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Construction of a Urologic Robotic Surgery Training Curriculum: How Many Simulator Sessions Are Required for Residents to Achieve Proficiency?

Scott Wiener, MD,[1] Peter Haddock, PhD,[2] Steven Shichman, MD,[3] and Ryan Dorin, MD[3]

Abstract

Purpose: To define the time needed by urology residents to attain proficiency in computer-aided robotic surgery to aid in the refinement of a robotic surgery simulation curriculum.

Methods: We undertook a retrospective review of robotic skills training data acquired during January 2012 to December 2014 from junior (postgraduate year [PGY] 2–3) and senior (PGY4–5) urology residents using the da Vinci Skills Simulator. We determined the number of training sessions attended and the level of proficiency achieved by junior and senior residents in attempting 11 basic or 6 advanced tasks, respectively.

Results: Junior residents successfully completed 9.9 ± 1.8 tasks, with 62.5% completing all 11 basic tasks. The maximal cumulative success rate of junior residents completing basic tasks was 89.8%, which was achieved within 7.0 ± 1.5 hours of training. Of senior residents, 75% successfully completed all six advanced tasks. Senior residents attended 6.3 ± 3.5 hours of training during which 5.1 ± 1.6 tasks were completed. The maximal cumulative success rate of senior residents completing advanced tasks was 85.4%.

Conclusion: When designing and implementing an effective robotic surgical training curriculum, an allocation of 10 hours of training may be optimal to allow junior and senior residents to achieve an acceptable level of surgical proficiency in basic and advanced robotic surgical skills, respectively. These data help guide the design and scheduling of a residents training curriculum within the time constraints of a resident's workload.

Introduction

Historically, surgical skills have been acquired through an apprenticeship-training model.[1] Restricted duty hours for residents in the United States, however, have made it challenging to schedule training sessions for residents in fundamental surgical skills.[2] To address this issue, computer-aided surgical training programs have become a more popular, contemporary option.[3] Modalities for this type of surgical simulation system include the use of case scenarios and procedural training (eg, laparoscopic box trainers, complex anatomically accurate models, and virtual reality simulations). Residents from the University of Connecticut Urology program rotating at our busiest clinical training hospital-Hartford Hospital-are enrolled in a unique milestone-based curriculum at the Center for Education, Simulation, and Innovation (CESI).[4]

Similar training programs have been developed, validated, and implemented across other surgical disciplines. Curry and associates[5] assessed the proficiency of otolaryngology residents using Objective Structured Assessments of Technical Skills in which residents participated in progressively more complex phases of oral robotic surgery. Their performance was tracked during training sessions scheduled at equal intervals, and their task efficiency and skills were measured with objective metrics. This study determined that trainees and experts had less objective differences in skills at the end of the study, consistent with significant improvement in baseline proficiency, particularly for trainee learners.

In a similar study, the progress of medical students with no previous robotic surgery experience in achieving competency in a range of simulated robotic surgical tasks was described.[6] The validated training regimen used in this study was based on the Fundamentals of Laparoscopic Surgery (http://www.fls.org) curriculum—a nationally recognized training and certification program for the acquisition of laparoscopic surgical skills.

At CESI, the robotic surgery skills training program for urology residents uses the da Vinci® surgical platform and its associated da Vinci Skills Simulator™ (dVSS). Residents

[1]Department of Urology, University of Connecticut Health Center, Farmington, Connecticut.
[2]Urology Division, Hartford Healthcare Medical Group, Hartford Hospital, Hartford, Connecticut.
[3]Department of Urology and Center for Education, Simulation, and Innovation (CESI), Hartford Hospital, Hartford, Connecticut.

undergo didactic training followed by a mentored selection of virtual reality exercises tailored to their proficiency level.[4] We have previously demonstrated that urology residents experience statistically significant improvements in their scores after participation in the program.[7]

In the current study, we assessed the progress of junior and senior urology residents in acquiring proficiency in basic or advanced robotic surgical tasks, respectively. Our aim was to define proficiency benchmarks and curriculum-training requirements for our residency program.

Methods

We undertook a retrospective review of training data acquired during 2012 to 2014 from urology residents participating in our institutional, computer-aided robotic skills training curriculum. Participation in this course is a mandatory component of urology residency training at Hartford Hospital. For junior residents, this course immediately follows completion of the online American Urological Association fundamentals of robotic surgery course (https://www.auanet.org/education/modules/robotic-surgery/module1.cfm).

On achieving proficiency in the dVSS virtual reality setting, junior residents progress to the dry laboratory where they are introduced to the da Vinci robotic surgery platform (ie, setup, docking, bedside assist techniques, and trouble shooting), before bedside assist in live surgical procedures. For senior residents, completion of the advanced robotic skills training curriculum is immediately followed by further dry laboratory training before console operation in live surgical procedures.

Residents were stratified according to postgraduate year ([PGY] junior: PGY2–3 and senior: PGY4–5). The relationship between training time and the successful completion of 11 basic robotic surgical tasks (Pegboard I and II, Matchboard I, Ring walk I–III, Suture sponge I, Needle targeting, Ring and rail II, Energy dissection II, and Dots and needles I) from the Intuitive dVSS skills exercises library by junior residents was assessed.[4] Similarly, the performance of senior residents in completing a set of six advanced surgical tasks (Tubes, Dots and needles II, Suture sponge II, Thread the rings, Energy dissection I, and Energy switching I) was determined.

Basic tasks were chosen based on their demonstrated ability to differentiate between novice and intermediate robotic surgeons in a previous validation study.[4] Advanced tasks were chosen based on their ability to differentiate between intermediate and expert robotic surgeons in the same validation study.[4]

Junior and senior residents participated in bi-weekly robotic skills training sessions of 2-hour duration over two, nonsequential 10-week periods each year. A single urologist with fellowship training in robotic surgery proctored each training session. At each scheduled training session, residents attempted a number of robotic skills, and the highest score attained for each exercise was recorded. Proficiency in an individual task was judged to have occurred when a score of ≥90% was achieved. Residents were encouraged (but were not required) to achieve proficiency at a given exercise before moving on to the next one. There was no minimum performance requirement within a training session. Participants did not necessarily attempt all of the tasks in a single session.

For an individual task to be completed successfully, a resident only needed to achieve a score of ≥90% once. We have anecdotal evidence that residents who are successful in scoring ≥90% at the first attempt are able to consistently maintain this level of performance on subsequent attempts. Residents who fail to achieve ≥90% at the first attempt tend to incrementally improve their score at reach an acceptable level of proficiency in subsequent attempts.[7]

To allow for potential outliers in both the junior and senior resident populations, the curriculum has a contingency to

Table 1. Successfully Completed Tasks by Residents at Each Sequential Simulator Session

	Junior residents								
	Number of basic tasks completed during each session								
Simulator hours	*JR1*	*JR2*	*JR3*	*JR4*	*JR5*	*JR6*	*JR7*	*JR8*	*Mean ± SD*
2	9	0	5	7	6	3	0	0	3.8 ± 3.5
4	1	4	1	3	2	5	8	2	3.3 ± 2.4
6	1	4	3	1	1	2	2	4	2.3 ± 1.3
8	-	3	-	-	-	1	0	-	1.3 ± 1.5
10	-	-	-	-	-	-	1	-	1.0 ± 0.0
Total completed tasks	11	11	9	11	9	11	11	6	9.9 ± 1.8
	Senior residents								
	Number of advanced tasks completed during each session								
Simulator hours	*SR1*	*SR2*	*SR3*	*SR4*	*SR5*	*SR6*	*SR7*	*SR8*	*Mean ± SD*
2	1	6	2	1	3	2	0	1	2.0 ± 1.9
4	3	-	-	1	3	3	2	0	2.0 ± 1.3
6	2	-	-	2	-	1	0	1	1.2 ± 0.8
8	-	-	-	0	-	-	0	0	0
10	-	-	-	2	-	-	1	4	2.3 ± 1.5
Total completed tasks	6	6	2	6	6	6	3	6	5.1 ± 1.6

SD = standard deviation.

Table 2. Summary of Robotic Skills Training Data for Junior and Senior Residents

		Juniors	*Seniors*
Number of residents		8	8
Tasks attempted by each resident	Basic tasks	11	-
	Advanced tasks	-	6
Residents who completed all tasks (n, %)		5 (62.5)	6 (75.0)
Number of hours training attended (mean ± SD)		7.0 ± 1.5	6.3 ± 3.5
Number of tasks completed (mean ± SD)	Basic tasks	9.9 ± 1.8	-
	Advanced tasks	-	5.1 ± 1.6
Total number of simulator hours attended (n, %)	2	0 (0)	2 (25.0)
	4	0 (0)	1 (12.5)
	6	5 (62.5)	2 (25.0)
	8	2 (25.0)	0 (0)
	10	1 (12.5)	3 (37.5)

allow training to continue until assigned tasks are completed with the required degree of proficiency. Typically, this only requires a resident to attend a single additional training session.

The purpose of the study was to assess the proficiency of residents as a function of training time, and to use these data to define a reasonable training period for our curriculum. We quantified the number of sessions that each resident attended, the number of tasks that were completed successfully, and the number of attempts each resident needed to complete each task.

Results

Junior residents

The performance of eight junior residents in completing each of the 11 robotic tasks in the basic curriculum was assessed over sequential, 2-hour training sessions. Overall, junior residents successfully completed 9.9 ± 1.8 tasks (Table 1). The numbers of successfully competed tasks during a 2-hour training session are shown in Table 1. A total of 5/8 (62.5%) junior residents completed all of the 11 basic tasks successfully within the duration of the study (Table 2). Each of the junior residents completed at least 6 hours (3 sessions) of training. The majority (62.5%), however, attended just 3 sessions (Table 2). On average, junior residents attended 7.0 ± 1.5 hours of robotic skills training (Table 2).

We determined the cumulative success rate of junior residents in completing the panel of 11 basic tasks (Fig. 1A). After completing their first session, junior residents succeeded in completing 34.1% of the basic tasks. At the end of the second sequential session, 63.6% of tasks were completed. Over a period of 10 hours (ie, five training sessions), the maximal cumulative success rate was 89.8% (Fig. 1B).

Senior residents

In contrast to their junior counterparts, the eight senior residents were asked to complete six advanced robotic surgical tasks. The number of successfully completed tasks during each sequential training session are shown in Table 1.

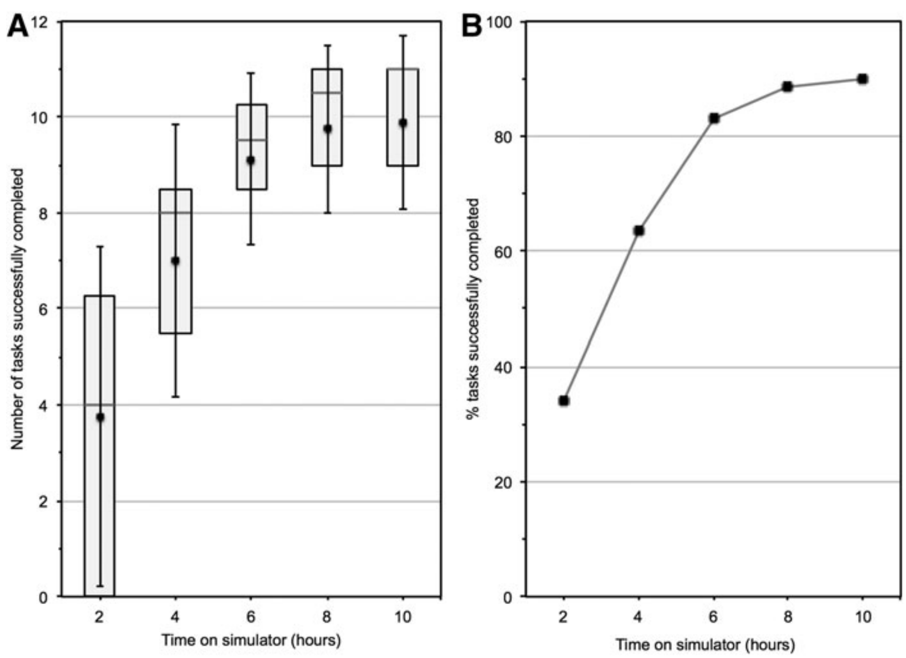

FIG. 1. (**A**) Cumulative number of basic tasks successfully completed by junior residents (data shown as mean ± standard deviation; median, and interquartile range). (**B**) Percent of basic curriculum completed by junior residents as a function of simulator time.

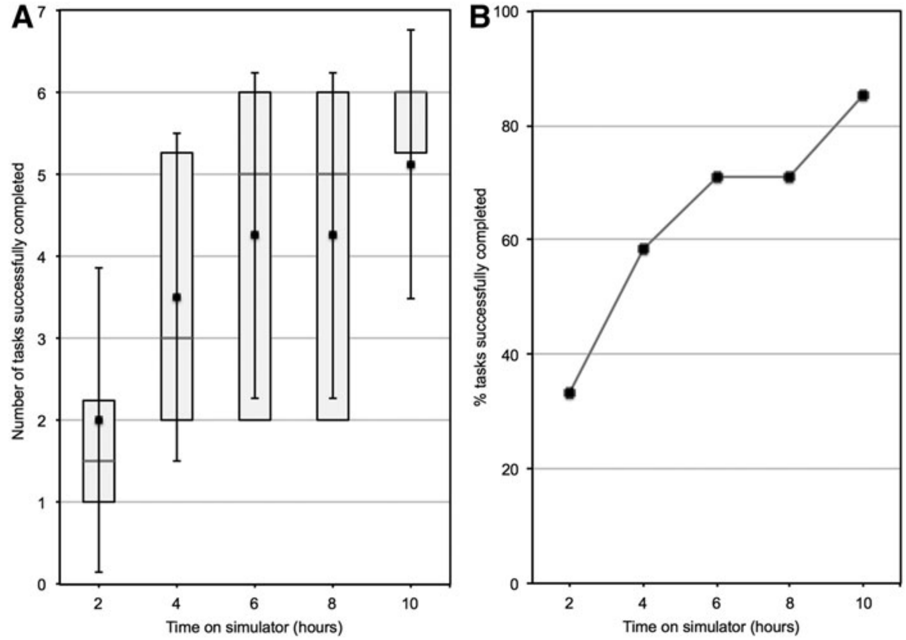

FIG. 2. (**A**) Cumulative number of advanced tasks successfully completed by senior residents (data shown as mean ± standard deviation; median, and interquartile range). (**B**) Percent of advanced curriculum completed by senior residents as a function of simulator time.

A total of 6/8 (75%) of senior residents successfully completed all of the six advanced tasks (Table 2). On average, each senior resident attended 6.3 ± 3.5 hours of training during which he or she successfully completed 5.1 ± 1.6 tasks (Fig. 2A and Table 2). A total of 5/8 (62.5%) of senior residents attended ≥6 hours of training (equivalent to three sequential sessions).

After completing their first session, senior residents succeeded in completing 33.3% of the advanced tasks. At the end of the second sequential session, 58.3% of tasks were completed successfully. Over a period 10 hours of training (ie, 5 sequential session) the maximal cumulative success rate was 85.4% (Fig. 2B).

Discussion

In recent years, duty-hour restrictions and the rapid implementation of a range of new technologies have provided the impetus to drive significant changes in how physicians are trained during their residency. The traditional apprenticeship model is becoming less feasible, with some studies reporting no console time for trainees in 24% of cases because of circumstances including case complexity, late hours, or limited trainee experience.[8]

The use of offline, computer-aided simulation platforms has been suggested as a potential tool to address these deficits.[9] While robotic surgery training in a virtual or otherwise simulated environment is not a perfect substitute for live operation, it may provide a valuable tool in which residents can master a series of standard surgical skills in a safe environment.

The relatively recent development, availability, and introduction of robotic skills simulators (both virtual reality and physical) have required existing training curricula to be reassessed and modified. We have modeled a formal robotic skills training curriculum for our residency program based on the Fundamentals of Laparoscopic Surgery course. The structure of this course incorporates a milestone-based system including online modules, simulation proficiency milestones, and one-on-one instruction in the laboratory with a fellowship trained robotic surgeon.

We have previously validated a robotics skills training course using the da Vinci surgical platform and its associated da Vinci dVSS simulation environment.[4] In this study, we demonstrated that scores on 11 basic tasks (Table 1) and 6 advanced tasks consistently distinguished novice from intermediate robotic surgeons and intermediate from expert robotic surgeons, respectively. Furthermore, novices achieved statistically significant improvements in scores for each module after completing this curriculum.[7]

In the current study, we sought to establish the learning curve for junior and senior resident participants to set benchmarks to guide the refinement of our training curriculum. In particular, we wished to define the number of hours of training needed by both junior and senior residents to achieve an acceptable degree of proficiency across each of the respective basic and advanced tasks. This information can be utilized to design an efficient curriculum that ensures adequate training and proficiency for the minimal time commitment.

In our study, this time commitment was approximately 10 hours, split between five sequential sessions, each of 2 hours duration. While additional sessions are likely to increase the cumulative success by junior and senior residents, the most significant improvement occurred within the first 10 hours of training.

Our data suggest that for residents who fail to complete all of the tasks within five sessions, an additional short period of training (1–2 sessions) is likely to result in their achieving proficiency in all tasks. Building in some flexibility to accommodate ''outliers'' is an important feature that we have incorporated into our training curriculum.

The goal of our study was to identify a training program that was both manageable within a resident's schedule and rigorous enough to ensure that the majority of residents achieve a high degree of proficiency within this period. As such, we suggest that 10 hours (or five sequential sessions, each of 2 hours duration) is a reasonable time to budget within our resident training curriculum.

A limitation of this study is that many participants had exposure to the dVSS surgical simulator before starting the milestone based training, including the senior residents, some of whom had operated at the console in live surgery before our initiation of the formal curriculum. Furthermore, as has been demonstrated,[4] the presence of an expert proctor hastens acquisition of proficiency in the simulation laboratory. Thus, a completely robotic naïve cohort of residents training independently may require more than 10 hours to achieve proficiency. Future curriculum validation studies on more diverse trainee groups are needed to provide this information.

Another potential limitation of our study is the selection of ≥90% total score on each exercise as our benchmark for achieving proficiency. This was based on two previous studies in which experienced robotic surgeons scored an average of 87.4%, and 88% across all dVSS exercises[4,10] on their first attempt. Although we think this represents a useful benchmark, it is not a score that has been proven to predict successful performance of live robotic surgery in a novice trainees peer-reviewed study. To our knowledge, such data have not been published yet.

The question of how proficiency in performing these robotic tasks in a simulation environment translates into performance in the operating room is a valid one. In our experience, junior residents who achieve ≥90% in basic tasks are proficient to subsequently perform well in the more advanced tasks. Similarly, the advanced tasks have proved to be a useful precursor to undertaking live operation. In addition, our attending surgeons believed that participation in the curriculum significantly improved residents' surgical skills and that they were more likely to give residents more live console training time.[7]

We acknowledge, however, that surgical training in a simulation environment is not a perfect substitute for hands-on experience in a live surgery setting. As such, our goal is to provide a training program that allows residents to become familiar with the robotic surgical platform and a range of commonly used techniques. On completion of the training program, our residents subsequently participate in live operations where they continue to receive one-on-one training and hands-on experience in a real-life setting.

Finally, we did not undertake a prospective study because of resource limitations and a requirement to acquire data to define the curriculum requirements in a rapid and efficient manner. As such, we used retrospective data that had already been acquired over the previous 12 months. We plan to regularly assess the effectiveness of our 10-hour training program and refining it accordingly as we acquire data from additional residents. In the future, we also wish to assess the predictive validity of skill training scores in predicting clinical performance on the robot in live operations.

Conclusion

In this study, urology residents training in robotic surgery needed up to 10 hours of proctored virtual reality robotic simulation to achieve proficiency in their assigned list of simulated tasks. These data may be useful in optimizing a robotic surgery training curriculum.

Author Disclosure Statement

No competing financial interests exist.

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Address correspondence to:
Peter Haddock, PhD
Urology Division
Hartford Healthcare Medical Group
85 Seymour Street, Suite 416
Hartford, CT 06106

E-mail: peter.haddock@hhchealth.org

Abbreviations Used

CESI = Center for Education, Simulation, and Innovation
dVSS = da Vinci Skills Simulator
PGY = postgraduate year