Effectiveness of Laparoscopic Computer Simulator Versus Usage of Box Trainer for Endoscopic Surgery Training of Novices

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OBJECTIVE: Teaching of laparoscopic skills is a challenge in surgical training programs. Because of the highly technical nature and the steep learning curve, students and residents must learn laparoscopic skills before performing them in the operating room. To improve efficiency of learning and patient safety, research in simulation is essential. Two types of simulators currently in use include virtual reality and box trainers. Our study examined which simulator technique was most effective in teaching novice trainees laparoscopic techniques.

DESIGN: This is a prospective, randomized, blinded, controlled trial that enrolled fourth-year medical students and surgical interns to participate in a supervised 6-month laparoscopic training program with either computer simulators or box trainers. Subjects were randomized and trained on appropriate laparoscopic camera skills, instrument handling, object positioning, dissection, ligation, suturing, and knot tying. Students within one group were not allowed to practice, learn or train on the opposing trainers. At time points 0, 2, and 6 months all subjects completed a series of laparoscopic exercises in a live porcine model, which were captured on DVD and scored by blinded expert investigators.

RESULTS: Scores improved overall from the pretest to subsequent tests after training with no difference between the virtual reality and box simulator groups. In the medical students specifically, there was overall improvement, and improvement in the needle-transfer and knot-tying skills specifically, with no difference between the box simulator and virtual reality groups. For the interns, both groups showed significant overall improvement with no difference between the virtual reality and box simulator groups or on individual skills.

CONCLUSIONS: We conclude that laparoscopic simulator training improves surgical skills in novice trainees. We found both the box trainers and the virtual reality simulators are equally effective means of teaching laparoscopic skills to novice learners. (J Surg 68:282-289. © 2011 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: simulators, box trainers, virtual reality, laparoscopy, training

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement, and Systems-Based Practice

INTRODUCTION

The exponential growth of minimally invasive surgery has challenged conventional systems for surgical training and establishment of competency. The longstanding dogma of "see one, do one, teach one," is being increasingly challenged by legal and ethical concerns for patient safety issues, malpractice concerns, operating room efficiency, and surgeon efficiency. Perhaps most importantly, it is inhibited by work-hour restrictions that limit resident availability for educational endeavors. The rapid explosion of minimally invasive surgical techniques being applied to more complex operations compounds this issue. Hence, a conundrum of how best to teach technical skills to residents complicates and challenges the current surgical training system.

A large body of evidence suggests that a well-structured curriculum, which incorporates simulated laparoscopic surgical training, improves performance in both the animal laboratory[1-5] and human[6-9] operating rooms. Most of these studies have evaluated surgery residents' training on commercially available laparoscopic simulators, but few have assessed subjects trained on a virtual-reality trainer compared with those trained with a traditional box trainer over a specified time period.[1,2,4,7,9,10] Hence, we propose to determine

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whether training with a laparoscopic computer simulator versus box trainers leads to improved performance of laparoscopic skills in the operating room environment during a 6-month interval, including training and assessment.

New methods of developing and teaching laparoscopic skill sets are necessary because it is becoming increasingly clear that laparoscopic surgery requires a different skill set with manipulation of surgical instruments on a 2-dimensional video screen in an actual 3-dimensional operative field.[11-15] Spatial relationships, psychomotor skills, and the development of ambidextrous skills in a small intra-abdominal space are often a difficult task for novices to perform when learning the principles of minimally invasive surgery.[16,17] With the added restrictions on work hours, teaching residents to perform these advanced laparoscopic procedures proficiently requires them essentially to master some of these techniques before their actual performance in the operating room environment. Learning these skills during medical school could also serve to plateau the learning curve during residency. This may be accomplished with the aid of surgical simulators.

Structured task repetition over several sessions instead of mass training during a single session is an important aspect of motor training that is pivotal to achieving proficient laparoscopic skill acquisition and long-term retention.[18,19] Although this principle has been embraced by many academic centers, more than half of the surgical programs with surgical simulations have mandatory resident attendance.[7,20-25] The number of schools using simulation for medical student training is even fewer. This infers that many programs may not be instituting an ideally structured simulation curriculum. Hence, uniform training and thus mandatory participation can lead to good compliance that can be translated to maximum curricular efficiency.

Both computer simulators and box trainers are being used in the training of surgical residents. Interestingly, it is not known which training vehicle is superior and more cost effective in teaching learners laparoscopic skills. It is also unclear which method equates with better compliance, and more importantly, which method best recapitulates the human operating room environment, which can potentially reduce trainees' errors and make the "see one, do one, teach one" a relic of the past.

We plan to illustrate that a well-structured, timed curriculum that incorporates simulated laparoscopic surgical training improves laparoscopic skill acquisition. Furthermore, we aim to decipher whether a laparoscopic computer simulator or usage of a box trainer leads to better intraoperative laparoscopic skills and a better module for learner education.

MATERIALS AND METHODS

Subjects

Novice fourth-year medical students and surgical interns enrolled voluntarily in an Institutional Review Board (IRB) exempt prospective, randomized, blinded, controlled trial that assigned novice subjects to formal scheduled laparoscopic training with either computer simulators or box trainers. These trainees were randomized to a scheduled training session in a laparoscopic computer simulator laboratory or to a control group (box trainer group) (Fig. 1). Subjects randomized were trained on appropriate laparoscopic camera skills, instrument handling, object positioning, dissection, ligation, suturing, and knot tying over a 6-month interval. Simulator skills were taught in both training arms and mandatory training time was required of each group. Training was geared toward the laparoscopic skill set for the assessment examination. All subjects then completed a series of laparoscopic exercises in a live porcine model, and their performance was assessed independently by blinded reviewers at each interval time period.

Experimental Conditions

All subjects underwent a group orientation to the computer simulator laboratory, box trainers, and the required basic skills tasks: laparoscopic camera navigation, instrument handling, object positioning, dissection, ligation, suturing, and knot tying. Each subject performed a single, supervised practice repetition to orient him or her to the computer simulator and box trainer, respectively. Subjects were required to perform a minimum of 10 repetitions, because a prior study demonstrated that the learning curve for junior surgeons reached a plateau around eight repetitions. Hence, a minimum of 10 repetitions is required to ensure that trainees received adequate training on the simulator exercises.

Subject training occurred over a 6-month period during which a series of laparoscopic skills were assessed at time zero, two, and 6 months. All subjects were oriented to the animate laparoscopic tasks by one of the primary investigators using scripted instructions and demonstration of optimal performance for each task. The tasks included a 30° camera navigation exercise, 2 eye-hand coordination exercises, clipping and electrocautery, and a knot-tying exercise. The 30° camera navigation exercise required the subject to find and focus on 4 "targets" measuring 1 cm in diameter which were placed at various preselected locations within the abdomen. The placement of the "targets" required the subject to use the 30° optics of the laparoscope to locate the objects within the abdomen successfully. The first eye–hand coordination exercise focused on 2-handed transfers. Using 2 laparoscopic graspers, the subject stood at the foot of the pig and transferred a needle with a left-handed grasper from the right lobe of the liver up into the air to be grasped by the right-handed grasper, and then placed gently down on the left lobe of the liver. This procedure was then reversed and repeated 2 times. One of the investigators held the laparoscope for this exercise. The second eye–hand coordination exercise evaluated 1-handed object transfer and 0° camera navigation skills. The subject handled the laparoscope first with his/her left hand and transferred a 1-cm "target" with a grasper in his/her right hand from the right lobe of the liver to the spleen while standing on the pig's left side. This procedure was then reversed with the subject standing on the pig's right side, and he/she was then asked to handle the laparoscope with their right hand while using a grasper