An Effective Repetitive Training Schedule to Achieve Skill Proficiency Using a Novel Robotic Virtual Reality Simulator

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PURPOSE: A robotic virtual reality simulator (Mimic dV-Trainer) can be a useful training method for the da Vinci surgical system. Herein, we investigate several repetitive training schedules and determine which is the most effective.

METHODS: A total of 30 medical students were enrolled and were divided into 3 groups according to the training schedule. Group 1 performed the task 1 hour daily for 4 consecutive days, group II performed the task on once per week for 1 hour for 4 consecutive weeks, and group III performed the task for 4 consecutive hours in 1 day. The effects of training were investigated by analyzing the number of repetitions and the time required to complete the "Tube 2" simulation task when the learning curve plateau was reached. The point at which participants reached a stable score was evaluated using the cumulative sum control graph.

RESULTS: The average time to complete the task at the learning curve plateau was 150.3 seconds in group I, 171.9 seconds in group II, and 188.5 seconds in group III. The number of task repetitions required to reach the learning curve plateau was 45 repetitions in group I, 36 repetitions in group II, and 39 repetitions in group III. Therefore, there was continuous improvement in the time required to perform the task after 40 repetitions in group I only. There was a significant correlation between improvement in each trial interval and attempt, and the correlation coefficient (0.924) in group I was higher than that in group II (0.899) and group III (0.838).

CONCLUSION: Daily 1-hour practice sessions performed for 4 consecutive days resulted in the best final score, continuous score improvement, and effective training while minimizing fatigue. This repetition schedule can be used for effectively training novices in future. (J Surg 72:369-376. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: education, simulator, learning curve, robotics

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

INTRODUCTION

Recently, robotic virtual reality (VR) simulators (Mimic dV-Trainer) have been accepted as an effective training tool for the da Vinci surgical system, and results from studies on the face, content, and construct validity of these simulation systems have been encouraging.[1-3] Potential benefits of simulator training include becoming rapidly familiar with the robotic system and all its controls, although the optimum goal for simulator training may be gaining a predefined proficiency level, rather than the completion of an arbitrary number of procedures using the simulator.[2,4] However, studies related to robotic VR simulator training generally required subjects to perform few simulator trials.[5-7] If the number of repetitions required to gain proficiency is too small, the significant cost of the robotic VR simulator may not be justified because the costs would greatly outweigh the

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benefits of such short training.[8] Therefore, VR programs should provide an opportunity for sufficient repetitive practice to achieve predetermined proficiency levels and to maximize the role of this expensive training tool. However, there are currently no guidelines or curricula available to help trainees effectively perform repetitive training while reducing fatigue associated with training.

According to principles of rehabilitation, motor learning consists of situation adaptation and skill acquisition.[9] Adaptation can be understood as learning a new movement and new spatial goal, whereas skill acquisition involves a higher level of performance. The potential goal of the VR simulator is acquiring the necessary skills to perform a complex procedure. However, excessive training may induce tissue injury according to the physical stress theory.[10] In addition, fatiguing exercises can induce postexercise depression, and decreased interest in the task may result after excessive training.[11] Conversely, intervals between training sessions that are too long may cause loss of skills acquired during previous training; therefore, adequate repetition sessions are needed to maximize the effects of training.[12,13] The task used in this study was the "Tube" task, known as the "Tube 2" task, and was introduced as part of the programs released with the Mimic dV-Trainer that was designed to simulate vesicourethral anastomosis. "Tube 2" was introduced as a complex procedure in previous reports, and analyses of the learning curve showed that approximately 4 hours of training was necessary to gain proficiency in this task.[5,14] Therefore, to understand how best to use 4 hours of training, trainees were divided into 3 groups (1 h daily for 4 consecutive days, 4 h in 1 d, and 1 h weekly for 4 consecutive weeks) according to the training schedule. The aim of this study was to determine the most effective repetitive training schedule.

MATERIAL AND METHODS

A total of 30 medical students were enrolled in this prospective nonrandomized, institutional review board–approved study. None had experience with the surgical robots used in this study. To determine the appropriate training schedule, participants were divided into 3 groups according to the practice schedule. The task used in this study was "Tube 2," and our previous study showed that 4 hours of practice is required to gain proficiency in this task.[15] "Tube 2" was introduced as one of the complex procedures released with the Mimic dV-Trainer (Mimic Technologies, Inc., Seattle, WA), and previous reports validated the face, content, and construct validity of the "Tube" task. Lyons et al.[16] described the Tube task as a suturing exercise that simulates performing an anastomosis and requires the user to drive a needle through a designated area near the edge of 2 adjacent tubes (Fig. 1).

The 30 participants were divided equally among the 3 study groups. Participants would listen to a lecture and watch a video clip, and then see a demonstration from the same proctor. Warm-up exercises consisted of "pick and place" and "peg board" to familiarize participants with the robot system, which involve EndoWrist manipulation, clutch pedaling, and camera handling. After the orientation and warm-up exercises, participants performed the Tube 2 by themselves without proctoring. Group I performed the "Tube 2" task for 1 hour daily for 4 days, group II performed the "Tube 2" task 1 hour weekly for 4 consecutive weeks, and group III performed the "Tube 2" task for 4 hours during 1 day.

With the mean of the values observed at each trial in each group, we basically performed the Kruskal-Wallis test to evaluate whether the population medians of the average time to complete the tube task were the same across all levels of the group factor. If the distribution of time to complete the tube task were similar in the 3 groups, there would be no difference in the median. The Mann-Whitney test was also used to compare medians between 2 groups while controlling for type I error across the tests using Bonferroni correction.

The cumulative sum control (CUSUM) chart developed by E.S. Page in 1954 is a sequential analysis method to

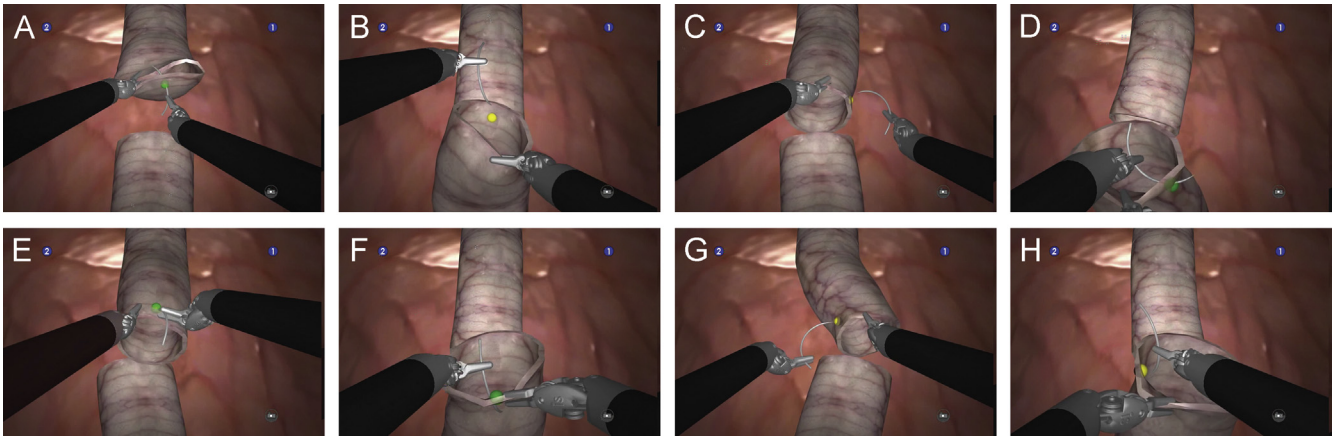

FIGURE 1. Tube 2 module in virtual reality simulator.