Single-Session Baseline Virtual Reality Simulator Scores Predict Technical Performance for Laparoscopic Colectomy: A Study in the Swine Model

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OBJECTIVE: Virtual reality (VR) simulation helps reducing the learning curve of laparoscopic colectomy. Moreover, it may be used to ascertain surgeons' pretraining skills. It was aimed to establish predictive validity of specific parameters gathered during VR simulation training on sigmoid colectomy and whether simulator parameters correlate with technical performance during the same operation in a swine model.

DESIGN: Surgeons novice to laparoscopic colectomy underwent a single VR simulation session on sigmoid colectomy. Next, all participants performed a laparoscopic sigmoidectomy in the swine. Operations were recorded. Performance evaluation was conducted by 2 board-certified colorectal surgeons blinded to surgeons' simulator scores using an instrument specific to laparoscopic colectomy. For each participant, a mean score of specific skills was calculated. Linear regression analysis was used to identify simulator parameters that were best related to the score. The stepwise method was used to select parameters. The magnitude of the regression model was measured by the coefficient of determination (R^2) value.

SETTING: The University of Sao Paulo Medical Center is a high-volume, public practice, university-affiliated hospital.

PARTICIPANTS: A total of 14 first-year residents in digestive tract surgery were included.

RESULTS: Analysis of variance demonstrated that the regression model was significant ($p = 0.0001$), and an association between simulation scores and specific skills was confirmed. The R^2 value was 99%. The VR simulator parameters that strongly correlated with specific skills during laparoscopic colectomy in the swine were safe use of electrosurgery/energy device and safety of medial-to-lateral dissection.

CONCLUSIONS: A single VR simulation session for novice surgeons in the sigmoid colectomy module generates baseline scores that highly correlated with performance of specific skills during a laparoscopic colectomy in the swine. This information may be useful in an attempt to tailor VR simulator practice according to a surgeon's needs. (J Surg 71:883-891. © 2014 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: laparoscopy, colectomy, colonic neoplasms, education, credentialing, clinical skills

COMPETENCIES: Patient Care, Medical Knowledge, Practice-Based Learning and Improvement

BACKGROUND

Surgical education has traditionally followed a model where a trainee surgeon plays a role of an apprentice in the operating room. Moreover, this education model can be time consuming and costly.[1] Minimally invasive surgery has challenged this model because a need to master specific skills, different from those used during conventional surgery, was imposed.[2] During laparoscopic surgery, reduced haptic feedback, instruments with limited degrees of motion freedom owing to the fulcrum effect, and loss of depth

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perception owing to the 2-dimensional imaging make a minimally invasive access surgery more difficult than the conventional approach. Therefore, competency requires dedicated training. Nowadays, trainee surgeons are required to gather more technical skills in less time, adding stress to an already busy clinical practice.[3] Minimally invasive and endoscopic surgical techniques demand a completely new set of psychomotor skills.[4] Therefore, the role of simulation in the development of technical skills is being extensively evaluated in recent years.[1,5]

Laparoscopic colorectal surgery is a complex procedure, often being self-taught by senior surgeons,[4] even though there is available evidence from the practice of other operations that the absence of appropriate training may lead to patient safety compromise.[6] The high level of technical complexity associated with laparoscopic colectomies was held partially responsible for its relatively low adoption rate when compared with other laparoscopic operations.[7,8] In colorectal surgery, the evidence regarding the implementation of virtual reality (VR) simulation–based training into clinical practice remains scarce[4] partially because specialty surgeons rather practice minimally invasive colorectal surgery in a cadaver model than in a simulator.[9] Moreover, simulation-based training requires investment in resources and faculty, which may be balanced against traditional surgical education.

The construction of a realistic scene graph, the possibility of task repetition, unsupervised training, and to register performance variables represent the main advantages of VR simulation training.[10] With the advancement of desktop computing, commercially available VR surgical simulators were developed. The LAP Mentor (Simbionix USA Corp., Cleveland, OH) is a high-fidelity medical simulator. It enables laparoscopic training of basic skills and advanced procedures. The laparoscopic colectomy integrates one of these modules. Moreover, the simulator provides feedback to the trainee at the completion of the task or procedure regarding operative time, efficiency of motion, and safety. Improved training and objective assessment of results are key strategies for reducing medical errors.

It was already demonstrated that training in a VR simulator improves technical performance in the simulator activities.[11,12] Other studies have demonstrated that the achieved improved performance can be observed during a real laparoscopic task.[13] Ultimately, it was demonstrated that VR simulation practice during surgical education improves operating room performance.[14-16] However, the adoption of VR simulation training by the surgical community remains investigational. The main criticisms of the aforementioned studies are the small sample sizes and the recruitment of residents as research subjects and not attending surgeons.

There is limited evidence on the best role of a VR simulator in education of surgical residents. Proficiency-based simulator curricula have proven effective in improving the performance of trainees.[14] An assessment of baseline skills level on laparoscopic colectomy for trainee surgeons may be used to fashion a tailored program dedicated to improve specific competences and to meet the needs of novice surgeons according to their specific pretraining skills. In such way, we intend to demonstrate the validity of using a VR simulator not only as a training tool but also as an evaluation tool, as it has been demonstrated that psychomotor testing may be of limited value in the prediction of baseline laparoscopic performance.[17]

We hypothesized that an evaluation of performance during a session in a VR simulator may be used to predict performance before a laparoscopic colectomy for beginner surgeons in the swine model. In the present study, we aimed at determining which parameters gathered during VR simulation training on sigmoid colectomy are best correlated with superior technical performance during a laparoscopic colectomy in the swine model.

METHODS

Subjects

We recruited 14 first-year digestive surgery residents of a university-affiliated hospital, who were inexperienced with laparoscopic colectomy, as chief surgeons. However, all recruited subjects had already operated on laparoscopic cholecystectomy, appendectomy, and fundoplication clinical cases.

The VR simulator–based training is not currently available for surgical education in our hospital.

All the included subjects had not previously joined a laparoscopic colectomy course.

Study Design

An institutional review board approved the present study. All recruited surgeons signed informed consent. The experimental anesthesia and surgical procedure protocols were approved by a review committee and met the guidelines of a Brazilian national responsible agency, and they were strictly followed in the experimental laboratory where this study was conducted.

The inclusion criteria were the availability to join the study and lack of previous laparoscopic colectomy training. As the inclusion of subjects was based on availability, sample size analysis was not conducted.

The main outcome measure of the present study was the degree of correlation between parameters generated during a single VR simulation training (sigmoid colectomy advanced module) and the performance of specific skills during a laparoscopic sigmoid resection in the swine model. The study flow diagram is presented in Figure 1.

All participant surgeons underwent a single VR simulation training session in the sigmoid colectomy module