Simulation Training in Laparoscopy Using a Computerized Physical Reality Simulator

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ABSTRACT

Objective: To describe a new simulator, SurgicalSIM LTS, and summarize our preliminary experience with system.

Methods: LTS was evaluated in 3 studies: (1) 124 participants from 3 Canadian universities: 13 students; 30 residents, fellows, attendings from surgery; 59 gynecologists; 22 urologists were classified based on laparoscopic experience as novice, intermediate, competent, or expert. All were tested on the LTS. Seventy-four were tested on the LTS and MISTELS (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills). Participants completed a satisfaction questionnaire. (2) Twenty-five international gynecologists in-training at Kiel Gynaecologic Endoscopy Center, and 15 students from the center pretested on LTS underwent voluntary additional trials and posttesting. (3) Seventeen experienced laparoscopic surgeons from 3 specialties were recruited to perform on randomly assigned simulators involving 5 commercial, computer-based systems. The surgeons practiced repetitively for 1.5 days. Efficient, error-free performance was measured and proficiency score formulas were developed.

Results: Study A: LTS showed a good correlation with level of experience (P=0.000) and MISTELS (0.79). Satisfaction: LTS vs MISTELS 79.9 vs 70.4 (P=0.012). Study B: Posttest scores were significantly better in all tasks for both groups, P<0.0001. Group mean scores with ≤5 trials were significantly better than with 2 or 3 trials (P<0.012, P<0.018). Study C: LTS had the highest effectiveness rating of the 5 simulators. Conclusions: A new computerized physical reality simulator can be used to assess/train laparoscopic technical skills.

Key Words: Computer-based physical reality simulator, Laparoscopy, Surgical training.

INTRODUCTION

Certain inherent abilities are required to perform laparoscopic surgery. These include the ability to operate on a 3-dimensional object from a 2-dimensional video image and to develop the psychomotor hand-eye coordination necessary for performing surgery on the projected image. Human abilities are based on inherent Basic Performance Resources (BPRs), which vary among different people. The ultimate level of excellence the individuals may achieve in playing a sport or a musical instrument or in performing laparoscopic surgery is determined by their innate ability. Training and practice help surgeons realize their full potential within the limits of their natural abilities.

BPRs defining laparoscopic abilities include simple visual hand response speed, visual information processing speed, visual spatial short-term memory capacity, and arm neuromotor channel capacity—the most common performance-limiting factor.

Enabling laparoscopic skills combine one or more basic skills to duplicate surgical procedures. Examples include cannulation, clip application, cutting, camera navigation, ligation, suturing, knot tying, and application of energy sources. A difference exists between acquiring (basically expressing) laparoscopic abilities and acquiring enabling skills. Basic skills reflect innate abilities requiring brief instructions/mentoring. On the other hand, enabling skills and tasks (especially suturing and knot tying) require detailed instructions and feedback from a mentor. Without such an arrangement, proper learning may not be possible regardless of the innate ability of the trainee.

It is becoming increasingly clear that the operating room is not the best place for training novices in laparoscopic surgery, because of the associated risk and expense. Animal and human cadavers provide excellent training opportunities; however, they are expensive, restricted, and lack objective assessment metrics. The new paradigm for laparoscopic surgery training utilizes computer-based simulators with embedded assessment metrics for objective measurement of laparoscopic skills. Following the lead of airline pilots, laparoscopic surgeons will need to...
rely on computer-based simulation systems for ongoing skill training and assessment outside the operating room.

The advantage of the new simulator system is that it combines realistic haptics-based skill exercises found in a box trainer with the objective assessment capability of virtual-reality systems.

**MATERIALS AND METHODS**

The METI SurgicalSIM LTS (www.METI.com) is a self-contained patent-pending computer-enhanced interactive laparoscopic physical reality simulator. It was previously named LTS3e and represents an updated version of the LTS2000-ISM60 where the same components were not integrated.5 The system is suitable for testing and training of basic and enabling laparoscopic skills. Sensors embedded within the

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**Figure 1.** Set Up1: Storage2; Cover opened3; Monitor unfolded4; Cover closed5; Insert instruments; simulator ready for practice.

**Figure 2.** Cover opened, monitor unfolded, sensor carousel exposed.
physical modules assess the performance of validated exercises on the basis of metrics validated at McGill University.

The new simulator consists of an enclosure that can be folded so as to be stored and transported in a compact configuration. A series of simple steps transforms the system into an active configuration (Figure 1). The enclosure houses a revolving sensor carousel (Figure 2). A folding cover covers the carousel and contains ports through which laparoscopic instruments are inserted (Figure 3). The instruments shown in Figure 4 are used to perform procedures on physical models mounted on the carousel. The physical models have embedded sensors that sense and monitor the performance of each exercise. A computer is housed at the distal end of the enclosure with an electronic display mounted on the folding arm. A digital camera captures and records video. Live video of the performance is viewed on an integrated computer monitor. Rotating the sensor carousel provides access to 10 exercises arrayed on 6 stations (Figure 5). Some of the exercises are repeated with the nondominant hand. The validated exercises assess basic laparoscopic coordination skills, cannulation, cutting and suturing skills, including one that verifies knot integrity with a disruptive force of 1 kilogram. The administrative software supports enrolling users in a database, selecting and performing exercises, viewing and printing past and present test reports, watching tutorials and shutting down. The user survey and login functions make it possible to validate individual or group improvement in performance over time and to establish benchmark criteria for skill proficiency.

Three studies were conducted to evaluate the simulator. The first study contained 124 participants from 3 Canadian universities including 13 medical students; 30 residents, fellows, attendings from surgery; 59 from gynecology; and 22 from urology who were classified into groups based on laparoscopic experience as novice, intermediate, competent, expert. All were tested on the LTS-ISM60, and 74 were tested on both the LTS and the MISTELS (McGill Inanimate System for Training and Evaluation of Laparoscopic Skills). Participants completed a satisfaction questionnaire.6 The second study involved 25 international gynecologists in-training at Kiel School of Gynaecologic Endoscopy and 15 medical students from the same center. All were pretested on the LTS3e and had voluntary additional trials followed by posttesting.7

In both studies, the performance was assessed with embedded McGill metrics: a preset maximum allowable time is established for each exercise/task. The speed score is calcu-

Figure 3. Simulator ready for practice.

Figure 4. Instruments used.
lated by subtracting completion time from maximum time. Penalty points are deducted from the speed score for committing errors or for lack of precision. The net score is the speed score minus penalty points.\(^8\) In the third study, 17 experienced laparoscopic surgeons including 7 in general surgery, 6 in gynecology, 3 in urology, and 1 unknown were recruited. The surgeons performed on randomly assigned simulator stations involving 5 commercially available, computer-based simulators: Lap Mentor, Symbionix, Cleveland, OH; Lap Sim, Surgical Science AB, Göteborg, Sweden; LTS, RealSim Systems, Albuquerque, NM; Pro MIS, Haptica, Boston, MA; and SurgicalSIM, METI, Sarasota, FL. The surgeons practiced repetitively for 1 and 1/2 days. Surgeon’s proficiency defined as efficient error-free performance was measured, and proficiency score formulas were developed for each simulator.\(^9\)

**RESULTS**

Summarized results of the first 2 studies are shown in Tables 1 and 2. In the third study, the LTS had the highest effectiveness rating of the 5 simulators.\(^9\)

**CONCLUSION**

Preliminary data indicate that a computerized physical reality simulator can be used successfully to assess/train laparoscopic technical skills with good user satisfaction.

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