Incorporation of the da Vinci Surgical Skills Simulator at urology Objective Structured Clinical Examinations (OSCEs): a pilot study

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Introduction: *To incorporate the da Vinci Surgical Skills Simulator (dVSSS) into Objective Structured Clinical Examinations (OSCEs) and to assess basic robotic skills of urology Post-Graduate Trainees (PGTs).*

Materials and methods: *PGTs in post-graduate years (PGY-3 to PGY-5) from two Quebec urology training programs were recruited. During a 20 minute OSCE station, PGTs were asked to fill in a questionnaire and perform two tasks: pick and place, and energy dissection level 1. For each exercise, the norm-referenced method was used to establish a passing score to determine competency. The participant was considered competent in these two basic dVSSS exercises if he/she gained the passing score on both tasks.*

Results: *All nine PGTs who attended the OSCE voluntarily participated in the study. They had performed a median of 10 (IQR: 2.5-16) laparoscopic procedures, 2 (0-8) robotic procedures, and assisted 10 (IQR: 0-15) robotic procedures at the bedside prior to this OSCE. Based on a passing score of 90 for task 1 and 72 for task 2, there were 3 (33%) competent PGTs, all of whom were from PGY-5 level. Therefore, there was significant difference among PGY levels in terms of competency for the basic robotic skills tested ($p = 0.01$). When compared with PGTs, experts had performed significantly higher numbers of robotic procedures (5.2 ± 2.4 versus 25 ± 8.7; $p = 0.02$). However, there was no significant difference in the performance parameters between PGTs and experts in both tasks.*

Conclusion: *This study confirms the feasibility of incorporating dVSSS into OSCEs to assess basic robotic skills of urology PGTs. Future studies need to include more complex exercises and larger sample size to expand on these results.*

Key Words: incorporation, robotics, simulation, urology

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Introduction

The availability of virtual reality simulators and incorporation of Competency Based Medical Education (CBME) in surgical training frameworks have made a paradigm shift in training curricula and technical skills assessment methods.[1-4] In light of recent restrictions on trainee hours and increased concerns over patient safety, virtual reality simulators have been introduced for purposes of training and objectively assessing competency of trainees in their technical skills.[5-8] Currently, robotic-assisted laparoscopic radical prostatectomy is the most common surgical extirpative therapy for the management of prostate cancer.[9,10] Although roboticassistance makes laparoscopic surgery easier, there is still a learning curve in achieving optimal results.[11] There are several commercially-available simulators to train basic robotic surgical skills such as the da Vinci Surgical Skills Simulator (dVSSS) (Intuitive Surgical, Inc., Sunnyvale, CA, USA), dV-Trainers (MIMIC Technologies, Inc., Seattle, WA, USA) and RoSS (Simulated Surgical Systems, LLC, San Jose, CA, USA).[12,13] The dVSSS has been recently validated for training in robotic skills.[14-18] However, the dVSSS has not been previously used to assess basic robotic skills of urology post-graduate trainees (PGTs) during Objective Structured Clinical Examinations (OSCEs).

The Royal College of Physicians and Surgeons of Canada and the American Board of Surgery are moving towards incorporating technical skills assessment during oral board exams. Previously, several low-fidelity and high-fidelity simulators have been incorporated into the semi-annual urology OSCEs to assess basic laparoscopic and endourologic skills.[8,19,20] However, basic robotic skills of urology PGTs have not been assessed during OSCEs. Therefore, the aim of the present study was to incorporate the dVSSS to assess basic robotic skills of urology trainees' at a semi-annual OSCE.

Materials and methods

The da Vinci Surgical Skills Simulator

The da Vinci Surgical Skills Simulator (dVSSS) using Mimic software has been previously described,[14-16,18] Figure 1a. The advantages of the dVSSS include the use of the same "Si console" of the da Vinci surgical system, which means that the trainee acquires robotic skills using the same endowrist manipulations in addition to the foot controls that are used in the operating room. Two tasks were chosen for this study. The first was to assess endowrist manipulation using the pick and place task. The second was to assess dissection and energy control using the energy dissection level 1. At the end of each task, the dVSSS generates an overall score based on different metrics including economy of motion measured as the total distance (in centimeters) traveled by all instruments, time to complete exercise measured as the total time (in seconds) the participant spends on the exercise, instrument collisions defined as the total number of instrument-on-instrument collisions exceeding a minimum force threshold, master workspace range defined as the diameter (in centimeters) of participant's working volume on master grips, instruments out of view defined as the total distance (in centimeters) traveled by instruments outside the participant's field of view, excessive force defined as the total time (in seconds) an excessive instrument force is applied above a prescribed threshold, drops defined as the number of times objects are dropped in an inappropriate region of the scene, and misapplied energy time defined as the total time (in seconds) an incorrect energy is applied to a target or energy is enabled while not touching a target.[16]

Study design

Ethics approvals were obtained from both McGill University (No: A11-E86-14A) and Sir Mortimer B. Davis Jewish General Hospital. PGTs in post-graduate years (PGY-3 to PGY-5) from two urology training programs in Quebec who showed up for the OSCE on March 28, 2015 were recruited in this study after signing written informed consents. Urology training is 5 years in Canada. One of the OSCE stations was replaced by the dVSSS station in the operating room. During the 20-minute station, participants were brought to the operating room housing the dVSSS to assess their basic robotic skills in endowrist manipulation and control of bipolar energy. Participants were asked to fill out a questionnaire regarding their age, gender, PGY level, handedness, previous laparoscopic and robotic experience within the previous 6 months. In addition, participants were asked about the number of hours of practice per week on the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills (MISTELS). Every participant underwent the same 2 minute orientation session on the dVSSS before he/she was asked to perform the two tasks on the simulator. The orientation session included adjustment of the console to the height of the participant so that he/she was comfortable. In addition, each component of the console was demonstrated including the unipolar and bipolar cautery, camera set up and endowrist instruments. Task 1 was the pick and place, where participants picked up objects and placed them in the same colored-bins. Task 2 was the energy dissection level 1, where participants cauterized the small feeding vessels using bipolar cautery and cut them using scissors, Figure 1b and 1c. Before starting task 2, all participants watched a 2 minute orientation video that demonstrated the task. At the end of the OSCE, data gathered from the questionnaires and the dVSSS were analyzed.

The norm-referenced method was used to set a passing score to determine competency in these two dVSSS excercises.[8,21] Three robotic experts who

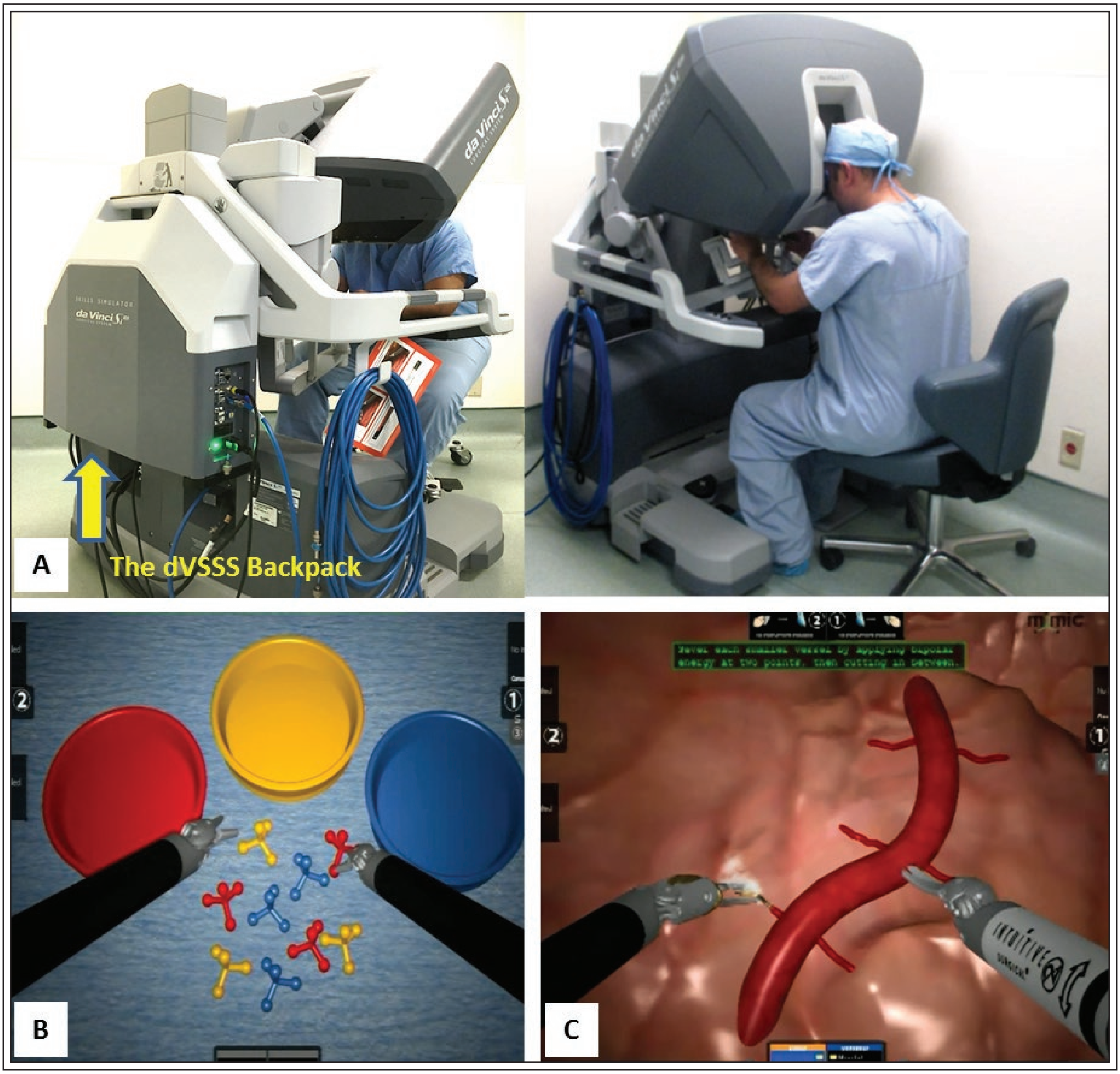

Figure 1. A) The da Vinci Surgical Skills Simulator (dVSSS) backpack on the Si console from Intuitive Surgical, Inc. (Sunnyvale, CA, USA) using the Mimic software (Mimic Technologies, Inc., Seattle, WA, USA). **B)** Pick and place task: participants need to pick up objects and place them in the same colored-bins. **C)** Energy dissection level 1: participants need to cauterize the small feeding vessels using bipolar cautery and cut them using scissors.

attended the OSCE were invited to participate in the study by filling the questionnaire, receiving the same orientation session, and performing the two tasks within 20 minutes. The pass score was calculated as the average of the experts' total scores minus one standard deviation for each task. Therefore, for task 1, the cut off for competency was 90 (93 – 3) and for task 2 was 72 (84 – 12).

Statistical analysis

Data analysis was performed using the Statistical Package of Social Sciences for Windows (SPSS, Chicago, IL, USA) version 20. Descriptive data were presented in terms of medians and inter-quartile ranges or numbers and percentages, whenever appropriate. Categorical variables were compared using Fisher's exact test while continuous variables

TABLE 1. **Comparison of non-competent and competent post-graduate trainees (PGTs)**

Variable	**Non-competent PGTs (n = 6)**	**Competent PGTs (n = 3)**	**p value**
Age (years)	30.7 ± 1.9	31.7 ± 0.3	0.15
Male gender	5 (83.3%)	3 (100%)	0.99
Post-graduate year (PGY)			0.01
PGY-3	3 (100%)	0 (100%)	
PGY-4	3 (100%)	0 (100%)	
PGY-5	0 (0.0%)	3 (100%)	
Laparoscopic cases in the previous 6 months	5.8 ± 2.1	20 ± 5.8	0.05
Robotic cases in the previous 6 months (as a surgeon)	2.5 ± 1.0	10.7 ± 6.4	0.29
Robotic cases in the previous 6 months (as a bed side assistant)	9.3 ± 2.3	16.7 ± 16.7	0.59
Hours of practice on MISTELS / week	0.66 ± 0.4	0.0 ± 0.0	0.28
Task 1			
Time to complete exercise (30-120 sec)	76.2 ± 9.7	94.3 ± 5.7	0.19
Economy of motion (100-200)	56.3 ± 5.7	69.3 ± 8.9	0.36
Instrument collision (0-5)	90 ± 6.8	100 ± 0.00	0.29
Drops (0-5)	100 ± 0.00	100 ± 0.00	0.99
Instrument out of view (0-5)	100 ± 0.00	100 ± 0.00	0.99
Master work place range (1-15)	98.3 ± 1.7	100 ± 0.00	0.48
Excessive instrument force (0-5)	100 ± 0.00	100 ± 0.00	0.99
Task 1 total score	**87.5 ± 1.8**	**94 ± 0.6**	**0.02**
Task 2			
Time to complete the exercise (120-240 sec)	59.2 ± 14.9	100 ± 0.0	0.05
Economy of motion (150-500)	94.7 ± 5.1	100 ± 0.0	0.29
Excessive instrument force (0-5)	90 ± 10	100 ± 0.0	0.48
Instrument collision (0-5)	53.3 ± 16.9	73.3 ± 26.7	0.49
Instrument out of view (0-5)	100 ± 0.0	100 ± 0.0	0.99
Master work place range (1-15)	91 ± 9.0	100 ± 0.0	0.48
Misapplied energy time (5-20)	38.5 ± 13.4	14.7 ± 14.7	0.28
Blood loss volume (0-50)	27 ± 15.9	66 ± 7.2	0.12
Broken blood vessels (0-1)	100 ± 0.0	100 ± 0.0	0.99
Task 2 total score	**70.8 ± 5.6**	**82.0 ± 5.3**	**0.19**

data are presented in mean ± standard error or number (percentage %)

were compared by Mann-Whitney U-test and Kruskal-Wallis test with significance detected at two tailed p value < 0.05.

Results

All nine PGTs, from two urology programs in Quebec, who attended the OSCE, voluntarily participated in the current study. There were three PGTs from each of PGY-3, PGY-4, and PGY-5 levels. All PGTs were right handed. The median age was 31 years (IQR: 29-32) with 88.9% being male participants. They had performed a median of 10 (IQR: 2.5-16) laparoscopic procedures, 2 (0-8) robotic procedures, and 10 (IQR: 0-15) robotic procedures at the bedside prior to this OSCE. There was no significant difference among PGY-3, PGY-4, and PGY-5 PGTs in terms of mean number of laparoscopic cases performed (4.3 ± 2.3, 7.3 ± 3.7, 20 ± 5.8; p = 0.12), mean number of robotic cases performed (1.7 ± 1.7, 3.33 ± 1.33, 10 ± 5.8; p = 0.38) and mean number of robotic cases assisted at bedside (8.33 ± 4.4, 10.33 ± 2.6, 16.7 ± 16.7; p = 0.83), respectively. In addition, there was no significant difference among PGY levels in all of the simulator metrics in both tasks (all p values > 0.05).

TABLE 2 . **Comparison between post-graduate trainees (PGTs) and experts**

Variable	**PGTs (n = 9)**	**Experts (n = 3)**	**p value**
Age (years)	31 ± 1.3	48.3 ± 3.8	0.01
Male gender	8 (88.9%)	3 (100%)	0.99
Laparoscopic cases in the previous 6 months	10.6 ± 3.2	9 ± 3.8	0.93
Robotic cases in the previous 6 months (as a surgeon)	5.2 ± 2.4	25 ± 8.7	0.02
Robotic cases in the previous 6 months (as a bed side assistant)	11.8 ± 5.2	1. 7± 1.7	0.15
Hours of practice on MISTELS/week	0.44 ± 0.3	0.0 ± 0.0	0.39
Hours of practice on the da Vinici SSS/week	0.33 ± 0.2	0.0 ± 0.0	0.39
Task 1			
Time to complete exercise (30-120 sec)	82.2 ± 7.1	96.3 ± 3.7	0.21
Economy of motion (100-200)	60.7 ± 04.9	67.7 ± 014.4	0.64
Instrument collision (0-5)	93.3 ± 4.7	100 ± 0.0	0.39
Instrument out of view (0-5)	100 ± 0.0	100 ± 0.0	0.99
Master work place range (1-15)	100 ± 0.0	98.9 ± 1.1	0.56
Excessive instrument force (0-5)	100 ± 0.0	100 ± 0.0	0.99
Task 1 exercise score	**89.7 ± 1.6**	**93.3 ± 1.8**	**0.19**
Task 2			
Time to complete the exercise (120-240 sec)	72.8 ± 11.8	93.7 ± 6.3	0.37
Economy of motion (150-500)	96.4 ± 3.4	92.7 ± 7.3	0.71
Excessive instrument force (0-5)	93.3 ± 6.7	96.7 ± 3.3	0.47
Instrument collision (0-5)	60 ± 13.7	100 ± 0.0	0.12
Instrument out of view (0-5)	100 ± 0.0	100 ± 0.0	0.99
Master work place range (1-15)	94 ± 6	100 ± 0.0	0.56
Misapplied energy time (5-20)	30.6 ± 10.4	23.7 ± 12.1	0.63
Blood loss volume (0-50)	40 ± 12.3	64.3 ± 28.1	0.26
Broken blood vessels (0-1)	100 ± 0.0	100 ± 0.0	0.99
Task 2 exercise score	**74.6 ± 4.3**	**84.3 ± 7.2**	**0.16**

data are presented in mean ± standard error or number (percentage %)

None of the participants including the experts had a chance to practice on the dVSSS prior to the study. According to a passing score of 90 for task 1 and 72 for task 2, there were 3 (33%) PGTs who were competent on both tasks. There was significant difference among PGY levels in terms of competency since all 3 competent PGTs were from PGY-5 level (chief-resident year) (p = 0.01), Table 1. When compared with non-competent PGTs, competent PGTs had significantly better mean total score on task 1 (87.5 ± 1.8 versus 94 ± 0.6; p = 0.02). However, there was no statistically significant difference between both groups for total score on task 2 (82.0 ± 5.3 versus 70.8 ± 5.6; p = 0.19).

When compared with PGTs, experts were significantly older (31 ± 1.3 versus 48.3 ± 3.8; p = 0.01) and had performed significantly higher numbers of robotic procedures (5.2 ± 2.4 versus 25 ± 8.7; p = 0.02), Table 2. However, this did not translate into a significant difference between PGTs and experts on metrics measured during both tasks.

Discussion

There is a substantial increase in the number of robotic surgeries over the last few years with an average yearly increase of about 9% from 2009-2014. For example, the overall number of robotic procedures performed worldwide has increased from 205,000 in 2009 to 278 000 in 2010.[22] In the current study, the dVSSS was successfully incorporated into a semi-annual urology OSCE to assess competency of urology PGTs in performing basic robotic skills. However, there are no established competencies for robotic skills. Competency is defined as "an observable ability of a health professional, integrating multiple components such as knowledge, skills, values, and attitudes".[3] Competency-based medical education (CBME) has been recently defined as "an outcomes-based approach to design, implementation, assessment, and evaluation of medical education programs".[3] There is neither globally agreeable definition for what constitutes technical competence, standard method for assessing technical competence, nor setting a pass score for competency during OSCEs.[23] Recently, there have been several attempts to improve technical competency assessment by making the process more objective using different validated tools such as the Objective Structured Assessment of Technical Skills (OSATS) tool and the virtual-reality high-fidelity simulators during OSCEs.[8,20,24] Recent studies have shown that the GreenLight simulator and the PERC Mentor simulator could be used to assess competency of urology PGTs in photoselective vaporization of the prostate and obtaining percutaneous renal access, respectively.[8,20,24] There are various methods to set a cut off score for competency. However, there is no standardized one.[21] In this study, the norm-referenced method was used.[21] We found it more appropriate for assessment of technical skills of PGTs as the cut off score of competency is calculated based on the average scores of experts minus one standard deviation. This makes the cut off score more flexible and not arbitrary such as when using the 50th percentile or the 60th percentile.

In the present study, there was significant difference among PGY levels in terms of competency in these two dVSSS exercises ($p = 0.01$). However, there was no significant difference between experts and PGTs in terms of metrics measured and total tasks scores (p values > 0.05). There are several reasons to explain these findings. First, the low level of difficulty of both tasks. Second is the small sample size. Despite recruiting all PGTs from PGY3-5 from two Quebec urology programs, there were only nine PGTs versus three experts. Third, PGTs in the present study could be considered intermediates in terms of experience. In a previous study, there were no significant differences among experts and intermediates in most tasks on the dVSSS. Although energy dissection level 1 was able to distinguish between intermediates and experts in terms of total scores (84 versus 96; $p = 0.03$), there was no significant difference between intermediates and experts in terms of other metrics measured.[18] In another study comparing novices, intermediates, and experts, none of the five tasks used was able to distinguish intermediates from experts.[17] The only study demonstrating significant differences among novices, intermediates and experts on 10 tasks including energy dissection level 1 was the study by Hung and colleagues.[14] Perhaps they were able to demonstrate significant difference due to large number of intermediates (32) and experts (15) in addition to 16 novices composed of medical students.[14] However, they did not perform post-hoc analysis to compare intermediates and experts alone.[14] There were two reasons why we did not use more complicated skills: first, none of the participating PGTs had previously practiced on the simulator prior to this OSCE. Second, the time limit of OSCE station was limited to only 20 minutes. In addition, since the objective of the present study was to assess basic robotic skills of urology PGTs during OSCEs, medical students (novices) were not included in the present study.

Finally, while the dVSSS was able to assess competency in basic robotic skills among different PGY levels, it suffers from several disadvantages. First, the high cost of the dVSSS makes it difficult to be acquired by urology training programs. Second disadvantage is that PGTs can not practice on the dVSSS during working hours while the console is being used for robotic-assisted procedures in the operating room. Third, it is a software-based high-fidelity simulator which may malfunction during practice or assessment. During the present study, while assessing one of the experts, the dVSSS malfunctioned and necessitated restarting the simulator.

This study has several limitations which could be addressed as follows: first, the small sample size despite recruiting PGTs from two urology programs. Second, all PGTs and experts had no chance to practice on the simulator prior to the study. Although this is useful in obtaining baseline assessment of all participants, it was not possible to determine the effect of previous practice on the simulator. The lack of previous practice on the simulator was also the reason why basic robotic exercises were used in the present study. Third, this study included only two tasks as the OSCE station was limited to 20 minutes. Nonetheless, this is the first prospective study to incorporate the dVSSS at urology OSCEs for assessment of competency of PGTs in performing basic robotic tasks.

Conclusions

This study confirms the feasibility of incorporating dVSSS into OSCEs to assess basic robotic skills of urology PGTs. Future studies need to include more complex exercises and larger sample size to expand on these results.

Conflict of interest

No financial relationships with Intuitive Surgical or Mimic Technologies. □

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