Conventional Laparoscopic vs Robotic Training: Which is Better for Naive Users? A Randomized Prospective Crossover Study

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OBJECTIVE: Robotic training (RT) using the da Vinci skills simulator and conventional training (CT) using a laparoscopic "training box" are both used to augment operative skills in minimally invasive surgery. The current study tests the hypothesis that skill acquisition is more rapid using RT than using CT among naive learners.

DESIGN AND PARTICIPANTS: A total of 40 subjects without laparoscopic or robotic surgical experience were enrolled and randomized to begin with either RT or CT. Then, 2 specific RT tasks were reproduced for CT and repeated 5 times each with RT and CT. Time and quality indicators were measured quantitatively. A crossover technique was used to control for in-study experience bias.

RESULTS: The tasks "pick and place jacks" (PP) and "thread the rings" (TR) were achieved faster with RT than with CT despite crossover ($p < 0.0001$). An RT-favoring difference was observed in speed for both tasks when changing modality. Percentage improvement with increasing trials was similar for RT and CT: RT completion time averaged 39 seconds and 211 seconds (PP and TR, respectively), compared with 65 seconds and 362 seconds when using CT ($p < 0.0001$); final improvement averaged 26% and 46% for RT (PP and TR, respectively) vs 31% and 47% for CT (p was 0.76 for PP and 0.20 for TR). Within the PP task, RT times averaged 41 seconds without previous CT experience vs 35 seconds with previous CT experience ($p = 0.20$); CT times averaged 61 seconds without and 69 seconds with previous RT experience ($p = 0.48$). Comparable times for the TR task were 212 seconds vs 216 seconds ($p = 0.66$) and 388 seconds vs 334 seconds ($p = 0.17$). Both instrument collisions and excessive force occurred more commonly for RT than for CT within the TR task ($p < 0.0001$).

CONCLUSIONS: Speeds were faster overall with RT than with CT, but the percentage of speed improvement with trials was similar, suggesting similar learning curves, with minimal transfer effect appreciated. (J Surg 72:592-599. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: robotic training, conventional laparoscopy, learning curve, naive, transfer effect, efficient

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

INTRODUCTION

Though most minimally invasive surgeries are still performed with conventional laparoscopic techniques, robotic surgery (RS) is an increasingly common alternative modality, especially in urology, gynecology, and certain general surgical settings.[1,2] The da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA) is the only US Food and Drug Administration–approved surgical robotic assistant in the United States. It is widely considered to have the potential to compensate for technical drawbacks inherent in conventional laparoscopic surgery (CLS), such as limited degree of freedom, 2-dimensional (2D) vision, and fulcrum and pivoting effects. By contrast, advantages of RS include 3D, high-definition stereoscopic vision, hand tremor–canceling ability, and EndoWrist pivoting technology, allowing for enhanced dexterity, precision, and control.[3,4] The benefits of robotics seem more evident where a fine dissection and complex surgical reconstruction are required.[5] Even though movement dynamics of the robotic master manipulators are currently still believed to have room for future improvement,[6] current robotic systems show superior handling and ergonomics compared with

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  1931-7204/$30.00
http://dx.doi.org/10.1016/j.jsurg.2014.12.008

CLS techniques.[7,8] A clear advantage of CLS over current-generation RS is the presence of haptic feedback in CLS, which is absent in RS.

As RS systems, notably the da Vinci system, become increasingly mainstream and standard of care in certain well-defined surgical settings, the number of studies comparing RS and CLS has likewise increased. As a topic of comparative research, learning curves can inform surgical training and the adoption of new clinical procedures and devices; a representative review of learning-curve literature[9] has called for improved reporting and statistical evaluation of learning curves. However, most previous studies have included participants with varying degrees of experience, which complicates interpretation of this literature.

With this in mind, we wanted to test both learning effectiveness and transference of skill using the 2 training methods most commonly used by general surgical residents at our hospital: a standard laparoscopic "training box" and a da Vinci Surgical Skills Simulator (dVSSS). Each has predictive validity as a reliable bellwether of future clinical performance. We hypothesized that in naive users, the rate of skills acquisition (learning curve) would be faster with robotic training (RT) than with conventional training (CT).

MATERIALS AND METHODS

The subjects in the study were recruited from among medical students and junior surgical residents in the general surgery program at St. Agnes Hospital. Overall, 40 subjects were enrolled, of whom 32 were medical students and 8 were junior surgical residents, and 14 were women and 26 were men. Importantly, no subject had prior laparoscopic or robotic instrument experience: the junior residents, recruited and tested at the beginning of residency, were selected from foreign medical graduates who were unexposed to laparoscopic techniques in medical school. The medical students enrolled were third-year medical students on their surgical clerkships. Participants were enrolled after they signed consent forms and after approval was obtained from the Institutional Review Board.

The data were collected independently by 2 researchers. One researcher carried out instruction and camerawork, and the other did task assessment and data recording. The same roles were maintained in a consistent fashion throughout the study.

For the CT component of the study, the standardized workspace was reproduced uniformly and in consistent fashion for each participant; each was given a standardized oral explanation of the desired tasks and a manual demonstration of correct technique. In addition, a single explanatory demonstration of each of the tasks was performed by a researcher before commencement of the trials. Camerawork for each participant was carried out in a uniform fashion by the same researcher throughout. The data parameters were recorded on a standardized datasheet (Appendix A). All participants were allowed to ask questions, to which uniform answers were given (Appendix B) and to notify the researchers of technical or equipment-related difficulty, which was addressed by halting the clock and restarting when the issue had been addressed. All participants were prohibited from observing or communicating with each other about their study experience. The robotic simulation space was reproduced to scale and dimensions, as shown in Figure 1.

The materials used to carry out the study consisted of the Intuitive Surgical dVSSS, mounted on the da Vinci *Si* robotic console and scale wood-and-wire models of the pick and place jacks (PP) and thread the rings (TR) tasks from the dVSSS menu; needle holders 26173 KAR/KAL, Hopkins II 30° scope, and Tri-Cam NTSC camera system from KARL STORZ; TASKit laparoscopic training box and XCEL 12-mm trocars from Ethicon; and SL-693 C-14 needles with 2 in of 3-0 black Lactomer suture from Synetur.

Two dVSSS tasks, PP and TR were selected from its menu and reproduced to scale for CT. These were repeated

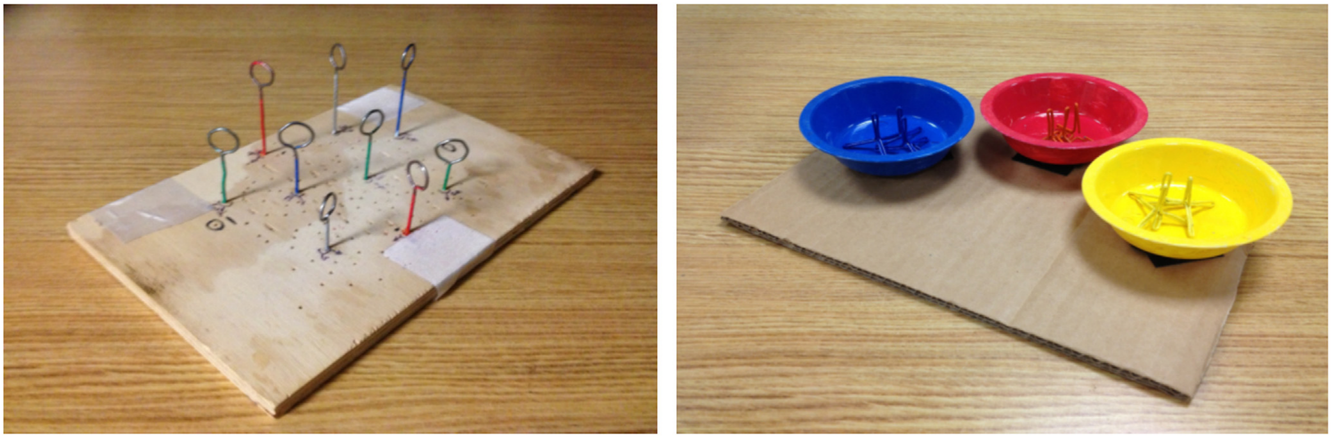

FIGURE 1. Reproductions of robotic tasks to scale for laparoscopic use, *left panel*: TR, *right panel*: PP.