Construct validity of the LapSim virtual reality laparoscopic simulator within a urology residency program

Evan Kovac, MD, CM; Raed A. Azhar, MD; Adrienne Quirouet, MD; Josee Delisle, RN, BSc, MSc; Maurice Anidjar, MD, PhD

Division of Urology, Department of Surgery, McGill University Health Center, Montreal, Quebec, Canada

Cite as: *Can Urol Assoc J* 2012;6(4):253-9. http://dx.doi.org/10.5489/cuaj.12047

Abstract

Objective: We assessed the construct validity of the LapSim laparoscopic surgical simulator in a urology residency training program.
Methods: In total, 15 residents participated in the study between July 2007 and July 2008. The subjects were tested six times at one-month intervals on three skill tasks (lifting and grasping, cutting and clip application) using the LapSim laparoscopic simulator. The testing sessions were divided into the first three sessions (seminar 1), and the subsequent three sessions (seminar 2). We evaluated the following parameters: total time, path length, angular path length, tissue damage, maximum damage and stretch damage. The subjects were divided into junior (PGY 1,2) and senior resident groups (PGY 3,4,5). The Wilcoxon Signed-Rank test for paired samples was used to compare the performances of the juniors and seniors during seminar 1 to their performance in seminar 2 to determine whether there was improvement over time. The Wilcoxon Rank-Sum test for independent samples was used to compare the performance of the juniors to that of the seniors for seminar 1, seminar 2 and the combination of both seminars to determine whether the more experienced senior residents performed better than the less experienced juniors.
Results: No significant performance improvement between testing sessions could be demonstrated. Similarly, there was no significant difference in performance between junior and senior residents.
Conclusions: Construct validity could not be demonstrated for the total time, path length, angular path length and tissue handling parameters of the LapSim laparoscopic surgical simulator when examined within the context of a urology residency program.

Introduction

The teaching of surgical skills has traditionally been based on an apprenticeship model. Although this type of training remains an essential component of residency programs, there has been tremendous interest in identifying and implementing additional curricula to serve as adjunct teaching methods. There is broad consensus that surgical trainees should acquire and demonstrate competency prior to performing procedures on patients. This scenario makes sense from both an ethical and an economic standpoint in an era in which patient safety is the foremost priority and operating room time constraints are increasing.[1]

There have been tremendous advances in minimally invasive techniques in urology in the last decade. It is clear that these techniques demand a different set of skills than those used for open surgery. Many simulators have been created to assist trainees in acquiring these skills, but none has been accepted as the gold standard. The two main types of simulators have been physical (box) trainers and virtual reality (VR) simulators, each of which confers unique advantages.[2,3] VR simulators are purportedly able to assess performance without requiring subjective human observation, but have been criticized for their lack of haptic feedback. According to various studies, force (tactile) feedback is fundamental for good laparoscopic training and results in significantly improved skills transfer to the trainee compared with training without force feedback.[4-6] Whether these simulators are able to meaningfully assess performance remains to be demonstrated.

Surgical simulation has become an important part of many residency-training programs. For these systems to be accepted and successfully integrated into teaching curricula, it is important that their construct validity be demonstrated. Therefore, validation is essential for proving the importance of this type of training and for justifying the associated costs. Our group previously demonstrated construct validity of the ProMIS (Haptica, Ireland) hybrid simulator for assessing laparoscopic smoothness in our centre's urology laparoscopic training program. Using the same methodology, we investigated whether a well-studied VR simulator, such as LapSim, could also demonstrate construct validity in our minimally invasive education program.

Methods

Between July 2007 and July 2008, 15 urology residents from PGYs (post-graduate years) 1 to 5 participated in the study. Residents were tested within the context of their monthly laparoscopic skills evaluation, which is part of the McGill urology residency minimally invasive surgery (MIS) program curriculum. The McGill urology MIS program consists of laparoscopic physical box simulator and operative-based training, designed to teach and maintain basic laparoscopic skills. Residents receive MIS training in the first month of residency and are assessed at monthly intervals. Scores are derived using built-in simulator assessment tools. In addition, residents are expected to practice their laparoscopic skills at least four hours per month using either physician simulators or operating room exposure under the direct supervision of attending staff; residents also must log their practice time. Residents begin their laparoscopic training at the PGY-1 level continue until the end of residency (PGY-5). Residents are expected to attain increasing normalized scores by the end of each year of residency. In addition, laparoscopic experiences and expectations evolve as residents progress through the program, with junior residents receiving most of their laparoscopic operating room training under the umbrella of general surgery and their respective procedures aimed at residents in their first two years of training (e.g., laparoscopic cholecystectomy). Once residents begin year three of their training, laparoscopic responsibilities evolve annually and culminate in the fifth year with PGY-5 residents assisting during the most advanced and surgically challenging cases (i.e., radical laparoscopic prostatectomy, partial and radical laparoscopic nephrectomy). In general, laparoscopic cases increase in number and complexity as residents move from general surgery to urology. However, in our study, case logs were not compared between junior and senior residents. Based on the amount of MIS operative exposure and the evolution of exposure from more simple to an increasing complexity of cases, we hypothesized that senior residents would perform better on the LapSim simulator than junior residents.

For the purposes of our study, residents were evaluated on a novel simulator during their routine monthly assessment appointments. Participants were categorized into junior (PGY-1,2) and senior (PGY-3,4,5) residents. At each session, the resident was tested on the lifting and grasping, cutting and clip-applying tasks on the LapSim simulator. All tasks were performed during the same session and in succession. Tasks were performed once, each, and not repeated until the next monthly session. All participants were naïve to LapSim prior to commencing the study. Therefore, an orientation to the LapSim system was given prior to beginning the study. Our group previously demonstrated construct validity of the ProMIS (Haptica, Ireland) using a similar cohort and 6 training sessions for each group of residents.[7] Therefore, for our current study, each resident was tested 6 consecutive times at 1-month intervals. The 6 testing sessions were divided into seminar 1 (sessions 1 to 3) and seminar 2 (sessions 4 to 6). Contrary to the normal protocols of the McGill MIS program, there were no practices in-between testing sessions, so experience and advantage were the same for all participants.

The VR simulator used in this study was the LapSim version 2.0 (Surgical-Science, Goteborg, Sweden). The simulator consists of software run on a dual processor Pentium III computer (Dell) using Windows 2000. The computer is equipped with 256 MB RAM, a 14-in monitor, and a virtual laparoscopic interface manufactured by Immersion Inc. (San Jose, CA) that includes two laparoscopic handles.

The LapSim tasks evaluated in this study were (1) lifting and grasping; (2) cutting; (3) clip application (Fig. 1, Fig. 2, Fig. 3). These were chosen because they were judged to have the greatest face validity by the attending urology MIS staff at our centre.

We assessed total time, economy of movement and the parameters pertaining to tissue handling to determine whether this system, which lacks haptic feedback, could meaningfully evaluate a subject's respect for tissue (Table 1).

In the lifting and grasping task, the subject must lift a box with one instrument, grasp a needle from under it with the other and then place the needle in a target area. Once the needle is released, a new box appears on the opposite side and the task is repeated.

In the cutting task, there is a structure representing a vessel. One of the subject's instruments is a grasper, and the other is a pair of ultrasonic scissors. The subject must grasp the loose end of the vessel and stretch it; then, the segment to be cut changes colour. The subject must then place the scissors over this area and use the diathermy pedal to cut the appropriate area. Once excised, the segment is placed into a target area. When the segment is released, the task is repeated again using the opposite hand.

Fig. 1. LapSim virtual reality simulator: "Lifting and grasping task."

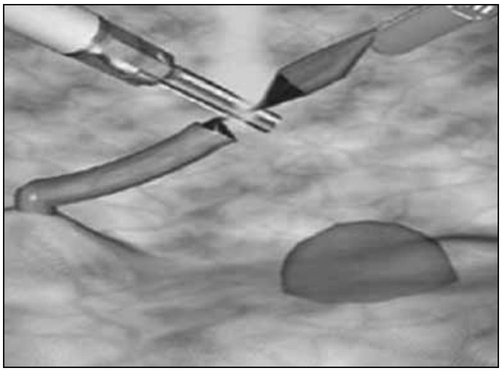

Fig. 2. LapSim virtual reality simulator: "Cutting task."

In the clip application task, a structure representing a vessel must first be stretched, then clipped on two, spaced target areas. The vessel is then cut between the clips.

The total time is measured in seconds. The tissue damage is the total number of times the tissue is hit by both instruments. The maximum damage is the maximum depth to which the tissue is damaged by an instrument and is measured in millimeters. The maximum stretch damage is a measure of excessive stretch on the vessel; this is measured as a percentage, where 100% represents a vessel that is stretched to the point of ripping off and bleeding. The path length is measured in millimeters and the angular path length is measured in degrees.

Statistical analysis was performed. To determine whether there was an improvement in performance over time, separately for junior residents and senior residents, we compared the scores obtained during seminar 1 to those obtained during seminar 2 using the Wilcoxon Signed Rank test for paired samples. To determine whether the experienced senior residents could be distinguished from the junior residents, we compared scores using the Wilcoxon Rank Sum test for independent samples. Comparisons were made for measurements for the first 3 sessions (seminar 1), for the last 3 sessions (seminar 2), and for all the sessions together. When comparing between seminars, in order to provide a single measurement per subject per seminar, the three measurements per subject were combined into a mean measurement. When all sessions were compared, a single measurement per subject was computed as the mean of the 6 sessions.

All analyses were done using SAS, version 9.2 (SAS Institute Inc., Cary, NC. Data were presented as median and interquartile range (IQR). All statistical hypothesis tests were two-sided and performed at the 0.05 significance level.

Results

When comparing within junior residents, the only parameters that showed a statistically significant difference were the path length in the cutting task and the maximum damage in the lifting and grasping task (p= 0.03 and p = 0.04, respectively) (Table 2).

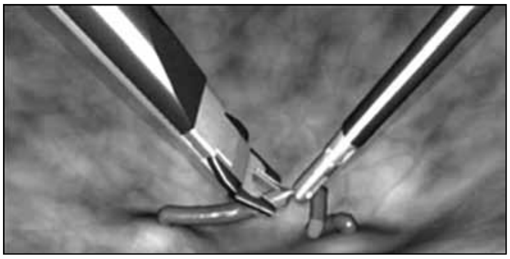

Fig. 3. LapSim virtual reality simulator: "Clip application task."

When comparing within senior residents, the only parameters that showed a statistically significant difference were the path length and angular path length in the cutting task (p = 0.03 for both) (Table 3).

Tables 4 and 5 demonstrate the median and IQR figures from each of the selected tasks and parameters for seminar 1 and seminar 2, respectively. They also show the p value from the Wilcoxon Rank Sum test comparing the distributions. When comparing junior resident to senior resident performances, the only parameters that showed a statistically significant difference were the angular path length in seminar 1 of the clip application task and the angular path length in seminar 2 of the cutting task (p = 0.05 and p = 0.01, respectively).

Table 6 shows the median and IQR from each of the selected tasks and parameters for both seminars 1 and 2, combined. It also shows the p value from the Wilcoxon rank sum test comparing the distributions. When comparing

Table 1. LapSim tasks and parameters examined
Lifting and grasping
Total time (seconds)
Tissue damage (number)
Max damage (millimeters)
Path length (millimeters)
Angular path length (degrees)
Cutting
Total time (seconds)
Max stretch damage (percentage)
Max damage (millimeters)
Tissue damage (number)
Path length (millimeters)
Angular path length (degrees)
Clip application
Total time (seconds)
Max stretch damage (percentage)
Path length (millimeters)
Angular path length (degrees)

Table 2. Comparison of junior residents between seminar 1 and seminar 2

Variable	Junior		*p* value
	Median (interquartile range)		
	Seminar 1	Seminar 2	
Clip application			
Total time (seconds)	106.05 (84.16,145.33)	103.57 (62.76,134.04)	0.43
Max stretch damage (%)	50.80 (44.01,75.34)	46.68 (34.10,67.76)	0.50
Path length (mm)	1.26 (0.97,1.79)	1.15 (0.66,1.28)	0.30
Angular path (degree)	219.06 (176.55,381.30)	228.08 (103.56,256.09)	0.30
Cutting			
Total time (seconds)	108.42 (97.75,137.89)	96.62 (92.52,104.58)	0.20
Max stretch damage (%)	50.11 (42.79,91.05)	56.92 (48.28,85.94)	0.50
Tissue damage (#)	1.33 (0.67,2.67)	1.33 (1.00,2.00)	0.09
Max damage (mm)	4.37 (2.23,7.02)	2.81 (0.66,8.95)	0.91
Path length (mm)	1.05 (0.89,1.11)	0.92 (0.91,1.14)	0.03
Angular path (degree)	255.36 (208.05,294.35)	237.93 (202.50,269.32)	0.36
Lifting and grasping			
Total time (seconds)	66.15 (58.90,112.73)	77.64 (65.63,88.15)	0.65
Tissue damage (#)	5.33 (3.66,11.66)	4.00 (2.33,88.15)	0.65
Max damage (mm)	13.5 (6.77,22.67)	6.00 (4.61,8.51)	0.04
Path length (mm)	1.4 (1.58,2.048)	1.77 (1.74,1.92)	1.00
Angular path (degree)	388.17 (378.74,481.83)	426.25 (409.23,462.65)	0.57

Table 3. Comparison of senior residents between seminar 1 and seminar 2

Variable	Senior		*p value*
	Median (interquartile range)		
	Seminar 1	Seminar 2	
Clip application			
Total time (seconds)	93.85 (81.38,106.62)	78.92 (55.32,107,18)	0.31
Max stretch damage (%)	46.22 (27.88,81.38)	40.05 (24.17,74.37)	1.00
Path Length (mm)	0.87 (0.78,1.12)	0.75 (0.62,0.86)	0.44
Angular Path (degree)	170.89 (112.93,189.29)	128.35 (109.18,192.44)	1.00
Cutting			
Total time (seconds)	101.16 (92.64,109.66)	91.20 (80.08,104.10)	0.31
Max stretch damage (%)	58.71 (55.55,82.29)	61.67 (52.33,74.02)	0.84
Tissue damage (#)	1.17 (1.00,2.00)	1.17 (1.00,1.33)	0.63
Max damage (mm)	4.65 (0.22,7.93)	1.54 (1.14,5.01)	0.31
Path length (mm)	0.98 (0.831.01)	0.85 (0.62,0.86)	**0.03**
Angular path (degree)	216.99 (196.71,250.92)	177.15 (148.75,226.26)	**0.03**
Lifting and grasping			
Total time (seconds)	76.13 (61.78,83.97)	66.89 (62.70,85.69)	1.00
Tissue damage (#)	4.50 (2.66,7.33)	5.00 (2.00,12.50)	0.62
Max damage (mm)	13.64 (7.067,21.41)	8.01 (6.37,10.83)	0.84
Path length (mm)	1.61 (1.55,1.99)	1.69 (1.56,1.92)	0.69
Angular path (degree)	388.61 (368.87,477.49)	417.27 (378.61,438.64)	0.43

junior to senior resident performances, the only parameters that showed a statistically significant difference were the path length and angular path length in the clip application task and the angular path length in the cutting task.

Discussion

In this study, we could not demonstrate convincing construct validity of the LapSim, VR simulator in a cohort of urology residents over time and using multiple tasks.

Other surgical programs have demonstrated face validity for this simulator. Kundhal and colleagues previously demonstrated good correlation between LapSim task time and operating room time, as well as good correlation between operating room errors and the tissue damage construct of the LapSim platform in the context of a general surgery MIS program.[8] Schreuder and colleagues demonstrated face validity of LapSim for a gynecology residency program.[9] Woodrum and colleagues used the same tasks as our group to show construct validity of the simulator,[10] although no reference to face validity of these tasks can be demonstrated. Similarly, there is no literature in the context of a urology MIS program for either face or construct validity.

Recently, Palter and colleagues attempted to construct a validated VR simulator-based training curriculum in a colorectal residency program.[11] Expert laparoscopic surgeons and participants reached consensus on applicable tasks for a colorectal residency program and set benchmarks for proficiency. To date, no such curriculum exists for a urology residency program using VR simulation. While our results suggest that basic laparoscopic skills are learned and/or retained using the LapSim platform, further developments in the field of VR are required to attain construct validity for the

Table 4. Comparison of junior and senior residents in seminar 1

Variable	Seminar 1 Median (interquartile range)		*p* value
	Juniors	Seniors	
Clip application			
Total time (seconds)	106.04 (84.16,145.33)	93.85 (81.38,106.62)	0.45
Max stretch damage (%)	50.80 (44.02,75.34)	46.22 (27.88,81.38)	0.53
Path length (mm)	1.26 (44.02,75.34)	0.85 (0.78,1.12)	0.09
Angular path (degree)	219.06 (176.55,381.30)	170.89 (112.93,189.29)	0.05
Cutting			
Total time (seconds)	108.42 (97.75,137.89)	101.16 (92.64,109.66)	0.46
Max stretch damage (%)	50.11 (42.79,91.05)	58.71 (55.55,82.29)	0.75
Tissue damage (#)	4.38 (2.23,2.67)	1.17 (1.00,2.00)	0.79
Max damage (mm)	4.38 (2.23,7.02)	4.93 (0.22,7.93)	0.95
Path length (mm)	1.05 (0.89,1.11)	0.98 (0.83,1.01)	0.14
Angular path (degree)	255.36 (208.05,294.35)	37.37 (196.71,250.92)	0.11
Lifting and grasping			
Total time (seconds)	66.15 (58.90,112.73)	76.13 (58.90,112.73)	0.95
Tissue damage (#)	5.33 (3.67,11.67)	4.5 (3.66,11.66)	0.37
Max damage (mm)	13.5 (6.78,22.67)	13.64 (6.77,22.67)	0.95
Path length (mm)	1.78 (1.58,2.04)	1.61 (1.58,2.04)	0.69
Angular path (Degree)	388.17 (378.74,481.83)	388.6 (378.74,481.83)	0.45

Table 5. Comparison of junior and senior residents in seminar 2

Variable	Seminar 2 Median (Interquartile range)		*p* value
	Juniors	Seniors	
Clip application			
Total time (seconds)	103.57 (62.76,134.04)	78.92 (55.32,107.18)	0.33
Max stretch damage (%)	46.68 (34.10,67.76)	40.06 (24.17,74.38)	0.69
Path length (mm)	1.15 (0.66,1.28)	0.75 (0.62,0.86)	0.11
Angular path (degree)	228.08 (103.56,256.08)	128.34 (109.18,192.44)	0.22
Cutting			
Total time (seconds)	96.62 (92.53,104.59)	91.20 (80.08,104.10)	0.68
Max stretch damage (%)	56.92 (48.28,74.02)	61.67 (52.33,74.02)	1.00
Tissue damage (#)	1.33 (1.00,1.33)	1.17 (1.00,1.33)	0.67
Max damage (mm)	2.81 (0.67,5.01)	1.54 (1.14,5.01)	0.80
Path length (mm)	0.92 (0.91,1.14)	0.84 (0.62,0.86)	0.07
Angular path (Degree)	237.93 (202.50,226.26)	177.14 (148.75,226.26)	0.01
Lifting and grasping			
Total time (seconds)	77.65 (65.63,88.15)	66.89 (62.69,85.69)	0.78
Tissue damage (#)	4.00 (2.33,6.67)	5.00 (2.00,12.50)	0.98
Max damage (mm)	6.00 (4.61,8.51)	8.01 (6.37,10.83)	0.33
Path length (mm)	1.77 (1.74,1.92)	1.69 (1.56,1.92)	0.86
Angular path (degree)	426.25 (409.23,462.66)	417.27 (378.61,438.64)	0.52

purpose of training for advanced laparoscopic procedures.

The term construct validity refers to whether a test (or in this case, a simulator) accurately measures or correlates with the theorized construct that it purports to measure. In this case, we ask whether the LapSim simulator accurately measures surgical ability in a cohort of urology residents. We believe that our group is the first to examine this question specifically in the context of a urology residency MIS program. Only a small minority of parameters showed a significant difference when comparing within junior and senior resident cohorts between seminar 1 and seminar 2, as well as between junior and senior resident scores.

Several studies conducted in general surgery and gynecology have reported on the construct validity of this simulator, using similar tasks and performance evaluation parameters. Woodrum and colleagues found significant differences between medical students, residents and faculty in the total time required for the lifting and grasping and clip application tasks when examined in the context of a general surgery training program.[10] However, our study examined surgical ability in a much narrower cohort of trainees, which could explain the differences in our results. In addition, Woodrum's results did not show a difference in total time between these groups for the cutting task. They also did not demonstrate a difference between their groups for the tissue handling parameters, which is consistent with our results.

Similarly, in another general surgery program, Duffy and colleagues found significant differences in total time and tissue damage for the lifting and grasping and clip application tasks when comparing interns and attending physicians but failed to show a difference between their intermediate group, which consisted of upper-level residents, and either the interns or the attending physicians.[12] These findings concur with our results.

Table 6. Comparison of junior and senior residents for seminars 1 and 2, combined

Variable	Seminar 2		*p* value
	Median (interquartile range)		
	Juniors	Seniors	
Clip application			
Total time (seconds)	104.04 (89.36,116.38)	75.25 (68.16,106.90)	0.18
Max stretch damage (%)	47.56 (37.63,75.95)	43.14 (26.40,77.88)	0.61
Path length (mm)	1.21 (0.93,1.26)	0.82 (0.74,0.88)	0.01
Angular path (Degree)	219.69 (170.47,237.45)	135.85 (120.61,190.55)	0.03
Cutting			
Total time (seconds)	99.75 (92.15,118.94)	96.18 (91.88,101.37)	0.45
Max stretch damage (%)	50.27 (40.34,88.49)	58.43 (55.86,72.95)	0.61
Tissue damage (#)	1.33 (1.00,2.33)	1.27 (1.00,1.50)	0.89
Max damage (mm)	3.26 (1.44,8.36)	4.53 (2.13,4.92)	1.00
Path length (mm)	0.99 (0.93,1.04)	0.92 (0.73,0.98)	0.11
Angular path (degree)	239.68 (227.72,261.44)	202.54 (172.73,230.31)	0.05
Lifting and grasping			
Total time (seconds)	72.16 (65.89,98.47)	70.07 (67.96,73.46)	0.95
Tissue damage (#)	6.00 (3.17,9.17)	4.33 (2.67,10.50)	0.47
Max damage (mm)	9.62 (5.16,12.65)	13.41 (7.83,17.38)	0.39
Path length (mm)	1.79 (1.65,2.04)	1.64 (1.57,1.95)	0.60
Angular path (Degree)	417.56 (398.59,468.91)	395.52 (384.57,455.89)	0.53

Eriksen and colleagues compared beginners and experienced laparoscopists in general surgery and found a significant difference in total time and tissue damage in the lifting and grasping, cutting and clip application tasks.[13] However, their comparisons of maximum damage and maximum stretch damage did not reach statistical significance; this was the same in our study.

In a gynecological surgery setting, Schreuder and colleagues found that there were no parameters (including time, path length, angular path and tissue damage) measured for the clip application task that could differentiate between novice, intermediate and expert groups.[9] These results are similar to ours.

Larsen and colleagues tested groups of novices, intermediates and experts 10 consecutive times on the lifting and grasping, cutting and clip application tasks in a gynecology program.[14] They were able to demonstrate a difference between their groups for total time for all tasks and a difference in tissue damage for the lifting and grasping and cutting tasks when they compared the groups after the first and second testing sessions. However, at the tenth testing session, the differences between the various skill levels were no longer statistically significant. These findings are in agreement with our results. Larsen's results also highlight the important point that LapSim fails to sustain its construct validity after a certain period of time.

Fairhurst and colleagues conclude that inconsistencies remain in the validation of construct validity for most simulator tasks.[15]

For a simulator to be useful for residency training, it should be able to demonstrate construct validity and improvement in performance over time. Some studies on the LapSim suggests that the parameters for select tasks can reliably differentiate between novice subjects and experts with extensive laparoscopic experience. Our results demonstrated that this simulator failed to differentiate between subjects with a smaller gap in experience. This drawback of LapSim raises concerns as to whether this simulator is useful to train and assess urology residents, especially given the cost of these simulators. The LapSim simulator setup and associated training modules used in our study cost about $55,000. Most physical simulators are much less expensive.

However, our cohort of resident participants received concurrent operating room-based and VR training, using LapSim. The failure to demonstrate a statistically significant difference between junior and senior residents could signify that residents had already acquired basic laparoscopic skills from their operating room experience, from first-year residency to fifth year, and that the LapSim VR simulator strengthened the retention of these skills. Maagaard and colleagues demonstrated basic skill retention in novice laparoscopic surgeons six months after a series of 10 training sessions on LapSim.[16]

Our study included a relatively small number of subjects and may have been underpowered. However, this number reflected the actual number of residents within our training program at the time. Furthermore, we used the same methodology and study design that had previously been used within our department to demonstrate construct validity for the smoothness metric of the ProMIS hybrid simulator.[7] In that study, there were significant differences between the junior and senior groups for all tasks examined, and the number of subjects was the same as in our current study. These results suggest that our study design should have been adequate to demonstrate construct validity for the LapSim simulator. However, we acknowledge that in our current study, we compared laparoscopic skills between two groups with a narrow gap of experience. In addition, junior residents already display basic laparoscopic skills, since they regularly perform laparoscopic cholecystectomies during the first two years of residency.

Our results certainly call in to question whether the total time, economy of movement (path length and angular path length) and tissue handling parameters (tissue damage, maximum damage and maximum stretch damage) are meaningful evaluation criteria for this simulator. Alternatively, do our results show that basic laparoscopic skills are retained with training on the LapSim VR simulator? Further multi-institutional studies are required to clarify whether this simulator could demonstrate convincing construct validity in the context of a urology residency MIS training program. This is a significant finding, given the growth of dry lab simulation centres in many urology residency programs across North America. Appropriate selection of useful simulators is becoming increasingly relevant, given the choice and cost of available simulators.

Conclusion

Construct validity for the total time, economy of movement and tissue handling parameters could not be demonstrated for the LapSim laparoscopic surgical simulator when examined within the context of a urology residency MIS program.

Competing interests: None declared.

This paper has been peer-reviewed.

Acknowledgements: Special thanks to Dr. Jose Correa for providing the statistical analysis and accompanying explanations.

References

1. Scott DJ, Bergen PC, Rege RV, et al. Laparoscopic training on bench models: better and more cost effective than operating room experience? *J Am Coll Surg* 2000;191:272-83. http://dx.doi.org/10.1016/S1072-7515(00)00339-2
2. Haluck RS, Krummel TM. Computers and virtual reality for surgical education in the 21st century. *Arch Surg* 2000;135:786-7. http://dx.doi.org/10.1001/archsurg.135.7.786
3. Ghitulescu GA, Derossis AM, Feldman LS, et al. A model for evaluation of laparoscopic skills: is there correlation to level of training? [abstract]. *Surg Endosc* 2001;15:S127.
4. Van Sickle KR. Construct validation of the ProMIS simulator using a novel laparoscopic suturing task. *Surg Endosc* 2005;19:1227-31. http://dx.doi.org/10.1007/s00464-004-8274-6
5. Grantcharov TP, Kristiansen VB, Bendix J, et al. Randomized clinical trail of virtual reality simulation for laparoscopic skills training. *Br J Surg* 2004;91:146-50. http://dx.doi.org/10.1002/bjs.4407
6. Seymour N, Gallagher AG, Roman SA, et al. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Ann Surg* 2002;236:458-63. http://dx.doi.org/10.1097/00000658-200210000-00008
7. Feifer A, Delisle J, Anidjar M. Hybrid augmented reality simulator: preliminary construct validation of laparoscopic smoothness in a urology residency program. *J Urol* 2008;180:1455-9. http://dx.doi.org/10.1016/j.juro.2008.06.042
8. Kundhal PS, Grantcharov TP. Psychomotor performance measured in a virtual environment correlates with technical skills in the operating room. *Surg Endosc* 2009;23:645-9. http://dx.doi.org/10.1007/s00464-008-0043-5
9. Schreuder HW, van Dongen KW, Roeleveld SJ, et al. Face and construct validity of virtual reality simulation of laparoscopic gynecologic surgery, *Am J Obstet Gynecol* 2009;200:e1-8.
10. Woodrum DT, Andreatta PB, Yellamanchilli RK, et al. Construct validity of the LapSim laparoscopic surgical simulator. *Am J Surg* 2006;191:28-32. http://dx.doi.org/10.1016/j.amjsurg.2005.10.018
11. Palter VN, Graafland M, Schijven MP, et al. Designing a proficiency-based, content validated virtual reality curriculum for laparoscopic colorectal surgery: a Delphi approach. *Surgery* 2012;151:391-7. http://dx.doi.org/10.1016/j.surg.2011.08.005
12. Duffy AJ, Hogle NJ, McCarthy H, et al. Construct validity for the LAPSIM laparoscopic surgical simulator. *Surg Endosc* 2005;19:401-5. http://dx.doi.org/10.1007/s00464-004-8202-9
13. Eriksen JR, Grantcharov T. Objective assessment of laparoscopic skills using a virtual reality stimulator. *Surg Endosc* 2005;19:1216-9. http://dx.doi.org/10.1007/s00464-004-2154-y
14. Larsen CR, Grantcharov T, Aggarwal R, et al., Objective assessment of gynecologic laparoscopic skills using the LapSimGyn virtual reality simulator. *Surg Endosc* 2006;20:1460-6. http://dx.doi.org/10.1007/s00464-005-0745-x
15. Fairhurst K, Strickland A, Maddern G. The LapSim virtual reality simulator: promising but not yet proven. *Surg Endosc* 2011;25:343-55. http://dx.doi.org/10.1007/s00464-010-1181-0
16. Maagaard M, Sorensen JL, Oestergaard J, et al. Retention of laparoscopic procedural skills acquired on a virtual-reality surgical trainer. *Surg Endosc* 2011;25:722-7. http://dx.doi.org/10.1007/s00464-010-1233-5

Correspondence: Dr. Evan Kovac, Royal Victoria Hospital, MUHC, 687 Pine Avenue West, Suite S6.88, Montreal, QC H3A 1A1; fax: 514-843-1552; drevankovac@gmail.com