Thinking it Through: Mental Rehearsal and Performance on 2 Types of Laparoscopic Cholecystectomy Simulators

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OBJECTIVE: Simulation-based training (SBT) in laparoscopic cholecystectomy (LCCY) provides an opportunity for junior residents to learn the procedure in a safe, nonthreatening environment. Mental rehearsal (MR) has the potential of augmenting skill acquisition. This project investigated the correlation between MR of LCCY with performance on 2 different types of simulators: a procedural task (PT) training model and virtual reality (VR) machine.

DESIGN: Prospective, quasi-experimental design with purposeful sampling. Postgraduate years (PGYs) 1 through 3 general surgical residents underwent standardized, distributed SBT in LCCY on either a PT trainer or a VR machine with group-based MR undertaken before 2 SBT sessions. Participants completed a pre-MR and post-MR session mental imagery questionnaire (MIQ) containing 8-items using a 7-point Likert-type scale. Data related to VR objective measures and PT video-based performances were also collected. Total scale mean scores were calculated for the first MR session and the second MR session and were compared using the *t* test. Pearson correlation analysis of MIQ scores with performance scores was determined.

SETTING: Louisiana State University Health New Orleans Health Sciences Center in New Orleans, Louisiana. This health sciences center is a tertiary care, academic state institution located in the Southeastern United States.

PARTICIPANTS: A total of 21 PGYs 1 through 3 general surgery residents participated. They were purposefully divided into the PT and VR training groups to allow for even PGY distribution. Of the 21 participants, 19 completed both training sessions ($n = 10$ for PT [PGY1 = 4, PGY2 = 4, PGY3 = 2] and $n = 9$ for VR [PGY1 = 4, PGY2 = 3, PGY3 = 2]).

RESULTS: After the Bonferroni adjustment, significant gains in the MIQ items related to confidence, visual imagery, and knowledge of the procedure were found. VR performance data demonstrated some statistically significant improvements. A significant negative correlation was present between the two-handed clip-and-cut VR task and MIQ gains.

CONCLUSIONS: Group MR in LCCY before SBT on a VR machine is related to improved performance time for the VR two-handed clip-and-cut task. MR may be a useful adjunct to SBT LCCY. Future work will look at the translation of these skills to clinical practice. (J Surg 72:740-748. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: mental rehearsal, simulation, technical skills, surgical education, procedural training, skills acquisition

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

INTRODUCTION

Laparoscopic cholecystectomy (LCCY) is one of the most common procedures performed by general surgeons.[1] The incorporation of simulation-based models to teach the critical aspects[2] of this common procedure to surgical trainees early in their residency holds the prospect of improving surgical efficiency, shortening the learning curve, and decreasing the risk of the rare but devastating complication of common bile duct injury.[2] Simulation-based training (SBT) offers inexperienced residents (i.e., those most at risk for causing a common bile duct injury) the opportunity to gain experience outside the operating room (OR) in a safe learning environment.

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Educational research has helped to develop curricula incorporating the components of training to criterion (i.e., proficiency standards), deliberate practice, and distributed learning to enhance novices' acquisition of skills related to LCCY and to demonstrate an improvement in performance on hepatobiliary porcine specimens.[3-5] Additionally, mental rehearsal (MR) has been successfully incorporated into the SBT curricula for both basic open skills[6] and LCCY.[7,8] Defined as the cognitive rehearsal of a task or process, MR is also known as "imagery practice," "covert rehearsal," "conceptualization," and "mental imagery rehearsal."[9] Practiced by athletes and surgeons alike,[16] MR has been demonstrated to lead to improvement in motor performance of targeted tasks through the recruitment of brain areas involved in motor skills similar to the active observation of said tasks being performed.[10] In fact, this improvement in performance can be striking, attaining on an average higher scores of a half standard deviation.[11] A recent systematic review[12] identified several key characteristics of effective MR. They include its use in an individual, supervised, nondirected setting, wherein the participant keeps his/her eyes closed, assumes an internal perspective, and focuses on a kinesthetic mode. The efficacy of MR in teaching LCCY was demonstrated in a randomized control trial incorporating mental practice into a proficiency-driven SBT curriculum using a virtual reality (VR) machine.[15] Novice laparoscopic surgeons practicing this SBT curriculum who underwent MR before performing LCCY on a VR machine had statistically superior technical performance than controls who did not undergo MR.[15]

For surgical educators, the logistics of coordinating resident training in skills laboratories with faculty and resident schedules, work-hour duty restrictions, and the growing number of training requirements often necessitate planning group skills laboratory practice. Yet, group training is constrained by cost considerations related to having multiple sophisticated simulators. For example, deploying VR simulators includes a capital cost (i.e., approximately $150,000/device) and an annual support cost that may reach tens of thousands of dollars. Fortunately, other lower cost, inanimate LCCY procedural task (PT) training models have been developed. To date, group MR has not been incorporated into a SBT curriculum employing both such models.

The specific aims for this project were the following:

(1) To determine if residents' scores on the Mental Imagery Questionnaire (MIQ) LCCY change from pre- to post-MR practiced in a group setting before SBT.

(2) To determine if residents' performance scores for LCCY change from the first trial of LCCY to the second trial of LCCY.

(3) To determine if there is a relationship between residents' MIQ scores and performance scores on PT and VR simulators.

MATERIAL AND METHODS

Training Overview

From January to June 2011, 21 residents underwent instruction and SBT in LCCY at the School of Medicine's Russell C. Klein MD ('59) Center for Advanced Practice (CAP). The residents were assigned pretraining web-based materials (i.e., readings and video) to review before each session. Each session consisted of a didactic and SBT component. For the SBT, residents were assigned to either PT or VR training, based on PGY level to distribute those residents at each level as evenly as possible within each training group. The didactic instructional content and the content for each SBT modality were standardized.

Training Equipment, Format, and Tasks

SBT using the PT model was conducted within a previously described virtual operating room (VOR)[13] environment within the CAP. The VOR was developed by Stryker Communications (Flower Mound, TX) and housed state-of-the-art, boom-mounted flat panels, lights, and housing unit for the insufflator (CORE 40L, Stryker Endoscopy, San Jose, CA), light source (X7000, Stryker Endoscopy, San Jose, CA), and high-definition camera (1188HD, Stryker Endoscopy, San Jose, CA) units (Fig.). In addition, it had an affiliated workstation with recording ability. A Quad Screen video capture design allowed simultaneous recording of the endoscopic camera, in-room camera, and in-light camera during training.

Within the VOR was a full-scale computer-operated mannequin (CAE Healthcare, Sarasota, FL). The PT trainer was placed at its knees, as has been previously described (Fig.).[14] LCCY SBT occurred on the Torso Trainer (Simulab Corporation, Seattle, WA). This PT inanimate torso model had a replaceable outer skin through which ports could be placed. The trainer housed a removable small bowel and a mold of the upper abdomen with exposed gall bladder fossa. Within this fossa, a space for Velcro placement of a detachable gallbladder model containing replicas of the cystic duct and cystic artery was located. Beside the OR table, a Mayo Stand was placed with equipment for the procedure.

SBT VR training used a VR machine (LapMentor, Simbionix Corporation, Cleveland, OH) containing 4 training tasks: (1) one-handed clipping and cutting of the cystic duct and artery, (2) two-handed clipping and cutting of the cystic duct and artery, (3) dissection of the triangle of Calot with division of the cystic duct and artery, and (4) dissection of the gall bladder off the gall bladder fossa. Additionally, it has software to conduct "free training" (i.e., completion of a LCCY from retraction of the gall bladder to its removal from the liver fossa).

Each resident underwent 2 standardized training sessions within a month to improve retention of learning through