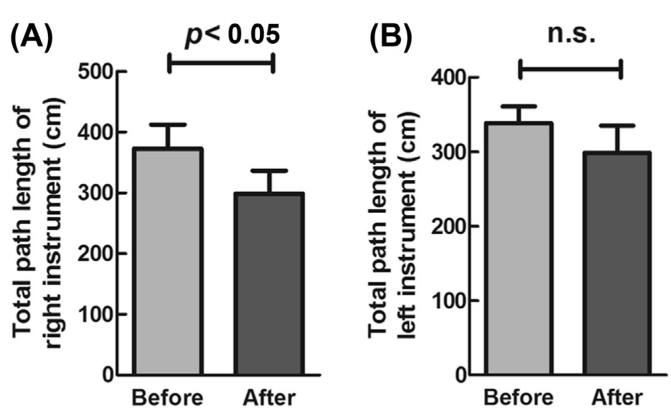

Figure 5. Total instrument path length during the two-handed maneuvers task. (A) Right hand, 372.7 ± 111.7 cm versus 298.6 ± 107.7 cm, $p < 0.05$; (B) left hand, 338.6 ± 62.62 cm versus 298.5 ± 102.6 cm, $p = 0.25$. n.s. = not significant.

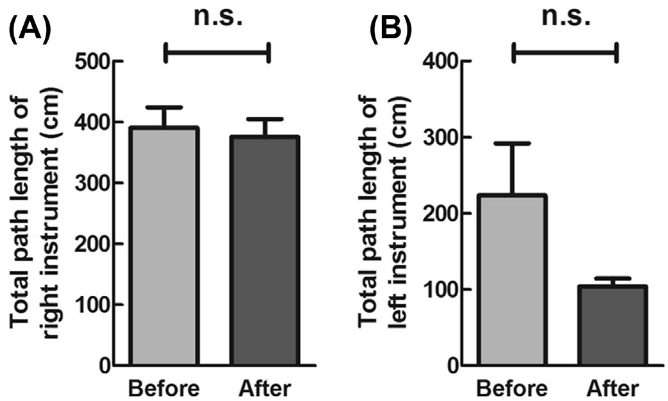

Figure 6. Total instrument path length during cutting task. (A) Right hand, 390.5 ± 94.55 cm versus 375.4 ± 82.96 cm, $p = 0.64$; (B) left hand, 223.5 ± 194.0 cm versus 104.1 ± 29.32 cm, $p = 0.13$.

Our study also showed that residents can improve their skills even without acting as the primary surgeon. Akl et al[11] showed that laparoscopic skills can be improved by watching educational videos. We contend that our training course provides similar visualization, but in live settings, leading to enhanced skills despite the fact that trainees do not act as the primary operator.

According to the instrument path lengths in the eye-hand coordination task and two-handed maneuvers task, dominant-hand skills were acquired more readily than nondominant-hand skills were acquired. This is in agreement with results of a previous study that involved 3 days of training.[6] A training period longer than 2 months might have resulted in significant improvements in the nondominant hand skills of our trainees. There is evidence that experienced surgeons, in comparison with novice surgeons, show better nondominant hand skills in the basic LAP mentor tasks.[12] Our residents completed the cutting task quicker after their training, but the total path length did not decrease, even when the dominant hand was used. This might be explained by the fact that only this task required residents to simultaneously coordinate the movements of two hands. At least 2 months of further training might be needed to improve skills that involve such coordinated activity.

In conclusion, we obtained objective evidence that a 2-month clinical training period yields significantly enhanced manual dexterity of the dominant hand as applied to laparoscopic surgery techniques. Our data confirm that short-term laparoscopic surgery training is effective as the initial step toward acquisition of the skills needed for more advanced training in laparoscopic techniques. Residents adapted to two-dimensional visualization, improved their eye-hand coordination, and became proficient in using surgical instruments even without performing procedures as an operator. Furthermore, the objective VR simulator-based confirmation of trainees' newly acquired surgical skills is likely to be the strong, positive feedback they need to increase their motivation for continued learning.

Acknowledgments

We thank the residents who voluntarily participated in this study.

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