The Surgical Skill of a Novice Trainee Manifests in Time-Consuming Exercises of a Virtual Simulator Rather Than a Quick-Finishing Counterpart: A Concurrent Validity Study Using an Urethrovesical Anastomosis Model

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OBJECTIVE: The purpose of this study is to determine an optimal training curriculum using a robotic virtual simulator (RVS) that enables unexperienced trainees to perform a complex task in a hands-on setting.

PATIENTS AND METHODS: This study was conducted in 2 phases. In the RVS phase, 43 participants sequentially completed 12 exercises consistent with all primary exercises in the EndoWrist manipulation and advanced needle-driving category, until the overall score reached more than 80% by repeated practice. In the hands-on phase using a robotic surgical system, 10 randomly selected trainees performed 8 sutures once, simulating urethrovesical anastomosis, and the console time was recorded.

RESULTS: The median total time and total attempts for the RVS phase was 195.2 minutes and 54 times, respectively. The trainees were divided by median total time, and times to accomplish each RVS exercise were then compared between the early- and the late-completion groups; among 12 exercises trained, 6 exercises (prolonged course) requiring significantly more time in the late-completion group were identified. The prolonged course occupied 88.18% of the total time and 77.61% of the total attempts. For participants the in hands-on phase, a multiple linear regression model showed that the time to accomplish the prolonged course was a single independent predictor of the console time ($R^2 = 0.524$, $B = 0.05$; p = 0.018).

CONCLUSION: After establishment of a high standard cutoff score, the time spent for the prolonged course showed a significant association with console time in hands-on training simulating urethrovesical anastomosis, implying educational efficacy of training involving time-consuming exercise in performance of a complex task. (J Surg Ed 73:166-172. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: radical prostatectomy, virtual simulator, urethrovesical anastomosis, education

COMPETENCIES: Interpersonal and Communication Skills, Practice-Based Learning and Improvement, Systems-Based Practice

INTRODUCTION

During the last decade, in accordance with rapid and wide adoption of robotic surgery, the "gold standard" procedure for removal of the prostate gland shifted from the open retropubic approach to a robotic one.[1] However, universal agreement on how a surgeon can attain a proper level of surgical skill that is sufficient to perform robot-assisted radical prostatectomy (RARP) has not been reached, and development of training modalities for robotic surgery has been slow.[2] A conventional animal model provides an ideal environment with the advantage of high-fidelity real-life experience in tissue handling without concern for the patient's safety; however, facility and cost restraints limit use of this modality to selected centers.[3] Hands-on training is an alternative safe option, but it does not obviate concerns about equipment damage caused by unexperienced trainees, only providing a limited number of practices.[4]

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In this background, enthusiasm for robotic virtual simulator (RVS) training has been growing, which enables repetitive training in a risk-free environment, eliminating ethical issues. Several types of RVS systems have been developed,[5-8] and improved surgical performance driven by RVS was reported.[9] However, the development of educational contents using RVS is still in the early stage, and most of the studies were based on face and content validities pertaining to simple, quick-finishing exercises. Hence, questions regarding development of a proper RVS curriculum that enables trainees without prior robotic or surgical experience to perform a complex task such as urethrovesical anastomosis, a key step in RARP, have not yet been answered.

From our RVS data on robot-experienced surgeons, we observed a significantly different level of surgical dexterity from performance of time-consuming RVS exercises, not the easy counterpart; we then hypothesized that baseline surgical skill cannot be acquired from simple, quick-finishing training. The aim of this study is to investigate the difference of training proficiency in a novice group depending on the level of training difficulty assessed by RVS as well as the associations between variables of RVS and the trainee's performance in hands-on practice, rehearsing urethrovesical anastomosis.

PATIENTS AND METHODS

Overview of Study and Participants Enrolled

This study was conducted in 2 phases: the RVS phase and the hands-on training phase. For RVS, the da Vinci Skills Simulator (DVSS), which integrates Mimic (Mimic Technologies, Inc, Seattle, WA) virtual reality exercises with the da Vinci Si (Intuitive Surgical Inc, Sunnyvale, CA) surgeon console was used. DVSS simulates surgical instruments in a computer-generated 3-dimensional environment. In this study, a graduating class of medical school students without prior experience in performance of robotic or laparoscopic surgery was recruited for the RVS phase. Among the trainees who completed the institutional RVS curriculum, randomly selected participants then performed hands-on training.

RVS Training Curriculum Aiming at Advanced EndoWrist Control

Individualized login and password were distributed to each participant for evaluation of each RVS training exercise. A brief formal introduction on the RVS system was given at the start of training. Personal time for DVSS training was arranged, and all RVS curriculums were completed within a day for each trainee.

DVSS provides 30 exercises categorized as system settings and controls, EndoWrist manipulation, camera control, clutching, dissention, energy control, fourth arm control, needle control, basic needle driving, and advanced needle driving, which were divided into primary and additional courses based on skills focused.[10] Considering the surgical proficiency relevant to performing urethrovesical anastomosis, an RVS curriculum was developed, including all the primary exercises in the EndoWrist manipulation category (9 exercises including pick and place, peg board level 1, peg board level 2, match board level 1, match board level 2, ring and rail level 1, ring and rail level 2, ring walk level 1, and ring walk level 2) and advanced needle-driving category (3 exercises including dots and needles level 2, suture sponge level 3, and tubes). Each training course was preceded by a video explaining the task and its objectives within DVSS. On completion of an exercise, an overall score (range: 0%-100%) was automatically generated by combinations of metrics: instrument force, instrument collisions, instrument out of view, master workspace range, time to complete exercise, and economy of motion. The recruited participants performed each exercise repeatedly, until the overall score reached more than 80%. Each exercise was completed in consecutive order; if the cutoff score was obtained, the participant then moved on to the next exercise. The time and number of attempts to accomplish each exercise, which indicate training proficiency, were used as variables for statistical analysis.

Hands-On Training Using the Urethrovesical Anastomosis Model

A hands-on model for urethrovesical anastomosis was created using the proximal end of rectal tubes, which are slightly dilated with an external diameter of 30 F (Fig. 1A), and the procedure was performed using the da Vinci Si robotic surgical system. Similar to the urethrovesical anastomosis step during RARP using the van Velthoven technique, the initial stitch was started from the proximal tube, simulating the bladder wall, the suture direction was outside-in, using a single-arm 3-0 VICRYL suture with a 26-mm tapered needle (Fig. 1B). The needle was then passed into the distal tube, which simulates the urethra, with inside-out direction. In a counterclockwise direction, 8 sutures were performed in a continuous fashion (Fig. 1C). This training was performed once for each participant to completely coaptate both ends of the rectal tubes, and the total console time was recorded.

Number of Participants for Each Phase and Statistical Analysis

After approval of the study from the local institutional review board, 50 medical school students participated in the RVS phase. A sample size analysis was performed to determine the minimum number of participants required for the hands-on phase. In this study, the correlation coefficient between the RVS phase variables and console time in the hands-on phase was calculated at a target value of 0.8. A minimum of 9 trainees were required to detect this level of association with 80% power, a 2-sided type I error rate of 0.05.[11]