Creation and Global Deployment of a Mobile, Application-Based Cognitive Simulator for Cardiac Surgical Procedures

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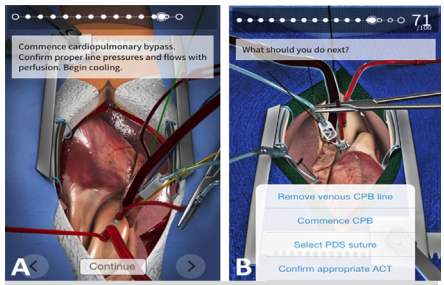
Several modern learning frameworks (eg, cognitive apprenticeship, anchored instruction, and situated cognition) posit the utility of nontraditional methods for effective experiential learning. Thus, development of novel educational tools emphasizing the cognitive framework of operative sequences may be of benefit to surgical trainees. We propose the development and global deployment of an effective, mobile cognitive cardiac surgical simulator. In methods, 16 preclinical medical students were assessed. Overall, 4 separate surgical modules (sternotomy, cannulation, decannulation, and sternal closure) were created utilizing the Touch Surgery (London, UK) platform. Modules were made available to download free of charge for use on mobile devices. Usage data were collected over a 6-month period. Educational efficacy of the modules was evaluated by randomizing a cohort of medical students to either module usage or traditional, reading-based self-study, followed by a multiple-choice learning assessment tool. In results, downloads of the simulator achieved global penetrance, with highest usage in the USA, Brazil, Italy, UK, and India. Overall, 5368 unique users conducted a total of 1971 hours of simulation. Evaluation of the medical student cohort revealed significantly higher assessment scores in those randomized to module use versus traditional reading (75% ± 9% vs 61% ± 7%, respectively; $P < 0.05$). In conclusion, this study represents the first effort to create a mobile, interactive cognitive simulator for cardiac surgery. Simulators of this type may be effective for the training and assessment of surgical students. We investigated whether an interactive, mobile-computing–based cognitive task simulator for cardiac surgery could be developed, deployed, and validated. Our findings suggest that such simulators may be a useful learning tool.

Semin Thoracic Surg 28:1–9 © 2016 Published by Elsevier Inc.

Keywords: Surgical Simulation, Online Learning, Education, Skills Assessment



Cognitive Surgical Simulation.

Central Message

Describes the successful creation, deployment, and validation of a mobile cognitive simulator for cardiac surgery procedures.

Perspective Statement

There is a need for novel educational tools for both physicians in training and those who wish to maintain current. This article describes the development of one such educational tool.

See Editorial Commentary pages 10–11.

INTRODUCTION

Changes in surgical resident educational programming have generated greater interest in simulation-based learning in cardiothoracic surgical training.[1-5] Surgical simulation permits the resident to interact in a less stressful environment and may provide structured graduated training of technical skills and crisis management. Furthermore, educators recognize this modality as one method by which proficiency may be formatively and summatively assessed. To this end, development of novel educational tools emphasizing the cognitive framework of operative sequences may be of benefit to surgical trainees. The ideal simulation environment for cardiac surgery education would be a fully functional cardiopulmonary bypass (CPB) circuit with biologic heart tissue. However, such a model requires a tremendous amount of resources, including equipment, lab personnel, and money. Most training programs do not have such resources for their trainees. Therefore, innovative portable simulators must be developed to have a broader effect on trainee education. Without such simulators, such as in the current era, trainees are limited in knowledge they can acquire outside the operating room and this

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Presented at the Annual Meeting of the Western Thoracic Surgical Association, Whistler, British Columbia, Canada

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has traditionally been in written form, such as in surgical textbooks. However, learning exclusively from textbooks has limits in a very visual and kinesthetic learning environment such as surgery, and thus many of the intricacies of surgical procedures are omitted. This posits further need for novel simulators.

Cognitive training is the first stage of the Fitts and Posner's 3-stage theory of motor skill acquisition, a learning model accepted in the surgical literature.[5] In the cognitive stage, the learner must demonstrate understanding of a skill. During this stage, performance is erratic, but with effective instruction, the learner moves on to the subsequent stages of integration and then automation, during which performance becomes more fluid and continuous. Technical skills and crisis management scenarios have been developed in cardiac surgery, which may be incorporated into a more portable format.[2,3] We see that in high-risk industries and sports there is a great focus on cognitive training. Cognitive Task Analysis (CTA) is a technique used to breakdown the required cognitive knowledge of performing a task of procedure. With CTA, a complex procedure can be taught step-by-step and prepare them for the subsequent phases of learning.

We propose the development of an effective, tablet or smartphone-based mobile cognitive cardiac surgical simulator to accelerate skill acquisition in the cognitive phase.

MATERIALS AND METHODS

Development of Cognitive Simulator Educational Modules

CTA was used to derive a step-by-step breakdown of performing a CPB. Combining this information with surgical videos, the team at Touch Surgery (London, UK) was able to recreate the surgical procedure on a virtual patient and then punctuated with didactic knowledge to guide the user to learn the procedure. Following this, multiple-choice questions (MCQs) were inserted to create a test version of the procedure.

Each module contains between 200 and 400 distinct animated surgical steps. Modules can be downloaded onto a smartphone or mobile computing devices and are made available free of charge. Once downloaded, the modules can be used in "learning" or "testing" modes (Fig. 1). In the learning mode, users interact with the virtual operating room, using finger swipes to proceed through the operation. In the testing mode, the simulated operation proceeds as the user answers interactive questions and correctly performs finger swipes. Touch Surgery collected user profile data and demographics, logged simulation time, and learner performance on the modules as a function of "percent correct" achieved in the testing mode. Performance data are available to the users for self-analysis and improvement.

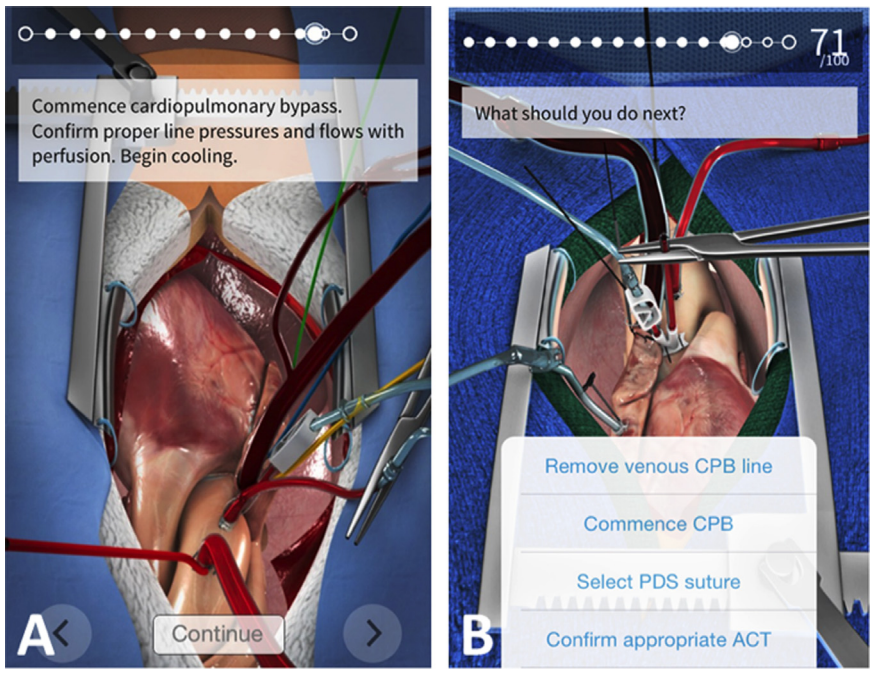

Figure 1. Screenshots of the mobile-computing based, interactive cardiac surgery simulator module in learning mode (A) and testing mode (B). The simulator is designed to be used with a touch screen on a tablet or smartphone, with progression through the operative steps indicated by timeline at the top of the screen. Users can interact with the virtual operation using "finger swipe" motions. (Color version of figure is available online at http://www.semthorcardiovascsurg.com.)