Simulation Training for Surgical Residents: Cool Computers or Core Curriculum?

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Objective: To demonstrate that virtual reality (VR) training transfers technical skills to the operating room environment.

Design: Prospective, randomized, controlled blinded study.

Setting: Department of Surgery, Yale University, New Haven, Connecticut.

Participants: Sixteen surgical residents PGY 1 to 4.

Methods: Sixteen surgical residents had initial psychomotor ability testing; then they were randomized to either the VR training group (n = 8) or the control non-VR-trained group (n = 8). Virtual reality training was done using the MIST-VR simulator diathermy task. Training was considered complete when expert criterion levels were achieved. All subjects in both groups then performed laparoscopic cholecystectomy with an attending surgeon blinded to their training status. The gallbladder dissection portion of the operation was videotaped and reviewed independently by two investigators blinded to the subject’s identity and training group. Each videotape was scored for 8 predefined errors for each procedure minute. The defined errors included lack of progress, gallbladder injury, liver injury, incorrect plane of dissection, burn nontarget tissue, tearing tissue, instrument out of view, and attending takeover.

Results: There were no differences in the baseline assessment tests between the 2 groups. All subjects in the training group were able to achieve the preset criterion levels, but the number of sessions required for each resident ranged from 3 to 8. Gallbladder dissection was 29% faster for VR-trained residents. Non-VR-trained residents were 9 times more likely to transiently fail to make progress (p = 0.007, Mann-Whitney test) and 5 times more likely to injure the gallbladder or burn nontarget tissue (chi-square = 4.27, p = 0.04). The mean number of errors in the VR-trained group was significantly less (1.19 vs 7.38 errors per case; p < 0.008, Mann-Whitney test).

Conclusions: The use of VR training improved the operative performance of residents during gallbladder dissection in laparoscopic cholecystectomy. This study validates the transfer of training skills from VR to the operating room.
blinded to the training status of the resident. The residents in the VR training group were 29% faster and had fewer errors. Injury to the gallbladder, burning of non-target tissue, and lack of progress was more likely to occur in the control group. These findings support the use of VR training to improve operating room performance.

PROVING THE VALUE OF SIMULATION IN LAPAROSCOPIC SURGERY.

Objective: To assess the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS) physical laparoscopic simulator for construct and predictive validity and for its educational utility.

Design: Retrospective review of prospectively collected data.

Setting: Multiple national and international medical institutions.

Participants: Over 250 surgeons and trainees.

Methods: Participants completed a series of individual experiments using MISTELS that were prospectively entered into a database along with their host institution and training status. Only the initial performance of each subject was used for validation studies to avoid the potential for a learning effect. Each task is scored for time and precision and then normalized to create an equivalent range of scores. Construct validity was established by dividing subjects into 3 groups according to laparoscopic experience. External validity was tested through the 5 beta test sites, comparing scores for different institutions. Predictive and concurrent validity were evaluated through a comparison between a subject’s MISTELS score and their intraoperative performance. Face validity was confirmed through questioning experienced laparoscopic surgeons using global rating scales.

Results: Evidence for construct validity was demonstrated as MISTELS scores increased progressively with increasing laparoscopic experience (n = 215, p < 0.0001) and residents followed over time improved their scores (n = 24, p < 0.0001). Results in the host institution did not differ from 5 beta sites (n = 215), proving external validity. The MISTELS scores correlated with a highly reliable validated intraoperative rating of technical skill during laparoscopic cholecystectomy (n = 19, r = 0.81, p < 0.0004), demonstrating concurrent validity. Novice laparoscopists were randomized to practice/no practice of the transfer drill for 4 weeks. Improvement in intracorporeal suturing skill was significantly related to practice but not to baseline ability, career goals, or gender (p < 0.001).

Conclusion: The MISTELS is a well-developed system used to teach and measure technical skills in laparoscopy. This study demonstrates the simulator’s validity and utility as an educational tool.

This study evaluates the MISTELS physical laparoscopic simulator for construct, predictive, and face validity as well as its utility as a training tool. The simulator includes a CD-ROM that demonstrates the 5 tasks in MISTELS: transfer, cutting, ligating loop, intracorporeal suturing, and extracorporeal suturing. Scores are assigned based on efficiency (time) and precision (lack of errors). A total of 215 participants completed the MISTELS program and were divided into 3 groups based on laparoscopic experience: junior, intermediate, and senior. Construct validity was shown through the stepwise progression in score for each level of surgical skill. To determine predictive validity, an intraoperative assessment tool to evaluate gallbladder dissection during a laparoscopic cholecystectomy was developed. Correlation between MISTELS score and intraoperative measurements was high (r = 0.81) showing good predictive validity. Face validity was confirmed by questionnaire administered to experienced laparoscopic surgeons. This well-validated simulator can be used as both an educational system and an assessment tool.

LAPAROSCOPIC VIRTUAL REALITY AND BOX TRAINERS: IS ONE SUPERIOR TO THE OTHER?

Objective: To compare a VR simulator with the classic box trainer, and to determine whether one has advantages over the other.

Design: Prospective, randomized controlled trial.

Setting: St. Mary's Hospital, London, England.

Participants: Twenty-four medical students (novices to surgery).

Methods: To determine baseline laparoscopic skills, subjects were asked to watch an instructional video of a laparoscopic cutting and clipping task and then complete the same task without training or direct instruction. Students were subsequently randomized into 1 of the following 3 groups: LapSim VR simulator, box trainer, and no training (control).
training groups completed 3 weekly 30-minute training sessions, whereas the control group had no training. After training, all subjects were completed the same original laparoscopic task. Assessment of performance was made through motion analysis, time, and error scores.

**Results:** Baseline performance was similar in all 3 groups. Both groups that had training made significant improvements in all parameters measured, including number of movements made by both hands, distance traveled by both hands, time for task completion, economy of hand movement, and number of errors. Compared with the controls, the box trainer group performed significantly better on all parameters except time. There were no significant differences between the LapSim and the box trainer groups, or between the LapSim and the control groups.

**Conclusions:** Both box trainers and VR simulators are effective in teaching skills that are transferable to a real laparoscopic task. There seems to be no substantial advantages of one system over the other.

**REVIEWER COMMENTS**

The study compares the effectiveness of skill acquisition through the use of a VR simulator versus a standard box trainer. The participants were novices randomized into 3 groups: box trainer, LapSim VR simulator, and control. All subjects were given instructions and watched a video of a laparoscopic task; then they were asked to complete the task to establish a baseline performance. The 2 training groups completed three 30-minute sessions of their respective training devices. After 3 weeks, all subjects repeated the same laparoscopic task, and performance was assessed by a motion-tracking system. Their results show that both trained groups made significant improvements in their performance. In comparison with the controls, the box trainer group performed better in all parameters, whereas there was no significant difference between box trainer group and VR simulator group or between control group and VR group. Possible explanations for these findings include the use of real laparoscopic instruments in the box trainer group and the lack of haptics in the VR simulators. Likely, a larger cohort of subjects is needed to distinguish differences in the 2 modalities of skills training.

**VIRTUAL REALITY SIMULATION FOR THE OPERATING ROOM: PROFICIENCY-BASED TRAINING AS A PARADIGM SHIFT IN SURGICAL SKILLS TRAINING.**


**Objective:** To inform surgeons about the practical issues to be considered for successful integration of VR simulation into a surgical training program.

**Design:** Literature review.

**Setting:** Emory University School of Medicine, Atlanta, Georgia.

**Participants:** Surgical education, human-factor, and psychology literature.

**Methods:** A review of the literature was performed to identify important factors that will impinge on the successful integration of VR training into a surgical training program.

**Results:** Systematic integration of VR into a structured education and training program is optimal. The program should objectively assess the improvement of technical skill proximate to the learning experience. Trainees should be required to reach an objectively determined proficiency level. This criterion level must be based on tightly defined metrics, and residents should perform at this level consistently. The literature demonstrates that training is more likely to be successful if scheduled on an interval basis, rather than massed into a short period. Although high-fidelity VR simulators may offer the greatest skills transfer to the in vivo surgical situation, less-expensive VR trainers will also lead to improved skills.

**Conclusions:** Successful implementation of VR into a surgical training program requires a thoughtfully prepared curriculum.

**REVIEWER COMMENTS**

This article provides an outline for successful implementation of VR and simulation technology into a training program. The optimal curriculum for training has several components: didactic teaching of relevant knowledge, task instruction, illustration of common errors, testing of cognitive skills, technical skills training on simulators, immediate feedback, and repetition to a performance goal. The authors have identified key factors for optimal skill acquisition with simulation including distributed interval training, use of validated performance metrics, and training to an established proficiency level. Several training strategies can be used: shaping (progressive increase in level of difficulty), fading (fewer clues and guides with increasing difficulty), and backward chaining (task deconstruction into simpler steps).
Mastery of minimally invasive surgery requires a unique set of operative skills. The psychomotor challenges inherent to endoscopic manipulations have frustrated skilled surgeons and trainees alike. These variables include 2-dimensional visualization, blunted tactile feedback, and the fulcrum effect in which directional movements of the surgeon’s hand result in opposite deflections in the working end of the instrument. To overcome these limitations, several simulators have been developed to help the trainee hone their endoscopic skills. The sophistication of these training devices range from periscope viewing with foam models to high-fidelity VR simulators. These trainers can emulate many of the basic steps of minimally invasive surgery such as manipulating tissue, clipping, cutting, and even suturing. The trainee can work independently in a life-like environment on a platform that is always available. Skills can be rehearsed until mastered without affecting patient outcome or undue utilization of operating room time.

Many simulators are available, each with its unique set of qualities. Every simulator must prove to be valuable and reliable through validation studies. With our current level of technology, there seems to be no significant advantage in the VR simulators compared with the physical box trainers. Validation studies in both types have shown that surgical simulators are more than just fancy video games. As most are computer based, training and results can be tracked for each student. Also, the level of difficulty for a particular task and performance criteria can be easily configured to meet the needs of the trainee. With proper use and sufficient training, operative performance can be improved and number of errors decreased. As simulators become more advanced, we may ultimately be able to use them to control resident progress as well as credentialing for surgeons.

The Halsteadian model for apprenticeship learning is becoming more difficult to practice given the constraints of work-hour limitations, health-care policy, and patient expectations. Residency programs across the country are trying to determine the optimal method for integrating simulation into their program. The real challenge is incorporating these simulators into a structured curriculum that involves both an educational component as well as technical skills training. In addition, levels of proficiency must be established to use as a goal for students to achieve. A stand-alone training unit without instruction, metrics, and performance goals is unlikely to benefit the trainee. The ultimate success of simulation depends not only on the technology but also on its appropriate use in the training environment. Despite these challenges, simulation will become an integral part of our future in surgical training.1-6

doi:10.1016/j.cursur.2005.10.003

REFERENCES


QUESTIONS AND ANSWERS

Questions

1. The optimal method for introducing surgical simulation into a residency is:
   a. Multiple sessions clustered together into a short period of time
   b. Sessions at regular intervals throughout an extended period
   c. Repetition to the highest level achievable by trainee
   d. Self-directed training at student’s own pace

2. Which statement regarding surgical simulators is TRUE?
   a. Students learn more with high-fidelity simulators.
   b. Virtual reality simulators are better than box trainers.
   c. Training on a VR simulator can lead to improvement in operative performance.
   d. Training on a VR simulator does not reduce errors.

3. Which of the following best describes “construct validity” for surgical simulators?
   a. Experts feels that the simulator is representative of the task being simulated.
   b. The simulator correlates well with operative performance.
c. The simulator gives consistent results from one institution to another.
d. Simulator scores correlate well with the level of expertise of the surgeon.

Answers

1. b. Sessions conducted at regular intervals over a long period of time is the preferable way to build skill. Sessions massed over a short period will not allow for long-term retention. The trainee should train by repetition to a predefined expert criterion. Self-directed training without guidance, illustration, feedback, and didactics is not optimal.

2. c. Virtual reality simulators when properly used do lead to transfer of skills into the operating room, improve performance, and reduce errors. The type of simulator, whether virtual or physical (like a box trainer), does not seem to matter. Also, simulators that are high fidelity are not necessarily better for learning.

3. d. Statement (a) defines face validity, statement (b) defines predictive validity, statement (c) defines external validity, and statement (d) defines construct validity.

Oncology

PET Scans in Tumor Staging: Hope or Hype?

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Objective: To compare the diagnostic accuracy of integrated positron electron tomography-computed tomography (PET-CT) with that of CT alone, PET alone, and conventional visual correlation of PET and CT to determine the stage of disease in non-small-cell lung cancer.

Design: Prospective study.

Setting: Divisions of Thoracic Surgery and Nuclear Medicine, University Hospital of Zurich, Zurich, Switzerland.

Participants: Between July 2001 and February 2002, 49 consecutive patients with proven or suspected non-small-cell lung cancer were referred for surgery. The TNM stage was preoperatively assigned on the basis of image analysis. Postoperative histologic analysis revealed adenocarcinoma in 28 patients, squamous-cell carcinoma in 13, and large-cell carcinoma in 8. Extrathoracic metastases were confirmed histopathologically or by at least 1 other imaging method.

Results: Integrated PET-CT provided additional information compared with conventional visual correlation of PET and CT in 20 of 49 patients (41%). Tumor staging was significantly more accurate with integrated PET-CT than with CT alone (p < 0.001), PET alone (p < 0.001), or visual correlation of PET and CT (p = 0.013). Nodal staging was significantly more accurate with integrated PET-CT than with PET alone (p = 0.013). In metastasis staging, integrated PET-CT increased the diagnostic certainty in 2 of 8 patients.

Conclusions: Integrated PET-CT improves the diagnostic accuracy of the staging of non-small-cell lung cancer.

REVIEWER COMMENTS

Since the advent of PET scanners, numerous issues have developed because of the imprecise anatomic localization of certain detected abnormalities when PET is performed as a solo diagnostic measure. As a result, PET and CT have been combined in an effort to provide better anatomic definition of lesion location. The authors successfully illustrate that newer integrated PET-CT scanners have eliminated many former problems involved in preoperative oncologic staging. In fact, integrated PET-CT provides key pieces of additional information in this study, including the exact location of lymph nodes in 9 patients, precise evaluation of chest wall infiltration in 3 patients, mediastinal invasion in 3 patients, correct differentiation between tumor and peritumoral inflammation or atelectasis in 7 patients, and exact location of distant metastases in 2 patients. Although all of this information is key to improving the diagnostic accuracy during the preoperative TNM staging of non-small-cell lung cancer, this does not result in improved clinical management or outcomes.