

# Virtual Laparoscopy Simulation: a Promising Pedagogic Tool in Gynecology

Joalee Paquette, MD, Madeleine Lemyre, MD, Chantale Vachon-Marceau, MD,  
Emmanuel Bujold, MD, MSc, Sarah Maheux-Lacroix, MD, MSc

## ABSTRACT

**Background and Objectives:** Virtual simulators have played a vital role in preparing surgeons for laparoscopic and robotic procedures in gynecologic surgery. The efficacy of the simulator was evaluated to improve basic (trainee) laparoscopic skills and assess training levels.

**Methods:** This prospective, comparative study was conducted in volunteer residents in the obstetrics and gynecology training program of Université Laval. Study participants performed 9 laparoscopic simulator tasks on 2 different occasions. Skills improvement between sessions and differences between junior and senior residents were examined.

**Results:** Thirteen junior and 11 senior residents participated in the study. Junior trainees significantly improved their speed of execution, accuracy, and maintenance of horizontal view. Senior trainees mainly accelerated their rapidity in completing different tasks. They performed better than junior trainees, with economy of movements, and tended toward greater precision, speed of execution, and safe retraction in various tasks.

**Conclusion:** Virtual simulators are useful pedagogic tools that could benefit both junior and senior residents. Integration into the residency curricula should be considered.

Department of Obstetrics, Gynecology, and Reproduction, Université Laval, Québec, QC, Canada (all authors).

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Address correspondence to: Joalee Paquette, MD, Department of Obstetrics, Gynecology, and Reproduction, Université Laval, 2705 Boulevard Laurier, R-00762, Québec City G1V 4G2, Québec, Canada. Telephone: 418-525-4444, ext. 48679, Fax: 418-525-4281, E-mail: joalee.paquette.1@ulaval.ca

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**Key Words:** Education, Laparoscopy, Laparoscopic skills, Training, Virtual simulator.

## INTRODUCTION

Laparoscopic surgery, which brought about a new age in most surgical specialties, faces challenges associated with the nature of surgical training in residency programs. Given the evolution and complexity of minimally invasive techniques, exclusive apprenticeship in the operating room has become unpredictable and raises many ethics-related questions about care quality and patient safety.<sup>1</sup> Knowing that surgical experience directly affects surgical outcomes,<sup>2,3</sup> it is essential to validate trainee acquisition of surgical skills during residency. As an analogy, in aviation, pilots train on virtual simulators to practice flight skills, acquire experience, and confront different critical situations before their first air flight.<sup>4</sup>

Many simple simulators have been shown to benefit the acquisition of surgical skills and could serve evaluation purposes. However, their utility is limited by the need for qualified trainers.<sup>1,2,5,6</sup> Training on human cadavers and anesthetized animals can and does help but entails considerable cost and ethical constraints.<sup>7</sup> Virtual simulators offer didactic programs for simple laparoscopic tasks and recreate multiple surgical procedures, while providing immediate feedback.<sup>1,5</sup> We evaluated virtual simulator efficacy in improving basic (trainee) laparoscopic skills and discriminating training levels.

## MATERIALS AND METHODS

This prospective, comparative study was performed from July 2012 through March 2013 among residents in the obstetrics and gynecology training program at Université Laval. After participation in a pretest survey, the study subjects were asked to attempt 2 sessions on LAP Mentor II (Simbionix USA, Cleveland, Ohio, USA) (**Figure 1**), a virtual-reality laparoscopic surgical simulator. We allowed a time interval of 1 to 8 weeks between sessions. In each session, participants were instructed to perform 5 consecutive repetitions of 9 basic laparoscopic tasks (enumer-



**Figure 1.** The LAP Mentor laparoscopic surgical simulator. (Symbionix USA Corp., Cleveland, Ohio, USA).

ated in **Table 1**). If they were unable to complete 5 repetitions of each task in 90 minutes, the second session was started at the last task performed, to finish all tasks in chronological order.

Participants were divided into junior residents (postgraduate years [PGY] 1–2) and senior residents (PGY 3–5). Most discriminative parameters were compared<sup>8,9</sup> on each task between sessions 1 and 2 and between senior and junior residents. Data were extracted from the simulator for statistical analysis. The results were expressed as me-

Task
1. Snap photos of balls with camera at 0°
2. Snap photos of balls with camera at 30°
3. Touch flashing balls with blue and red tools
4. Clip leaking ducts within specific segments
5. Grasp and clip leaking ducts with both hands
6. Grasp with one hand and handle with the other
7. Cut a circular form with both hands
8. Cut highlighted with hook electrode
9. Overlap objects with their shadows

dians. The Wilcoxon signed rank-test and the Mann-Whitney *U*-test assessed differences between the 2 groups, by SPSS (Chicago, Illinois, USA). Statistical significance was set at  $P < .05$ . This study was approved by the Research Ethics Committee of Université Laval (2012-142), with all participants giving written informed consent at enrollment.

## RESULTS

Twenty-four (72%) of the 33 residents participated in the training program at the time of the study: 13 (54%) were junior and 11 (46%) were senior residents. **Table 2** lists

Characteristics	Junior Residents (n = 13)	Senior Residents (n = 11)
Age, years	25 (2.6)	27 (5.3)
Sex, female	13 (100)	10 (91)
Right-handed	8 (100)	7 (88)
Previous video game experience	0 (0)	1 (13)
Previous experience with a musical instrument	8 (100)	4 (50)
Number of sessions on simple simulator		
0	5 (63)	2 (25)
1–5	3 (38)	4 (50)
>6	0 (0)	2 (25)
Previous experience on virtual simulator	0 (0)	1 (13)
Previous laparoscopic experience on human cadavers or anesthetized animals	0 (0)	6 (75)
Number of simple laparoscopic procedures		
0	1 (13)	0 (0)
1–10	7 (88)	0 (0)
>11–30	0 (0)	8 (100)
Number of complex laparoscopic procedures		
0	5 (63)	0 (0)
1–10	3 (38)	5 (63)
>11	0 (0)	3 (38)

Unless otherwise specified, data are presented as median ± standard deviation (range) or *n* (%).

their main characteristics. Six senior residents (75%) had previous laparoscopic experience on anesthetized animals or human cadavers. Only 1 resident had used a virtual laparoscopic simulator before the study.

Junior residents showed performance improvement between sessions 1 and 2. Two performance parameters were improved: Task 1—snapping photos of balls with camera at 0° (median: 3:21 vs 1:53 minutes:seconds;  $P = .011$ ) and

maintaining horizontal view (median, 79% vs 94%;  $P = .008$ ). Total time between sessions 1 and 2 on Task 7—cutting a circular form with both hands—also decreased (median: 3:14 vs 2:28 minutes:seconds;  $P = .046$ ) (Table 3).

Senior residents improved their execution times with camera manipulation and eye–hand coordination. In fact, execution time decreased between sessions 1 and 2 on Task 2—snapping photos of balls with camera at

**Table 3.**  
Performance of Junior and Senior Residents on Virtual Simulator

Task/Parameters	Junior Residents			Senior Residents			Comparison Between Junior and Senior Residents	
	Session 1	Session 2	<i>P</i>	Session 1	Session 2	<i>P</i>	Session 1 <i>P</i>	Session 2 <i>P</i>
1. Camera manipulation at 0°								
Accuracy	70	80	.05	71	81	.40	.93	.81
Total time	3:21	1:53	.01*	1:51	2:01	.89	.13	.53
Maintaining horizontal view	79	94	.01*	84	86	.35	.30	.53
2. Camera manipulation at 30°								
Accuracy	73	71	.58	67	6	.78	.98	.49
Total time	3:14	2:28	.09	2:37	2:28	.049*	.69	.63
3. Eye-hand coordination								
Accuracy	100	100	.27	100	100	1.00	.26	.54
Total time	1:21	1:02	.07	1:16	0:53	.02*	.31	.14
Economy of movement, right instrument	47	44	.58	53	59	.13	.06	.03*
Economy of movement, left instrument	52	58	.21	61	62	.94	.66	.23
4. Applying clip								
Accuracy	86	90	.55	90	90	.67	.06	.55
Total time	1:04	1:05	.24	1:06	0:56	.25	.82	.10
7. Cutting								
Accuracy	100	100	.11	100	100	.32	.75	.39
Total time	3:14	2:28	.046*	2:23	1:50	.11	.56	.37
Safe retraction–overstretch	20	36	.34	75	89	1.00	.13	.12
8. Electrocautery								
Accuracy	100	98	.66	100	100	1.00	.56	.45
Total time	8:02	7:19	.69	7:41	9:14	1.00	.77	1.00
Efficiency of cautery	71	76	.89	76	81	.29	.17	.51
9. Translocation of objects								
Efficiency of translocations	41	53	.11	62	35	.41	.33	.37
Total time	10:19	10:15	.11	7:52	8:37	.29	.36	.68

Data are presented as medians. All times are minutes:seconds. The remaining data are percentages. Tasks 5 and 6 are not represented because 38% and 54% of data, respectively, were missing, due to informatics problems and instrument breakages. \*Statistically significant results.

30° (median: 2:37 vs 2:28 minutes:seconds;  $P = .049$ )—and Task 3—touching flashing balls with red and blue tools (median: 1:16 vs 0:53 minutes:seconds;  $P = .018$ ) (Table 3).

Senior trainees performed better than junior trainees with more economy of right-hand movement (Task 3—median: 44% vs 59%;  $P = .027$ ) and improved precision, speed of execution, and safe retraction in various tasks, although the difference did not reach statistical significance (Table 3). Performance Tasks 5 and 6 were not analyzed because 38% and 50% of the data were missing, respectively, because of instrument breakage and informatics problems.

## DISCUSSION

We evaluated virtual simulator efficacy—to improve basic (trainee) laparoscopic skills—and observed significant progress made by residents between sessions. Scott et al.<sup>10</sup> reported better resident performance on the video trainer after repeated practice sessions compared to no formal training. In the present study, junior residents seemed to improve their performance globally, whereas senior residents mainly tweaked their speed of execution. In fact, it appears that trainees with more laparoscopy experience had already acquired precision skills but still benefitted from the simulator to shorten their execution time, a primary and limiting factor in the operating room.<sup>1,10</sup> Also, practice on the video trainer had been reported to correlate directly with better basic in vivo laparoscopic skills, which also supports the positive impact that a virtual simulator could have by being integrated into residency curricula.<sup>3,10</sup>

The virtual simulator's ability to discriminate the training levels of residents was examined. It was determined that senior trainees performed better globally than junior trainees. Other studies also have reported that previous laparoscopic experience is associated with better basic laparoscopic skills and performing complex laparoscopic procedures on the virtual simulator.<sup>9,11–14</sup> Although these studies support a good correlation between virtual and laparoscopic skills in vivo, other evidence suggests that the virtual simulator may not predict in vivo surgical performance,<sup>15</sup> so that further research is needed to clarify this situation.

To master technical skills during training, residents need advanced anatomic knowledge, an understanding of each procedural step and precise instrument control. Use of various tools (e.g., inanimate box, practice on human cadavers or anesthetized animals, and virtual-reality sim-

ulator) improves the acquisition of elementary and even more complex laparoscopic skills. According to the literature, the virtual simulator could be useful in complementing mentorship in the operating room.<sup>1,16,17</sup>

The advantages of integrating virtual simulators in residency programs include increased practice time in a secure environment, improvement of precise abilities and integration of new laparoscopic concepts without time limits. They can also enable evaluation of different aspects of manual skills, compare the results with those of colleagues, and monitor progress during sessions.<sup>3,5,18</sup>

The strengths of this study are that only 1 trainee had practiced on the virtual simulator before the study. It generated results that were not influenced by previous practice and demonstrated the impact of practice over a short period. Also, objective feedback obtained at the end of tasks was a major advantage compared to training on a box trainer or under operating room supervision. These situations give subjective feedback and require supervision. Another study strength is that it reported on a representative sample in an obstetrics and gynecology training program. Unfortunately, informatics problems and instrument breakages prevented data analysis of Tasks 5 and 6. These issues can be an irritant to trainees and represent a limitation of laparoscopic simulators. Also, residents reported that access to the virtual simulator was difficult. Other surgery programs have access to it, and a reservation must be made because only 1 resident at a time can practice with the virtual simulator. This problem was beyond direct control and limited utilization.

Another limit to our study is the size of our sample. Despite the small sample size, we evaluated 72 hours of training on the simulator and observed significant improvement in resident performances. Differences in parameters such as total cutting time, safe retraction, and efficiency of cautery would likely have been significant with more powerful analyses.

Another limitation that should be pointed out is the variable exposure to laparoscopy in the operating room between the first and second sessions. Few participants had such hands-on exposure. Unfortunately, this exposure was not quantified, and senior residents may have been more likely than junior resident to be exposed to laparoscopy.

Follow-up of a large multicenter cohort of residents could help establish a well-designed simulator training program adapted to each training level and ultimately set goals to

reach before performing some laparoscopic procedures in the operating room. Future studies could evaluate the impact of the training program in terms of patient safety and satisfaction of resident and attending physicians. Moreover, the simulator affords the opportunity to practice simple and complex procedures step by step, which could be advantageous.

## CONCLUSION

Virtual simulators have been demonstrated to be useful for improvement in laparoscopic skills of both junior and senior residents. Along with the existing literature, the present study disclosed that junior residents bettered their speed of execution, accuracy, and maintenance of horizontal view, whereas senior residents shortened their speed of execution with a virtual simulator. At this stage, the virtual simulator benefits both junior and senior residents, even after significant hands-on operating room experience. Virtual simulators should be integrated into residency curricula as tools for practicing coordination and precision. As in aviation, it could become a requirement for trainees to demonstrate adequate mastery of technical skills before embarking on real surgery.

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