

Physical Reality Simulation for Training of Laparoscopists in the 21st Century. A Multispecialty, Multi-institutional Study

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ABSTRACT

Background: Simulation is the most effective and safe way to train laparoscopic surgeons in an era of limited work hours, lack of funding, and increasing malpractice costs. However, the costs associated with the use of virtual reality simulators are significant, and although very technically sophisticated they still lack tactile feedback. We are proposing a physical reality simulator, the LTS 2000, as a reliable and effective alternative to virtual reality. This study was carried out to establish how reliably the simulator was able to differentiate between different levels of laparoscopic experience and to analyze the detection of skills improvement after simulation and clinical training.

Methods: This study was carried out, between July 2002 and August 2003, in the departments of Surgery and Obstetrics and Gynecology at 2 separate institutions. We enrolled 40 individuals in the study who had experience ranging from postgraduate year-1 to full-time faculty level. Five postgraduate year-3 residents were subsequently retested after rotating on clinical services, performing advanced laparoscopic procedures to assess whether the simulator was sensitive enough to detect improvements in laparoscopic skills at the intermediate level. Six tasks were included in the test, and they were scored for speed and precision with the McGill system. Two scores were obtained: a coordination score and a suturing score combined in a total score. Other variables analyzed were handedness, specialty, number of laparoscopic procedures performed, and hours spent on the simulator.

Results: Forty-five tests were performed. The number of subjects in each group based on level of experience was equally distributed. No difference occurred in scores between institutions, specialty, and right- or left-handed surgeons. A significant increase occurred in the coordination score and suturing score combined in the total score with increasing experience ($P<0.05$) at each level. Furthermore, the simulator was sensitive enough to detect a significant difference in all 3 scores between subjects who had practiced with the simulator before being tested ($P<0.05$). The scores of the 5 postgraduate year-3 participants doubled when tested, without reaching statistical significance due to the small sample size.

Conclusions: Our study shows that the LTS 2000 reliably and reproducibly detects different levels of laparoscopic expertise and progression of the learning curve. LTS 2000 as a model of physical reality simulation should be considered a reliable alternative to virtual reality simulation.

Key Words: Laparoscopy, Medical training, Virtual reality simulation, Physical reality simulation.

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INTRODUCTION

Training residents in general has become a difficult task associated with significant costs¹ and risks. In an era of limited resident work hours, lack of funding, and increasing malpractice costs, simulation offers the opportunity to effectively and safely train our residents in laparoscopy, without putting ourselves and, more importantly, the patients at risk.² Simulation has also been used to develop new procedures and to further laparoscopic skills of practicing surgeons.³

Unfortunately, virtual simulation is an expensive technology, and although technically sophisticated, it still lacks tactile feedback. Physical reality simulators, on the other hand, while less technically advanced, offer the opportunity to appreciate depth perception and tactile feedback at a much lower cost. A comparison between the 2 models is not practical, and a few stud-

ies^{4,5} have shown no difference in the overall effectiveness if the adequate endpoints were evaluated.

We have adopted a physical reality simulator, the Laparoscopic Training Simulator 2000 (LTS 2000)⁶ (**Figure 1**), as a reliable, inexpensive, and effective alternative to virtual reality for training of residents across specialties.

To further validate this model, this study was carried out between 2 institutions to evaluate how the simula-

tor was able to differentiate between different levels of laparoscopic experience and to detect skills improvement over time.

METHODS

Between July 2002 and August 2003, in the departments of Surgery at the University of Chicago and Obstetrics and Gynecology at the University of Chicago and University of Louisville, we enrolled and tested 40 individuals with different levels of laparoscopic experience ranging from postgraduate year (PGY)-1 to full-time faculty.

Five PGY-3 residents were subsequently retested after rotating on clinical services, performing advanced laparoscopic procedures to detect improvements in laparoscopic skills at the intermediate level.

All the laparoscopic skill tests were supervised and scored by the same individuals (AF, VP, and SK).

Six, previously described,^{7,8} standard laparoscopic skill tasks were included in the test and scored for speed and precision with the McGill scoring system.

Two separate scores were obtained and analyzed: a coordination score (TS1) and a suturing score (TS2) combined in a total score (TT). Scores were compared as means \pm standard deviation.

Other variables analyzed were handedness, specialty, number of laparoscopic procedures performed, and hours spent on the simulator.

Nonparametric analyses were performed using the Mann-Whitney *U* test corrected for ties. Means were compared using the Student *t* test. A *P* value of <0.05 was considered statistically significant. Data were analyzed by linear regression to assess the relationship of performance with level of residency training for each task.

RESULTS

Forty-five tests were performed. The 40 subjects were equally distributed based on specialty and level of experience. A preponderance of subjects in the study were right-handed (**Table 1**).

With these limitations in mind, we did not notice a significant difference or a trend in scores between institutions, specialty, and right- or left-handed surgeons.

With increasing experience, a progressive and linear increase occurred in the coordination score (TS1) (**Fig-**

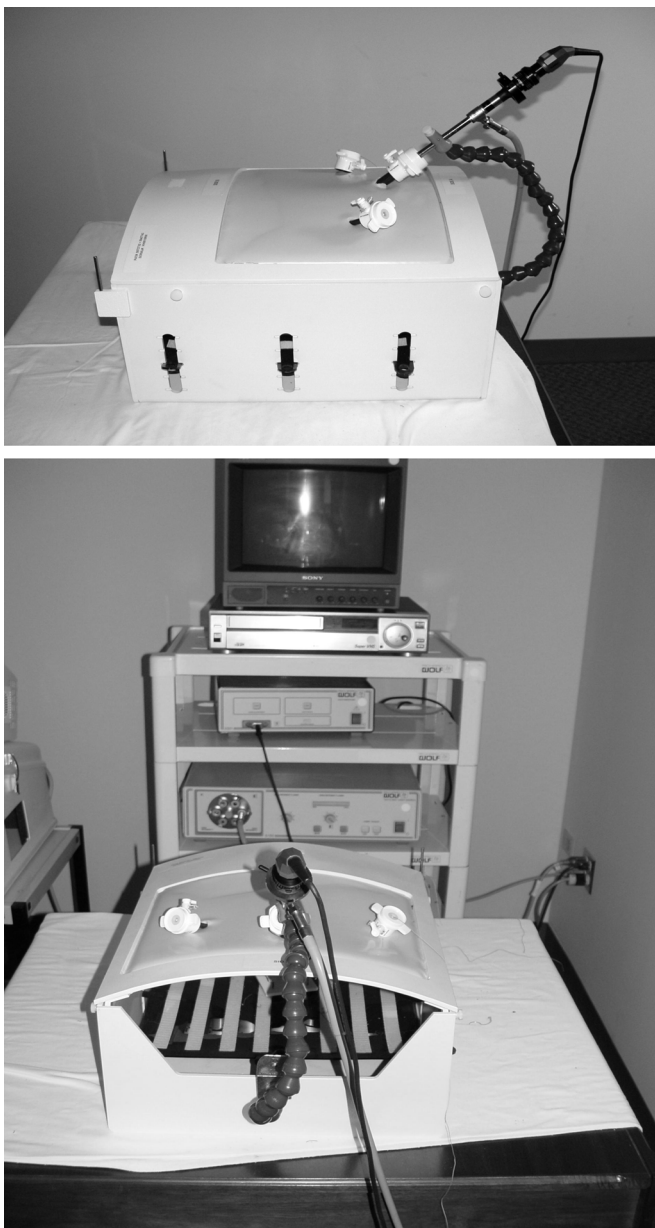


Figure 1. LTS 2000.

Table 1.
Study Participants' Characteristics (n=40)

Age (median)	31
Handedness	
Right	37
Left	3
Specialty	
Surgery	21
Ob/Gyn	19
Experience	
PGY 1	9
PGY 2	9
PGY 3	11
PGY 4	3
Faculty	8

ure 2), suturing score (TS2) (Figure 3), and total score (TT) (Figure 4).

A subgroup of individuals had the opportunity to practice and was familiar with the LTS 2000 before being tested. The simulator detected a difference in all 3 scores between this subgroup and the rest of the study population (Figure 5). However, in this group, these differences did not reach statistical significance.

In the group of 5 PGY-3 residents retested after advanced laparoscopic rotations and training, we noted an improvement in both coordination and suturing scores and therefore of the total scores (Figure 6).

Statistical significance was not reached due to the very small sample size.

Overall, the whole group of subjects felt that after being tested on the LTS 2000, they were more aware of their specific technical weaknesses and that subsequent training with the LTS 2000 improved their hand-eye coordination and depth perception.

DISCUSSION

The ideal laparoscopic simulator should be able to differentiate between different levels of experience and to detect improvement with training over time. It should also be easy to use and relatively inexpensive still offering adequate skill learning.^{9,10}

Several studies^{3,11-14} have validated virtual reality simulation for evaluation of laparoscopic skills and training of residents and practicing surgeons. This technology is quite expensive and still lacks tactile feedback. In the original models, depth perception was very limited. This limitation has been almost completely overcome by the newer models. We need to keep in mind that this is an evolving field, and in the very near future, we will be able to completely and accurately reproduce any laparoscopic procedure with virtual reality simulation. The cost of this technology remains an issue.

The only available alternative to virtual reality is physical reality simulation. By using the same instruments and cameras that we use in the operating room, several tasks can be taught and practiced, mimicking different skills needed in the operating room.⁶

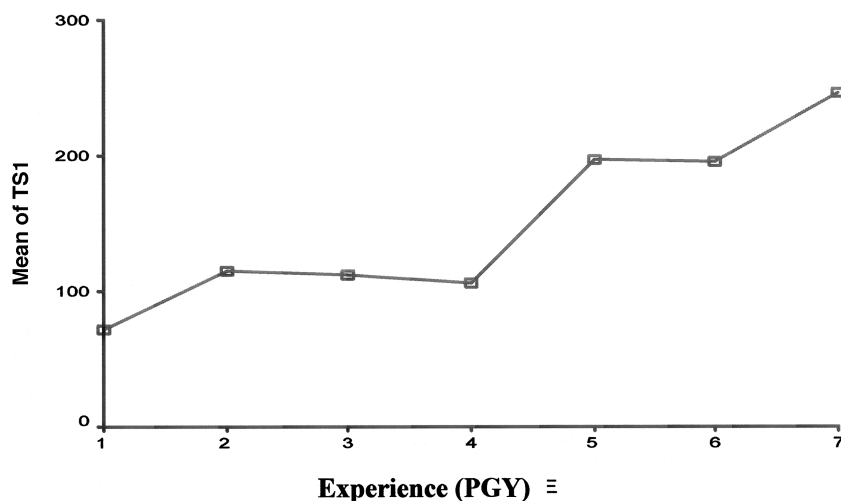


Figure 2. Coordination Scores (TS1).

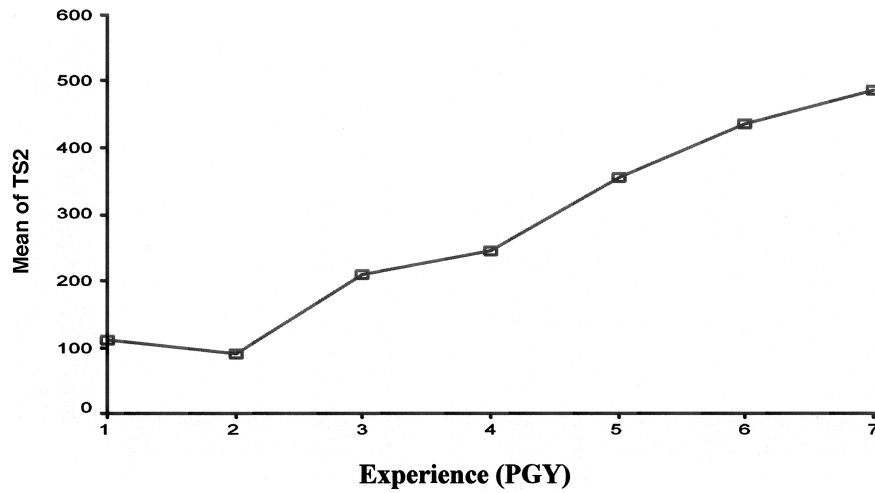


Figure 3. Suturing Scores (TS2).

The LTS 2000 has been widely used for training laparoscopic surgeons. Initial results of a study of 39 physicians showed significant improvement in laparoscopic skills after training with the simulator.¹⁵ However, the system has never been tested in a formal construct validity study. To obtain an unbiased and thorough evaluation of the LTS 2000 physical reality simulator, we included in our study 2 different specialties from 2 separate institutions, with participants at all levels of laparoscopic experience, and we used the previously validated McGill scoring system.

The LTS 2000 has reliably and reproducibly detected increasing levels of laparoscopic expertise across specialties when coordination and suturing skill were tested. Assessing laparoscopic competency has always

been inaccurate, and having a reliable tool could be particularly useful for granting laparoscopic privileges in a hospital setting, for evaluating residents' skill levels at the beginning of their training to provide more exposure for those who need it, and for grading applicants in laparoscopic courses trying to provide them with the most beneficial experience.^{9,16} The LTS 2000 has also reliably and reproducibly detected progression of the learning curve, although, due to the small sample size, we were not able to reach statistical significance. It would be indeed extremely useful to document residents' progress during training beyond just the mere number of cases and American Board of Surgery In-Training Exam (ABSITE) scores. That will allow us to graduate a competent 21st century generation of lapa-

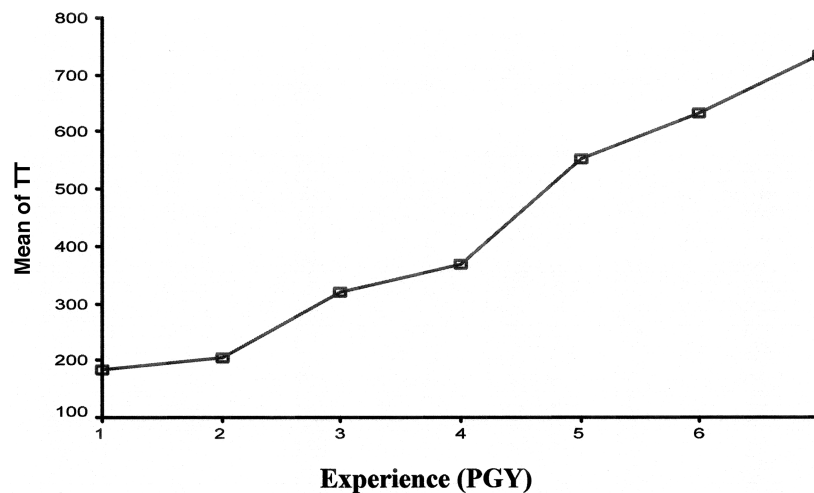


Figure 4. Total Scores (TT).

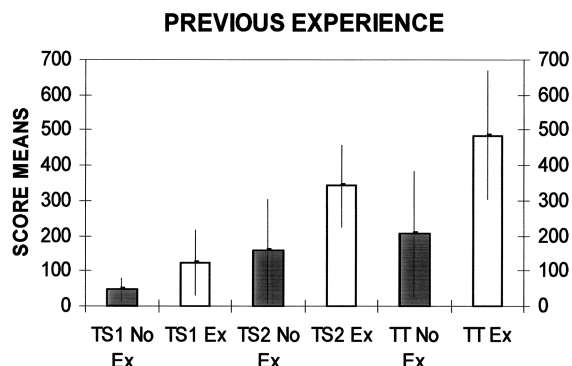


Figure 5. Coordination scores (TS1), suturing scores (TS2) and total scores (TT). No Ex=no previous exposure to the LTS 2000. Ex=previous exposure to the LTS 2000.

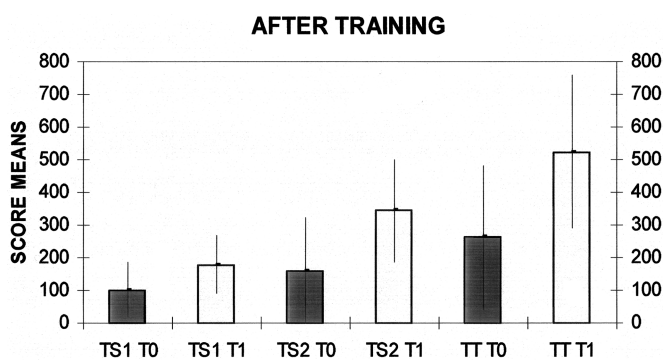


Figure 6. Coordination scores (TS1), suturing scores (TS2) and total scores (TT) before (T0) and after advanced laparoscopic training (T1).

roscopic surgeons, despite the limitations imposed by the new regulations.

CONCLUSION

In conclusion, our study shows that physical reality simulation clearly is a reliable, effective, and inexpensive alternative to virtual reality simulation, with potential implications not only in residents' evaluation and training, but also in the assessment of laparoscopic competency.

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