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SURGICAL ENDOSCOPY
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Training the novice in laparoscopy

More challenge is better

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Abstract
Background: Virtual reality simulation is effective in training the novice to perform basic laparoscopic skills.
Methods: Using the Minimally Invasive Surgery Training—Virtual Reality (MIST-VR) trainer, 27 honors high school students were tested at the easy level, prospectively randomized to eight training sessions at the easy (group A, $n = 14$) or medium (group B, $n = 13$) level, then retested at the easy level.
Results: Both groups were statistically similar at baseline. All scores improved significantly (50.1% to 81.3%) over the period of training ($p < 0.05$). Although the group A scores were significantly better than the group B scores throughout training ($p < 0.05$), on final testing at the easy level, group B surpassed group A for all the tasks except TransferPlace ($p = 0.054$).
Conclusions: Virtual simulation is an effective laparoscopic training method for the novice, providing significant improvement in skill levels over a relatively short period. More challenging training seems to predict greater improvement over time and better final skill levels.

Key words: Laparoscopy — Virtual reality — MIST-VR — Surgical training

Laparoscopic training remains a challenge in surgical education. A recent survey of surgery training program directors stressed the importance of virtual reality and computer-based simulation as technological tools in surgical education [7].

It is not only important to develop technology to accomplish these goals of virtual surgical training [1, 3, 4, 10, 11, 16], but it also is imperative to structure simulation to meet the needs of the trainee [13] and to provide meaningful data for a variety of training conditions [14]. We examined the feasibility of training a group of complete novices in a defined set of simulated laparoscopic tasks using a virtual reality system.

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Materials and methods

For this study, 27 honors high school students were recruited as subjects. None of these students had any previous surgical experience. All the subjects received the same orientation to the Minimally Invasive Surgery Training—Virtual Reality (MIST-VR) system (MENTICE Medical Simulation, Gothenberg, Sweden).

The MIST-VR is a computer-based virtual reality trainer designed to simulate basic laparoscopic tasks. This system consists of a personal computer equipped with a Pentium III 750-MHz processor with 128 mb of RAM, a 19-gb hard drive, and an Nvidia TNT2 64-mb video card. The user input interface consists of the standard frame with two laparoscopic graspers and a foot pedal. The user manipulates these controls to interact with the virtual reality environment. Instrument movements are translated into actions within a cubic virtual field designed to simulate 10 cm^3 of volume [17].

Each virtual task in the MIST-VR skills set represents a surgical maneuver during laparoscopic cholecystectomy (Table 1). As each skill increases in level of difficulty (easy, medium, hard), the target sphere becomes smaller and is moved farther from the instruments while the three-dimensional box shrinks in size.

The following six laparoscopic tasks were simulated in this study: acquire place (AP), transfer place (TP), transversal (T), withdraw insert (WI), diathermy (D), and manipulative diathermy (MD). After orientation, all the students were tested on all the tasks at the easy level. The subjects then were prospectively randomized to eight training sessions at the easy (group A, $n = 14$) or the medium (group B, $n = 13$) level (Table 2). Whereas more students in group A played video games, equivalent numbers of students in both groups reported proficiency in typing or in playing a musical instrument. At the completion of training, each student underwent a single retest in each of the six tasks at the easy level.

Scores were based on speed, accuracy, and error, with lower scores signifying better results. Accuracy and error scores were calculated (by an algorithm built into the software) as equally weighted factors of instrument-to-instrument interactions and instrument-to-target interactions. The means of paired comparisons were analyzed via the Student's *t*-test, whereas comparisons of the means of multiple groups were made with analysis of variance (ANOVA). The *F*-test was used to compare sample variances. To determine statistical significance, α was set at the 0.05 level for all analyses.

Table 1. Description of the tasks in the skills set of the MIST-VR trainer and the respective related laparoscopic surgical maneuver

Task	Description	Surgical manuever
Acquire place (AP)	Acquire sphere and place it in 3D box	Grasp cholangiogram catheter and place it into opening in cystic duct
Transfer place (TP)	Acquire sphere; place it in opposite hand; and place it in 3D box	Grasp fundus of gallbladder and pass it to opposite hand for retraction
Traversal (T)	Traverse the length of a cylinder hand over hand	Proceed from the gallbladder fundus to the neck
Withdraw insert (WI)	Acquire sphere; remove and reinsert opposite instrument; and touch sphere	Maintain control of cystic duct as instruments are exchanged
Diathermy (D)	Cauterize nodes on surface of sphere	Cauterize specific bleeding points in gallbladder bed
Manipulative diathermy (MD)	Acquire sphere and hold it within 3D box; exchange other instrument for diathermy; and cauterize nodes on object	Replace dissecting instrument with cautery and control bleeding points on the gallbladder

Table 2. Demographics of the experimental groups

	Group A (easy, $n = 14$)	Group B (medium, $n = 13$)
Mean age (range)	16.89 (16–17)	16.69 (16–18)
Male *n* (%)	5 (35.7)	9 (69.2)
Female *n* (%)	9 (64.3)	4 (30.8)
Video games *n* (%)	9 (64.3)	5 (38.5)
Musical instrument *n* (%)	7 (50.0)	7 (53.8)
Typing *n* (%)	6 (42.9)	8 (61.5)

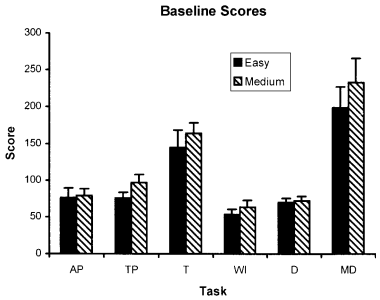

Fig. 1. Results of baseline testing (mean ± SEM) on the six tasks of the MIST-VR skills set. No significant differences exist between the two groups for all tasks.

Table 3. Results of initial and final testing as well as interval improvement for each task in the MIST-VR skills set

	Baseline		Final		Change (%)	
Task	*A*	*B*	*A*	*B*	*A*	*B*
Acquire place (AP)	75.9	78.9	20.1	15.7[a]	66.9	74.9
Transfer place (TP)	75.4	96.4	26.3	22.4	60.2	72.1[a]
Traversal (T)	144.4	163.6	34.2	27.4[a]	70.6	81.3[a]
Withdraw insert (WI)	53.2	63.3	20.9	18.0[a]	52.9	64.9
Diathermy (D)	69.8	72.2	32.5	28.7[a]	50.1	57.4
Manip diathermy (MD)	199.1	233.4	67.1	53.7[a]	57.8	71.7[a]

[a] $p < 0.05$
A, group A (interval training at the easy level); B, group B (interval training at the medium level)

Results

Initially, all the students were tested at the easy level. At this baseline, there were no statistically significant differences between the two groups (Table 3), although the students in group A seemed to do better in all the tasks (Fig. 1).

Steady progress by students in each group was observed throughout the course of training for all the tasks (Fig. 2). Scores reached a plateau after an average of four trials for group B, as compared with only two trials for group A ($\alpha = 0.05$, ANOVA), consistent with the increased difficulty in the level of training for the students in group B. For all the tasks, the variances within each group decreased significantly over the period of training ($p < 0.05$), implying that students within each group attained similar levels of proficiency.

The subjects in both groups showed marked overall improvement in their scores in all the tasks ($p < 0.05$) (Fig. 3). On final testing, the mean scores of group B were significantly better than those of group A for all the tasks ($p < 0.05$) except TP ($p = 0.054$) (Fig. 4). The students in group B also showed greater improvement from baseline to final scores than the students in group A overall ($p < 0.05$), reaching statistical significance for each task in TP, T, and MD ($p < 0.05$) (Fig. 5).

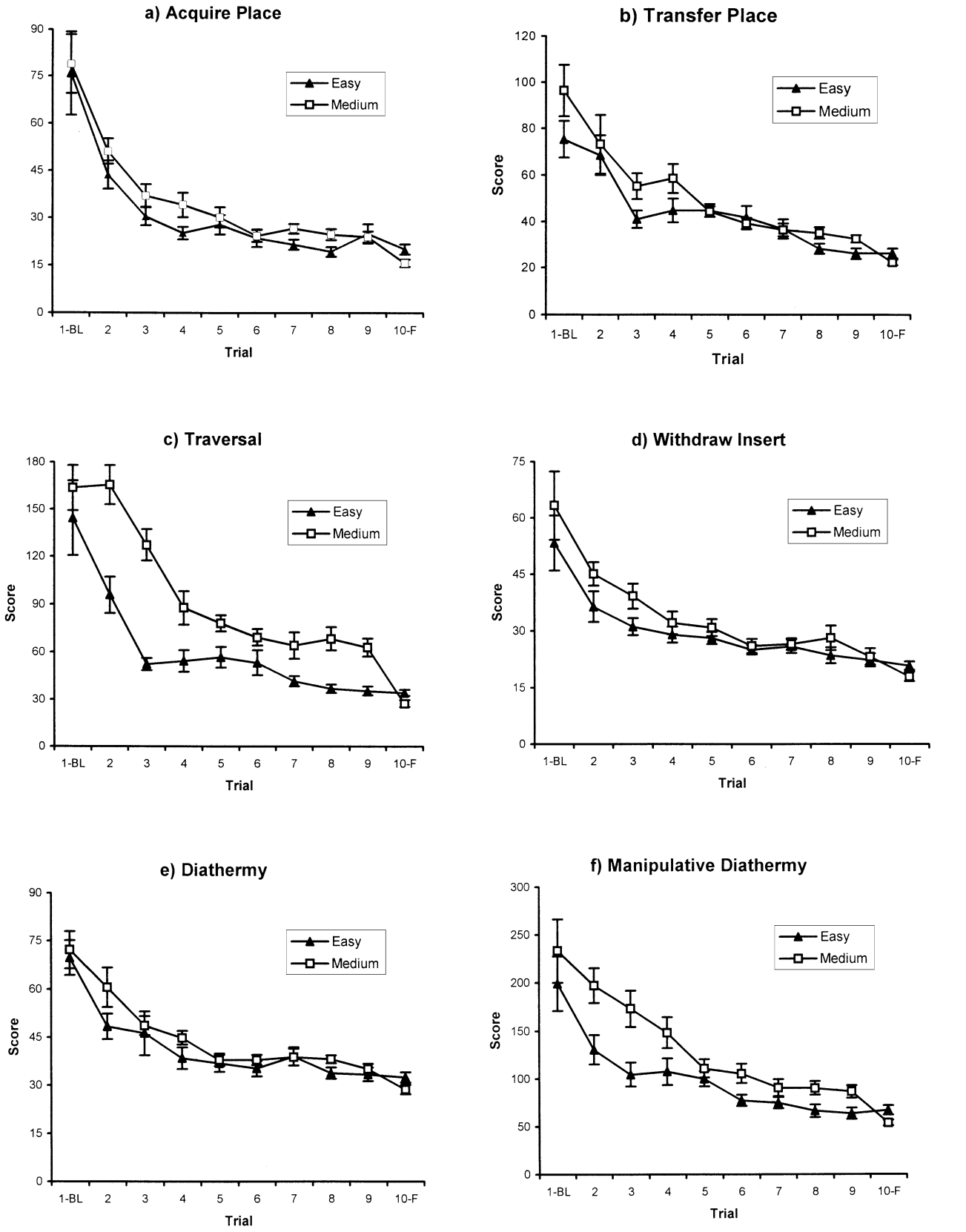

Fig. 2. Changes in scores (mean ± SEM) for each MIST-VR task over the period of training. All the scores improved steadily in all the tasks.

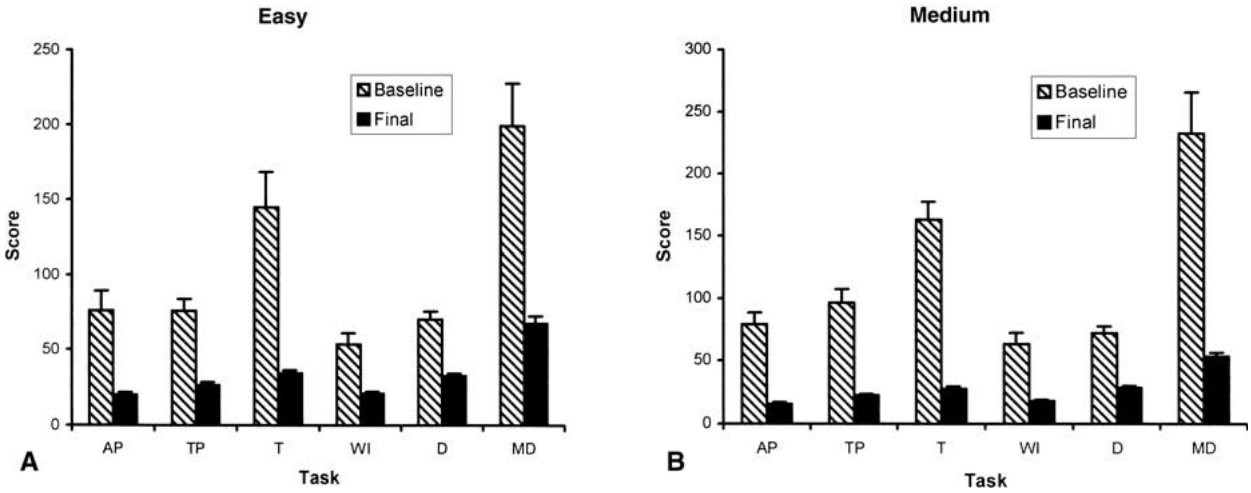

Fig. 3. Improvement in scores (mean ± SEM) for each task in the easy (**A**) and medium (**B**) groups. All the comparisons show statistically significant differences ($p < 0.05$).

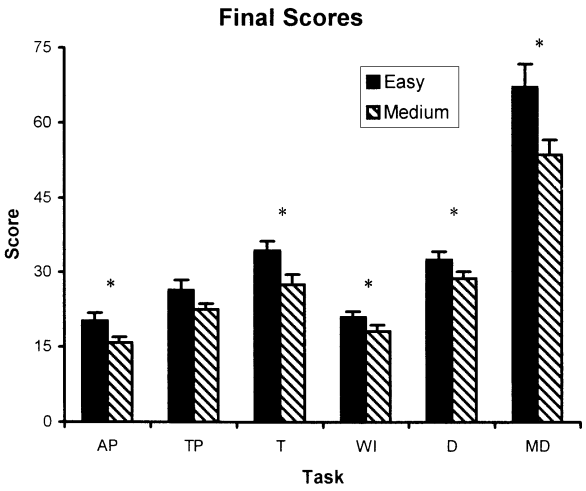

Fig. 4. Comparisons of final scores (mean ± SEM) between the two experimental groups for each task. *$p < 0.05$.

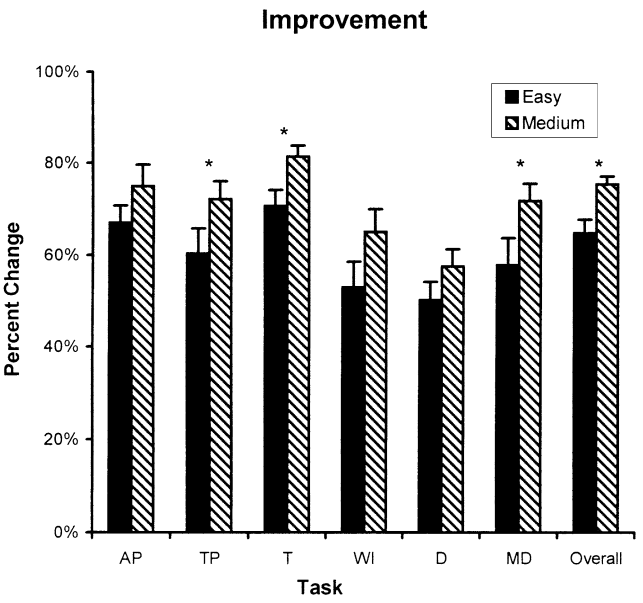

Fig. 5. Comparisons of improvement percentages (mean ± SEM) between the two experimental groups for each task and overall. *$p < 0.05$

Discussion

Virtual reality simulation plays a central role in personnel training for high-risk industries such as the military and airlines. There is a growing awareness of the potential applications of such technology to training in laparoscopic surgery [3]. These challenges have been met with enthusiastic research efforts to develop virtual environments for surgical education [10, 11].

An effective simulator must have a realistic interface that is easy to use. It should measure multiple parameters of performance and error. The simulation model should accurately reproduce the key aspects of laparoscopic skills and foster reliable and reproducible improvements in surgical proficiency with training. More advanced surgical simulators have added force feedback mechanisms to provide tactile sense [1, 12, 16]. Whereas some trainers focus on a single task such as camera operation [8], others highlight the steps of performing a specific procedure [5].

The MIST-VR trainer provides a realistic, intuitive interface that allows consistent improvement in a set of simulated basic laparoscopic skills [2]. Although there is no clear correlation between achievement in training on the MIST-VR and improvement in operative skill, some data exist to support this method of laparoscopic education. Our previous work showed that the MIST-VR is equally effective as the pelvic trainer in teaching laparoscopic knot tying [9]. Other investigators have shown experienced surgeons to be faster and more efficient than novices [15]. A program of training on the simulator resulted in improved efficiency and fewer errors [15]. Furthermore, proficiency in the manipulative diathermy task (the most advanced task, which combines many elements of the other skills) seems to correlate with improved performance in an animal model of laparoscopic cholecystectomy [6].

This study focused on a surgically naïve population. Although the subjects were motivated honors students, they had no previous surgical experience. The results clearly demonstrate that the complete novice can attain significant proficiency in basic simulated laparoscopic tasks over a relatively short course of training. Even by the second session (first training session), the scores in both groups had significantly improved for all the tasks. In fact, a plateau in the learning curves for the MIST-VR skills set required only two sessions for the easy group and four sessions for the medium group.

The final scores in both groups for all the tasks were significantly improved from baseline testing. The students who trained at the medium level showed more improvement and had better final scores than those who trained at the easy level. Within each group, the trainees attained similar final levels of proficiency in all the tasks, underscoring the reproducibility of training on the MIST-VR system.

These data suggest that virtual simulation is an effective laparoscopic training method for the complete novice, providing significant improvement in skill levels over a relatively short period. Furthermore, increasing the difficulty of training seems to predict greater improvement over time and better final skill levels.

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