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Virtual reality simulation to enhance laparoscopic salpingectomy skills

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Abstract

Background: To assess skill enhancement and maintenance by virtual-reality simulation of laparoscopic salpingectomy in gynecologic surgery fellows. Skill acquisition by virtual-reality surgical simulation is an active field of research and technological development. Salpingectomy is one of the first gynecologic surgery techniques taught to fellows that requires accompanied learning.

Methods: A single-center prospective study was performed in the University of Lyon, France, including 26 junior fellows (≤ 3 semesters' internship) performing laparoscopic salpingectomy exercises on a LapSim® virtual reality simulator. Salpingectomy was performed and timed on 3 trials in session 1 and 3 trials in session 2, at a 3-month interval. Analysis was based on students' subjective assessments and a senior surgeon's objective assessment of skill. Progress between the 2 sessions was assessed on McNemar test and Wilcoxon test for matched series.

Results: 26 junior specialist trainees performed all trials. Most performed anterograde salpingectomy, both in session 1 (69%) and session 2 (86%). Mean procedure time was significantly shorter in session 2: 6.10 min versus 7.82 min ($p=0.0003$). There was a significant decrease in blood loss between the first trial in session 1 and the last trial in session 2: 167 ml versus 70.3 ml ($p=0.02$). Subjective assessment showed a significant decrease in anxiety and significant increase in perceived efficacy, eye-hand coordination and ergonomics. Efficacy, performance quality and speed of execution as assessed by the senior surgeon all improved significantly from trial to trial, while hesitation significantly decreased.

Conclusions: The study showed that junior trainees improved their surgical skills on a short laparoscopic exercise using a virtual reality simulator. Virtual reality simulation is useful in the early learning curve, accelerating the acquisition of reflexes. Maintaining skill requires simulation sessions at shorter intervals.

Key-words: Laparoscopic salpingectomy; Simulation; Virtual Reality Simulator; Training; Teaching

1 **Introduction**

2

3 Laparoscopy has for several years been the attitude of choice in gynecologic surgery [1]. It
4 has become indispensable for fellows to be trained in the technique, and this requires
5 teaching methods. In-vivo training runs up against organizational and legal issues [2].
6 Various kinds of training modules are available to meet the challenge. The box-trainer device
7 is simple and accessible, but allows only a limited range of exercises [3]. Porcine and cadaver
8 models involve problems of access and cost, considerably restricting their contribution to
9 training [4-6]. Laparoscopic virtual reality simulation (VRS) could improve training for
10 surgery fellows, enabling autonomous practice. Laparoscopic salpingectomy is a procedure
11 that is frequently performed in emergency to manage ectopic pregnancy and is often
12 entrusted to fellows as it is seen as being straightforward; however, it incurs a risk of
13 collateral injury, notably to the ovaries, that may jeopardize fertility, and of hemorrhage that
14 may prove life-threatening.

15 VRS allows a variety of exercises to be undertaken so as progressively to acquire the basic
16 skills of surgery [7,8]. How to maintain skill levels, on the other hand, is presently a burning
17 issue in all training approaches [9,10].

18 The aim of the present study was to assess the improvement in and maintenance of surgical
19 skills using laparoscopic VRS in junior gynecologic surgery fellows.

20

21 **Methods**

22

23 A single-center prospective study was conducted from January to June 2017 in the Surgery
24 School of the Rockefeller Medical Faculty of the University of Lyon, France. It included 26
25 junior fellows specializing in gynecology-obstetrics: i.e., with less than 4 semesters of
26 internship. All were novices in laparoscopic surgery and none had performed in-vivo
27 salpingectomy.

28 Two sessions were scheduled, with 3 VRS trials each, at a 3-month interval (figure 1).
29 Session 1 was run during January and February and session 2 during May and June 2017.
30 Between the two, fellows were required to perform in-vivo salpingectomy as part of their in-
31 hospital training. The study objective was explained, and informed consent was collected.

32 The LapSim® laparoscopic VRS (Surgical Science, Gothenburg, Sweden) was programmed,
33 using the LapSim Basic Skills 3.0 package, to run a personalized laparoscopic salpingectomy

34 exercise (figure 2). The simulator included a force feedback system. The LapSim server used
35 Microsoft's SQL package to create and store data.

36

37 *Task performance and skill levels*

38

39 Laparoscopic salpingectomy was first explained in a video demonstrating the two techniques:
40 anterograde, from the ovarian fimbria to the uterine horn, and retrograde, from horn to
41 fimbria.

42 The fellows then performed 3 trials of salpingectomy under ectopic pregnancy with active
43 bleeding, on the LapSim® simulator. The first trial was performed with no explanations, the
44 second was guided by the senior surgeon, with explanations, and the third had no assistance.
45 This procedure was the same in session 2.

46 A single senior surgeon supervised and assessed all fellows in all trials.

47 Instruments were chosen using a pedal. The objective was to perform salpingectomy using
48 bipolar gripping forceps for coagulation scissors connected to a monopolar electric current
49 for sectioning (figure 2). Fellows were advised to keep both instruments in the field of view,
50 on the left and on the right; whenever an instrument left the field of view, the exit was
51 counted and penalized. The fellow then used a virtual laparoscopic retrieval bag to extract the
52 specimen, and performed complementary hemostasis and peritoneal cleansing with an
53 aspiration-lavage cannula. Once the fellow considered the procedure to have been completed,
54 he or she pushed on the pedal to end the simulation. Procedures were timed on each trial,
55 from introduction of the forceps to extraction of the specimen in the bag. At the end of each
56 trial, the fellow filled out visual analog self-assessment scales.

57

58 *Assessment criteria*

59

60 The objective criteria assessed on each trial comprised: total procedure time (sec), blood loss
61 (ml), reserve volume (blood volume in pelvic cavity at end of procedure: ml), duration of
62 ovarian diathermia insult (sec), migration or lateral movement per instrument (cm) to assess
63 ergonomics, and number of times an instrument left the camera's field of view.

64 On the subjective assessment scales, fellows estimated their anxiety, efficacy, ease in using
65 the VRS and feeling of being "at ease" during the procedure. They also evaluated device-
66 related criteria: perceived visual field depth, perception of force feedback, eye/hand
67 coordination, and the realism of the simulation. The senior surgeon assessed the quality of the

68 fellow's simulated surgery. To limit inter-observer differences in the assessment, the same
69 senior surgeon supervised all exercises. The senior surgeon assessed the quality of the
70 fellow's simulated surgery using the same standardized scores for each exercise, based on
71 visual analog scales of performance, execution quality, speed, and hesitation. The evaluation
72 scoring system used is presented in figure 5.

73

74 ***Statistical analysis***

75

76 Statistical analysis used SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).
77 Continuous quantitative data were reported as mean \pm standard deviation, and qualitative data
78 as number and percentage. Comparison between sessions used the McNemar test for
79 qualitative variables and Wilcoxon test for matched series for quantitative variables. The
80 significance threshold was set at $p < 0.05$.

81

82 **Results**

83

84 All 26 fellows completed all 3 trials of both sessions. Median age was 25 years (range, 23-35
85 years). Population data are shown in Table 1. Most fellows (84.62%) were right-handed.
86 Twelve were in their 1st semester of internship (46.15%). 84.62% performed an in-vivo
87 laparoscopic salpingectomy for ectopic pregnancy or prophylactic reasons during their in-
88 hospital training between the 2 sessions.

89 Most fellows performed anterograde salpingectomy in both session 1 (69.23%) and session 2
90 (86.36%) ($p=0.29$). Mean procedure time was significantly shorter in session 2 (6.10 min
91 versus 7.82 min; $p=0.0003$) (Table 2). Specimen extraction was successful in all cases.

92 The objective results showed significant reduction in blood loss between the first trial in
93 session 1 and the last trial in session 2 ($p=0.02$) (figure 3a). Reserve volume likewise
94 decreased from trial to trial (figure 3b). Ovarian diathermia insult also decreased
95 significantly, from a mean 1.4 sec in the first trial versus to 0.6 sec in the last ($p=0.03$) (figure
96 3b, Table 4).

97 Subjective results mostly showed significant improvement from trial to trial within sessions,
98 including the feeling of being "at ease" and perceived ergonomics (Table 3). Comparison
99 between the 3rd trial of session 1 and 3rd trial of session 2, however, showed no improvement
100 in subjective assessment, except for the feeling of being at ease ($p=0.009$) (Table 4). Image

101 quality was rated 6.9 ± 0.3 on average and realism 6.7 ± 0.3 on trial 1 of session 1, with no
102 significant change by session 2 (Table 4).

103 The senior surgeon's objective assessments showed significant improvement between
104 sessions for efficacy, execution quality and execution speed (Table 3). There were also
105 significant differences on these three criteria between the 3rd trial of session 1 and the 1st trial
106 of session 2 (Table 4). Hesitation as assessed by the senior surgeon decreased over trials in
107 both sessions 1 and 2 ($p < 0.0001$).

108

109 **Discussion**

110

111 This was the first study in gynecology to assess salpingectomy skills on the LapSim[®]
112 simulator. Simulation has been greatly developed in surgery over the last 10 years [9,11-13].

113 The spread of laparoscopic surgery has led to strong demand for training for fellows in
114 gynecologic surgery, and laboratory training methods are especially applicable in surgery,
115 where loss of chance and ethical considerations no longer allow accompanied practice in the
116 operating theater to be the sole means of training [13].

117 The LapSim[®] simulator used in the present study includes force feedback, which enables
118 students to experience the reality of laparoscopic surgery without risk to patients. A range of
119 exercises and virtual procedures allow progressive acquisition of the dexterity and know-how
120 that are going to be required in clinical practice.

121 A recent Cochrane review reported 8 VRS studies with 109 surgical trainees [9].
122 Methodologies varied, with a high risk of bias; notably, some studies included both novices
123 and experienced trainees [14], or experienced trainees only [15]. VRS training reduced
124 surgery time by about 10 minutes and improved performance in trainees with little
125 experience, as compared to box-trainer exercises or no training. However, there was no
126 evidence regarding impact on live surgery (i.e., skill transfer), healthcare funders or costs [9].

127 However, a recent systematic review has confirmed the transfer of skills from the simulation
128 to the operating room, particularly for basic acquisitions and during cholecystectomy [16,
129 17]. Shore et al. compared simulation-based training (associating box-trainer and VRS)
130 versus no training in left salpingectomy and laparoscopic knot tying, with significant benefit
131 in a small population (groups of 10 and 11 fellows) on in-vivo assessment, but without
132 comparing the box-trainer versus VRS [18].

133 In a randomized study, Brinkmann et al. assessed 36 novice trainees on a live porcine model,
134 finding better results for box-trainers than VRS in cholecystectomy [19]. The advantage of

135 VRS lies in the range of exercises that can be programmed, from simple knots to full
136 hysterectomy, and in the feedback provided by the simulator. This feedback was recently
137 shown to shorten the learning curve as compared to simple box-trainers [20].

138 Aggarwal et al. assessed 30 surgeons with various levels of experience: novice with less than
139 10 laparoscopic procedures, intermediate with 20-50, and expert with more than 100. They
140 performed 3 VRS procedures in each of 10 sessions, although only 23 participants completed
141 all 10 sessions [21]. Analysis by level of experience revealed a plateau effect at the 3rd
142 session for experts, at the 7th session for the intermediate group, and at the 9th for novices.
143 The interval between sessions was not reported. In the present study, skill maintenance
144 between sessions may seem poor, with many parameters falling back more or less to baseline
145 in the 1st trial of session 2. In a recent study by Sant'Ana et al., skill maintenance at 1 year in
146 36 students after a 1½ hour training session was 69% [22]. However, the rate of participation
147 in both sessions was only 52%, compared to 100% in the present study, which may have
148 biased results in favor of the more highly motivated students, who had probably been more
149 assiduous during the first session, leading to overestimation of skill retention [22]. In France,
150 the work by Crochet et al., which studied laparoscopic hysterectomy training using VRS,
151 helped increase the validity of this technology, building a strong training curriculum able to
152 differentiate experienced surgeons from inexperienced ones. In this particular work, the
153 learning curves plateaued fast from the 2nd to 6th trials, a result which our study seems to
154 confirm [23,24].

155 Regarding the training of gynecologic surgery fellows, the present study confirmed the
156 contribution of VRS in improving performance by repeating a given exercise. However, the
157 results indicated poor maintenance of skills between the end of session 1 and the start of
158 session 2. The literature on this point reports no difference in skill maintenance between the
159 various kinds of laparoscopic simulation, and notably between box-trainers and VRS [25,26].
160 According to Bosse et al., it would be helpful to repeat simulation sessions at shorter intervals
161 in terms of learning curve and skill maintenance [10]. VRS could then become an effective
162 means of maintaining surgical skill [27,28]. Thus, allowing fellows to practice with VRS
163 could provide a perfect solution to the problem of loss of chance associated with
164 accompanied live surgery. The senior guidance that was given during the second exercise of
165 each session may also have impacted skill performances, due to a form of companionship.

166 The present study suffers from a selection bias since students improved their knowledge of
167 the simulator at each exercise, artificially improving their performance of the procedure. This
168 may be limited since there were only 3 exercises per session, without any previous

169 experience of the simulator for the junior fellows. The senior guidance that was given during
170 the second exercise of each session may also have impacted skill performances, due to a form
171 of companionship. Moreover, since the senior surgeon assessing the fellows could not be
172 blind, limiting his objectivity during scoring, most of the results presented herein focused on
173 the metrics measured by the Lapsim itself. Finally, the design of the present study did not
174 allow for an assessment of in vivo skill transfers (Kirkpatrick model). Importantly, the
175 present study showed that residents can improve their level of skills during laparoscopic
176 training on a virtual reality simulator with repeated exercises. Interestingly, residents showed
177 great motivation to progress during exercises.

178

179

180 **Conclusion**

181

182 The present study showed that gynecology junior trainees improved their skills with short
183 VRS training. This is a precious gain, as the time given for in-vivo laparoscopic surgery
184 training is getting shorter. VRS is useful for young surgeons setting out on their learning
185 curve, accelerating the acquisition of reflexes and dexterity. The study also showed that
186 maintaining skill requires simulation sessions at shorter intervals, to keep the gestural
187 memory alive. Since the completion of this study, we set up a mandatory VRS salpingectomy
188 validation program for gynecology fellows in their 1st year of internship. Even if skill transfer
189 from VRS to in vivo laparoscopic salpingectomy could not be studied herein, it appears that
190 VRS may help young surgeons improve their learning curve, by accelerating the acquisition
191 of reflexes and dexterity. The present results also suggest that maintaining skill requires
192 simulation sessions at shorter intervals, to keep the gestural memory alive.

193

194

195 **List of abbreviations**

196 VRS = Virtual Reality Simulation

197

198 **Acknowledgments**

199 Ms. Patricia Renaud (School of Surgery, University Lyon 1, France) for the logistics of
200 simulation sessions

201

202

203 **Figure 1.** Study flowchart

204 **Figure 2.** (a) LapSim® laparoscopy virtual reality simulator, (b) Salpingectomy

205 demonstration (choice of instruments), (c) use of bipolar forceps

206 **Figure 3.** Objective simulation results

207 **3a.** Trial duration (sec) and blood loss (ml)

208 **3b.** Reserve volume (ml) and ovarian diathermia insult time (sec)

209 **Figure 4.** Instrument migration and field of view exit

210

211 **Table 1.** Population characteristics (n=26)

212 **Table 2.** Simulation session data

213 **Table 3.** Fellows' and senior surgeon's assessment of simulation trials (n=26)

214 **Table 4.** Comparison between training sessions

215

216

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Figure 1. Study flowchart

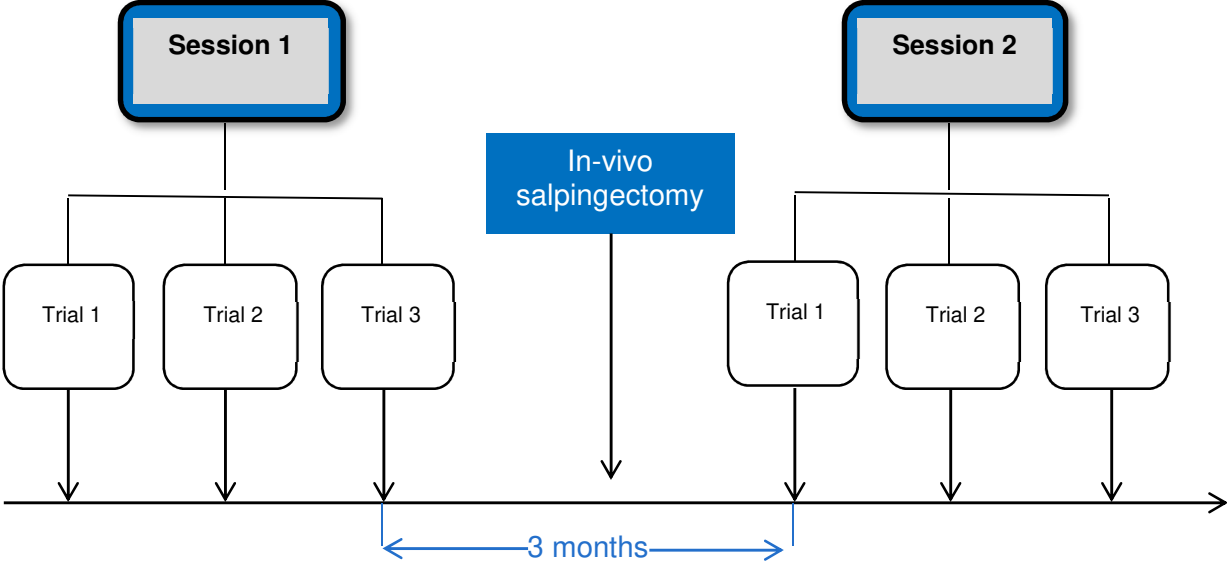
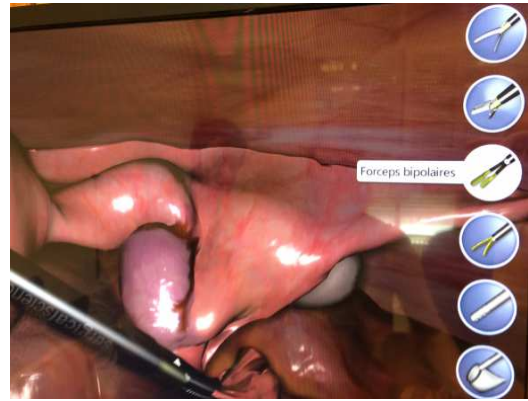


Figure 2. (a) LapSim® laparoscopy virtual reality simulator
(b) Salpingectomy demonstration (choice of instruments)
(c) use of bipolar forceps



(a)



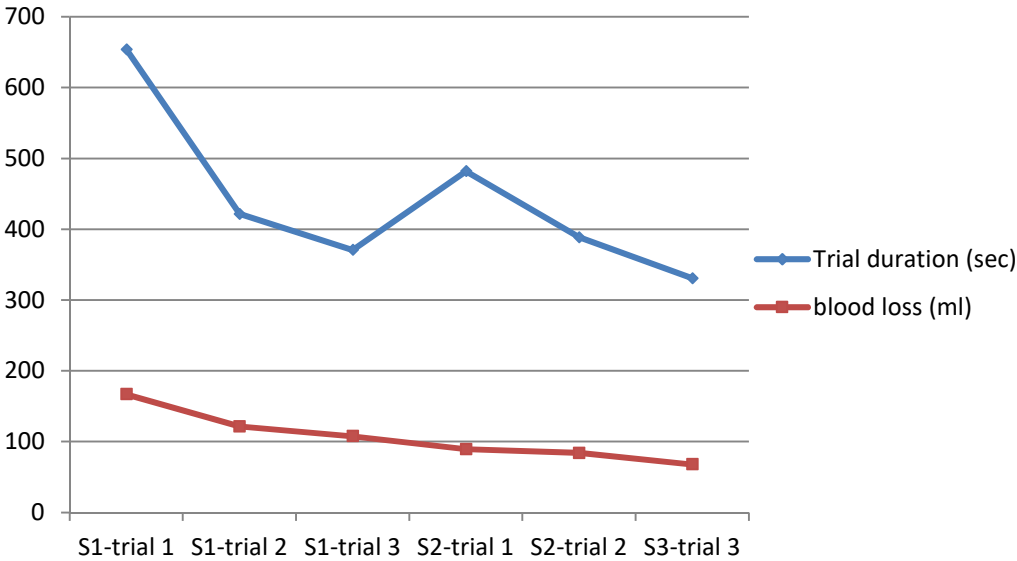
(b)



(c)

Figure 3. Objective simulation results

3a. Trial duration (sec) and blood loss (ml)



3b. Reserve volume (ml) and ovarian diathermia insult time (sec)

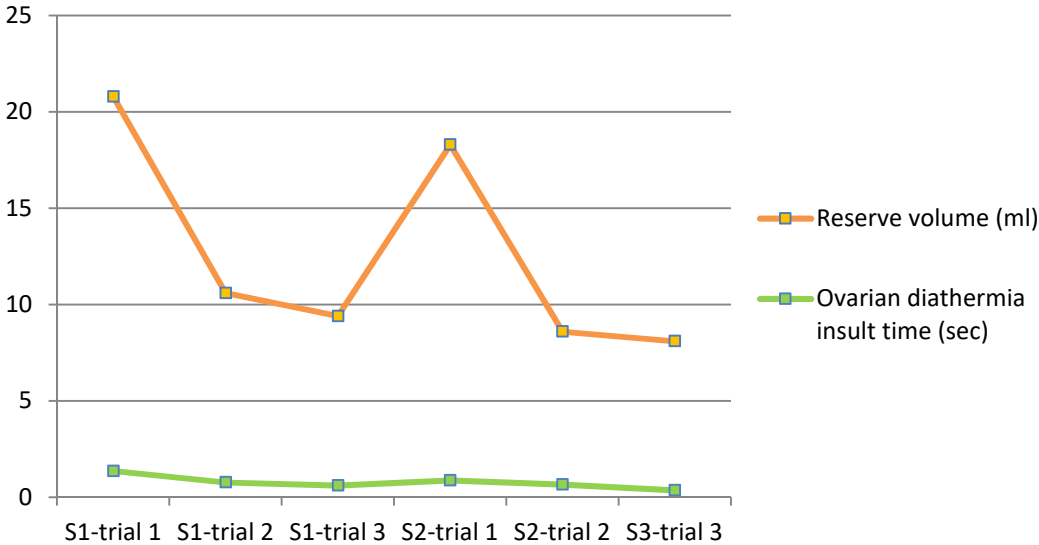


Figure 4. Field of view exit and instrument migration

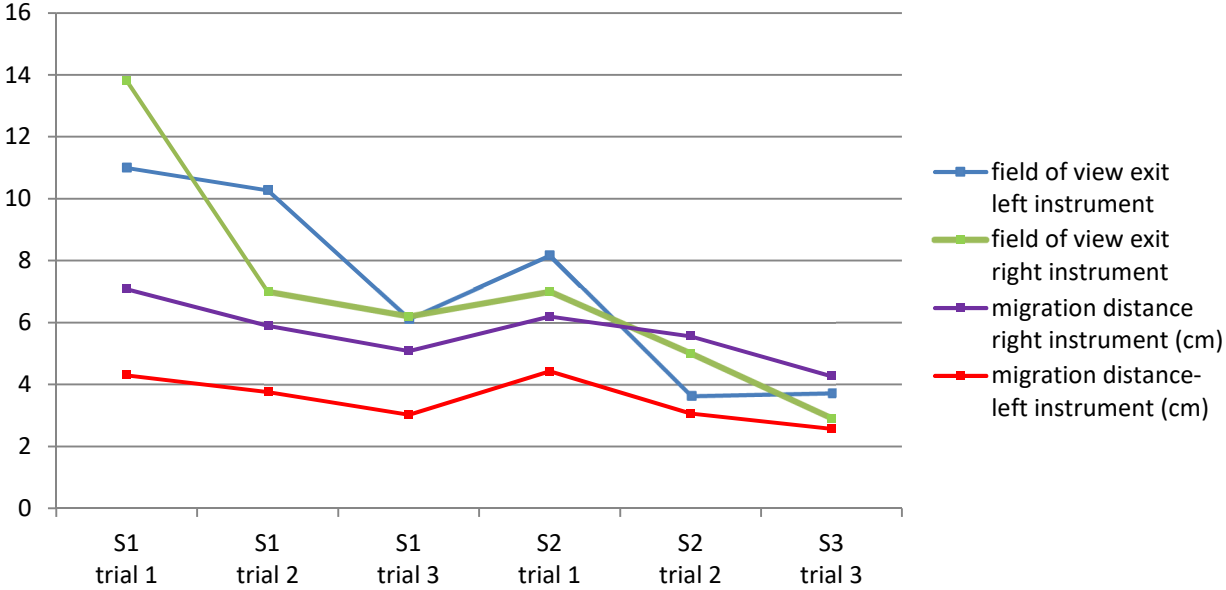


Table 1. Population characteristics (n=26)

Age (years)	25 (23-35)
Gender	
Female	25 (96.15%)
Male	1 (3.85%)
Handedness	
Right	22 (84.62%)
Left	2 (7.69%)
Ambidextrous	2 (7.69%)
Internship semester	
1 st	12 (46.15%)
2 nd – 3 rd	14 (53.85%)
≥1 semester of general surgery	2 (12.50%)
≥1 semester of gynecologic surgery	13 (81.25%)
Animal model training	1 (6.67%)
Video gaming	2 (7.69%)
Experience with pelvi-trainer	7 (26.92%)
Experience as surgical assistant	23 (88.46%)
Experience of in-vivo salpingectomy ^a	22 (84.62%)

Data reported as median (range) or n (%)

^a Salpingectomy performed between sessions 1 and 2

Table 2. Simulation session data

	Session 1	Session 2	p
Salpingectomy			
anterograde	18 (69.23%)	19 (86.36%)	
retrograde	8 (30.77%)	3 (13.64%)	0.29
Mean procedure time (min)	7.82 ± 0.35	6.10 ± 0.28	0.0003

Data reported as mean ± standard deviation or n (%)

Table 3. Fellows' and senior surgeon's assessment of simulation trials (n=26)

	Session 1				Session 2			
	Trial 1	Trial 2	Trial 3	Trial 1 / Trial 3 P	Trial 1	Trial 2	Trial 3	Trial 1 / Trial 3 p
<i>Fellows' assessment</i>								
Exercise time (min)	10.3 ± 0.7	7.3 ± 0.3	5.8 ± 0.3	<0.0001	7.2 ± 0.4	4.0 ± 0.4	5.1 ± 0.3	0.0004
Anxiety	6.3 ± 0.4	4.6 ± 0.3	2.4 ± 0.4	<0.0001	5.1 ± 0.4	6.0 ± 0.3	2.3 ± 0.5	<0.0001
Efficacy	3.0 ± 0.4	4.3 ± 0.3	5.0 ± 0.4	<0.0001	4.2 ± 0.3	5.4 ± 0.3	5.8 ± 0.4	<0.0001
Ease of use	4.7 ± 0.4	5.5 ± 0.3	6.2 ± 0.3	0.0001	4.6 ± 0.4	5.7 ± 0.3	6.5 ± 0.3	<0.0001
Image quality	6.9 ± 0.3	7.2 ± 0.3	7.0 ± 0.3	0.49	6.2 ± 0.3	6.5 ± 0.2	6.7 ± 0.2	0.10
Ergonomics	5.3 ± 0.4	6.0 ± 0.3	6.1 ± 0.3	0.01	5.0 ± 0.3	5.8 ± 0.2	6.5 ± 0.3	<0.0001
Instruments: visual aspect	7.8 ± 0.2	7.6 ± 0.2	7.5 ± 0.2	0.06	6.9 ± 0.2	6.9 ± 0.3	7.1 ± 0.3	0.57
Instruments: quality	7.3 ± 0.4	7.3 ± 0.3	7.3 ± 0.2	0.86	6.8 ± 0.2	6.8 ± 0.3	7.1 ± 0.3	0.21
Instruments: movement	6.6 ± 0.4	6.6 ± 0.3	6.9 ± 0.3	0.17	5.7 ± 0.3	6.0 ± 0.3	6.5 ± 0.3	0.01
Depth perception	5.5 ± 0.3	5.8 ± 0.3	6.1 ± 0.3	0.02	4.6 ± 0.2	5.4 ± 0.3	6.0 ± 0.3	<0.0001
Interaction with object	5.1 ± 0.4	5.7 ± 0.3	6.1 ± 0.3	0.003	4.8 ± 0.3	6.0 ± 0.3	6.3 ± 0.3	<0.0001
Force feedback	5.3 ± 0.4	5.6 ± 0.3	6.1 ± 0.4	0.008	5.5 ± 0.3	5.8 ± 0.3	6.1 ± 0.3	0.02
Eye/hand coordination	5.3 ± 0.4	5.7 ± 0.4	6.4 ± 0.4	0.0004	5.5 ± 0.3	6.1 ± 0.3	6.8 ± 0.3	0.001
2-handed navigation	5.3 ± 0.5	5.9 ± 0.4	6.4 ± 0.3	0.0005	5.7 ± 0.4	6.3 ± 0.3	6.7 ± 0.3	<0.0001
Realism	6.7 ± 0.3	6.7 ± 0.2	6.8 ± 0.2	0.73	6.2 ± 0.2	6.1 ± 0.3	6.5 ± 0.3	0.24
Feeling "at ease"	3.6 ± 0.4	4.1 ± 0.4	5.1 ± 0.3	0.01	4.4 ± 0.3	5.3 ± 0.3	6.3 ± 0.3	<0.0001
Senior surgeon's assessment								
Performance	2.7 ± 0.3	5.7 ± 0.3	7.5 ± 0.3	<0.0001	4.2 ± 0.4	6.0 ± 0.3	8.0 ± 0.2	<0.0001
Execution quality	2.7 ± 0.3	5.4 ± 0.3	7.5 ± 0.2	<0.0001	4.3 ± 0.4	6.4 ± 0.2	8.2 ± 0.2	<0.0001
Execution speed	2.8 ± 0.4	5.9 ± 0.3	7.6 ± 0.3	<0.0001	4.0 ± 0.4	6.2 ± 0.3	8.1 ± 0.2	<0.0001

Hesitation 7.8 ± 0.3 4.8 ± 0.3 2.4 ± 0.2 <0.0001 6.5 ± 0.5 3.8 ± 0.3 1.7 ± 0.2 <0.0001

Data expressed as mean ± standard deviation

Table 4. Comparison between training sessions

	Session 1 Trial 3	Session 2 Trial 3	p	Session 1 Trial 3	Session 2 Trial 1	p
Fellows' assessment						
Exercise time (min)	5.8 ± 0.3	5.1 ± 0.3	0.12	5.8 ± 0.3	7.2 ± 0.4	0.006
Anxiety	2.4 ± 0.4	2.3 ± 0.5	0.81	2.4 ± 0.4	5.1 ± 0.4	<0.0001
Efficacy	5.0 ± 0.4	5.8 ± 0.4	0.02	5.0 ± 0.4	4.2 ± 0.3	0.07
Ease of use	6.2 ± 0.3	6.5 ± 0.3	0.48	6.2 ± 0.3	4.6 ± 0.4	0.0005
Image quality	7.0 ± 0.3	6.7 ± 0.2	0.39	7.0 ± 0.3	6.2 ± 0.3	0.04
Ergonomics	6.1 ± 0.3	6.5 ± 0.3	0.27	6.1 ± 0.3	5.0 ± 0.3	0.005
Instruments: visual aspect	7.5 ± 0.2	7.1 ± 0.3	0.22	7.5 ± 0.2	6.9 ± 0.2	0.06
Instruments: quality	7.3 ± 0.2	7.1 ± 0.3	0.52	7.3 ± 0.2	6.8 ± 0.2	0.09
Instruments: movement	6.9 ± 0.3	6.5 ± 0.3	0.35	6.9 ± 0.3	5.7 ± 0.3	0.0004
Depth perception	6.1 ± 0.3	6.0 ± 0.3	0.76	6.1 ± 0.3	4.6 ± 0.2	0.0003
Interaction with object	6.1 ± 0.3	6.3 ± 0.3	0.43	6.1 ± 0.3	4.8 ± 0.3	0.002
Force feedback	6.1 ± 0.4	6.1 ± 0.3	0.96	6.1 ± 0.4	5.5 ± 0.3	0.07
Eye/hand coordination	6.4 ± 0.4	6.8 ± 0.3	0.22	6.4 ± 0.4	5.5 ± 0.3	0.02
2-handed navigation	6.4 ± 0.3	6.7 ± 0.3	0.42	6.4 ± 0.3	5.7 ± 0.4	0.08
Realism	6.8 ± 0.2	6.5 ± 0.3	0.45	6.8 ± 0.2	6.2 ± 0.2	0.01
Feeling "at ease"	5.1 ± 0.3	6.3 ± 0.3	0.009	5.1 ± 0.3	4.4 ± 0.3	0.14
Senior surgeon's assessment						
Performance	7.5 ± 0.3	8.0 ± 0.2	0.13	7.5 ± 0.3	4.2 ± 0.4	<0.0001
Execution quality	7.5 ± 0.2	8.2 ± 0.2	0.02	7.5 ± 0.2	4.3 ± 0.4	<0.0001
Execution speed	7.6 ± 0.3	8.1 ± 0.2	0.22	7.6 ± 0.3	4.0 ± 0.4	<0.0001
Hesitation	2.4 ± 0.2	1.7 ± 0.2	0.02	2.4 ± 0.2	6.5 ± 0.5	<0.0001
VRS data						
Simulation time (sec)	370.8 +/- 22.0	330.9 +/- 35.8	0.39	370.8 +/- 22.0	482.0 +/- 35.1	0.002
Blood loss (ml)	107.7 +/- 29.8	70.3 +/- 11.9	0.21	107.7 +/- 29.8	89.4 +/- 12.7	0.58
Reserve volume (ml)	9.5 +/- 1.5	8.3 +/- 1.5	0.61	9.5 +/- 1.5	18.3 +/- 5.5	0.15
Ovarian diathermia insult time (sec)	0.6 +/- 0.1	0.4 +/- 0.1	0.09	0.6 +/- 0.1	0.9 +/- 0.2	0.30
Left instrument migration ^a	3.0 +/- 0.3	2.6 +/- 0.5	0.35	3.0 +/- 0.3	4.4 +/- 0.7	0.03
Right instrument migration ^a	5.1 +/- 0.4	4.3 +/- 0.4	0.15	5.1 +/- 0.4	6.2 +/- 0.5	0.08
Instrument exit left ^b	6.9 +/- 2.9	3.7 +/- 1.3	0.44	6.9 +/- 2.9	8.0 +/- 1.9	0.85
Instrument exit right ^b	6.3 +/- 1.4	3.6 +/- 0.7	0.07	6.3 +/- 1.4	7.2 +/- 1.2	0.50

Data reported as mean ± standard deviation

^a Distance to instrument tip, measuring economy of movement and precision (lateral movements)

^b Number of times instrument leaves camera's field of view