Clinics in Surgery

Research Article
Published: 03 Feb, 2020

Laparoscopic Virtual Reality Simulation Combined with Live Animal Model Training: A Clinical Experience

Ulrika Johannesson[1], Sophia Ehrstrom[2], Tomas Askerud[3] and Magnus Kjellman[4]*

[1]Department of Clinical Sciences, Division of Obstetrics and Gynecology, Danderyd Hospital, Karolinska Institute, Sweden

[2]Department of Gynecology, Ultragyn Sophiahemmet Private Hospital, Sweden

[3]Clinical Skills Center, Karolinska University Hospital, Stockholm, Sweden

[4]Department of Molecular Medicine and Surgery, Karolinska Institute, Sweden

Abstract

Objective: Does virtual reality simulation combined with animal model training improve psychomotor skills over time?

Background: The advantages of laparoscopy are well known. An increase in 80% of emergency gynecological patients at Danderyd Hospital resulted in more surgical cases during nights and weekends. The doctors covering the shifts were residents and specialists either with an obstetric or gynecological profile. To ensure patient safety a clinical education model focusing on basic laparoscopic skills was needed.

Design: Fifty-three doctors were invited to a five step curriculum in laparoscopy consisting of (1) a two hour interactive lecture on laparoscopy, (2) a two hour box training and training of open entry technique, (3) a Virtual Reality (VR) simulator program of 16 different psychomotor skills (LapSim®), (4) a one day laparoscopic training on a live animal model, (5) six months later a repetition of step 3. Measurements on step 3 were compared to step 5 and analyzed by Wilcoxon Matched Pairs test and Sign test. Ethical permission was obtained.

Setting: Danderyd University Hospital and Karolinska University Hospital Solna, Stockholm, Sweden.

Participants: All fifty-three doctors working at the clinic were invited to the study.

Results: Thirty-nine doctors completed the curriculum. There was a significant improvement in psychomotor skills measuring camera navigation ($p=0.001$), coordination ($p=0.03$), grasping ($p=0.02$), lifting and grasping ($p=0.02$), cutting and clip applying ($p<0.05$) at step 5 compared to step 3.

Conclusion: Virtual reality simulation combined with animal model training can significantly improve psychomotor skills after 6 months. Patient safety may increase in larger clinics where there is a need for emergency gynecological laparoscopy. Further studies are required to measure the duration and quality of improvement.

Keywords: Laparoscopy; Surgical training; Virtual reality simulation

Correspondence:
Ulrika Johannesson, Department of Clinical Sciences, Division of Obstetrics and Gynecology, Danderyd Hospital, Karolinska Institute, 182 88, Stockholm, Sweden,
E-mail: ulrika.johannesson@sll.se

Received Date: *10 Jan 2020*
Accepted Date*: 28 Jan 2020*
Published Date*: 03 Feb 2020*

Citation:
Johannesson U, Ehrstrom S, Askerud T, Kjellman M. Laparoscopic Virtual Reality Simulation Combined with Live Animal Model Training: A Clinical Experience. Clin Surg. 2020; 5: 2729.

Introduction

In gynecology, laparoscopy is the golden standard surgical approach [1]. Since even a simple procedure has a risk of severe complications, it is important to secure evidence-based surgical training [2,3]. In order to improve surgical skills before entry to the operating room a Virtual Reality (VR) simulator program has been developed [4,5]. A common gynecological procedure such as laparoscopic salpingectomy can have a shortened learning curve by using VR simulation [6,7]. Other training methods such as box training, live animal training and animal cadaver training have also been implemented in different studies [8]. Besides being inexpensive, box training also has the advantage of haptic feedback, although this can be provided by some VR simulators [9]. Surgery on a live animal allows the trainee to practice on anatomy including management of bleeding and tissue injury [10]. The cadaver training also creates a good anatomical practice although management of complications becomes less evident due to lack of circulation and tissue change [11]. By using

Table 1: Basic skills at step 3 and 5 presented as median values (interquartile range).

Task	Score	Time (sec)	PathLength (mm)	Angular Path (mm)	Stretch damage	Tissue damage	Blood loss (liters)	P values (comparison between step 3 and 5)
Camera Navigation 1 Step 3	76 (61–86)	77 (49–102)	1.3 (1.0–2.2)	472 (328–920)	NA	NA	NA	
Camera Navigation 1 Step 5	76 (61–86)	77 (49–102)	1.4 (1.0-2.2)	505 (288-788)	NA	NA	NA	ns
Camera Navigation 2 Step 3	59 (47–74)	97 (60–139)	2.2 (1.6–3.3)	952 (571–1348)	NA	NA	NA	
Camera Navigation 2 Step 5	69 (55-76)	75 (53-95)	1.8 (1.4-2.4)	703 (536-944)	NA	NA	NA	0.01 (score) 0.001 (time) 0.04 (pathlength) 0.001 (angularpath length)
Coordination 1 Step 3	75 (63–84)	106 (86–127)	2.0 (1.6–2.6)	571 (480–804)	NA	4 (1–7)	NA	0.04 (time)
Coordination 1 Step 5	81 (64-87)	83 (67-137)	1.8 (1.6-2.7)	583 (465-854)	NA	3 (2-4)	NA	
Coordination 2 Step 3	83 (77–85)	59 (50–68)	1.2 (1.1–1.6)	341 (286–481)	NA	2 (1–5)	NA	
Coordination 2 Step 5	83 (77-88)	57 (50-62)	1.5 (1.1-1.8)	364 (310-463)	NA	2 (1-3.5)	NA	ns
Clip applying 1 Step 3	80 (67–90)	154 (104–235)	1.4 (.9–2.1)	326 (202–492)	100(59–100)	NA	0.05 (.0-0.29)	
Clip applying 1 Step 5	94 (79-99)	126 (105-174)	1.4 (1.1-2.0)	207 (135-363)	66(56-100)	NA	0 (0-0.07)	0.03 (score) 0.006 (time) 0.04 (path length) 0.02 (angular path length) 0.04 (stretch damage) <0.05 (blood loss)
Clip applying 2 Step 3	78 (61–80)	136 (100–208)	1.5 (.8–2.4)	320 (178–507)	100	NA	0.3 (0.2-0.8)	
Clip applying 2 Step 5	80 (78-90)	116 (89-144)	1.0 (0.7-1.5)	230 (140-330)	100	NA	0.2 (0-0.7)	0.006 (time) 0.03 (score) <0.001 (path length) 0.001 (angular path length)
Clip applying 3 Step 3	80 (74–84)	115 (70–185)	1.4 (0.7–2.1)	262 (106–450)	100	NA	0.2 (0.09-0.64)	
Clip applying 3 Step 5	80 (81-90)	98 (68-146)	0.9 (0.4-1.6)	152 (91-312)	100	NA	0.2 (0-0.4)	ns

NA: Not Applicable; ns: Not Significant

different training methods in psychomotor and perceptual skills before performing a procedure on a patient, patient safety increases and consequently this can be cost reducing [12]. A systematic review of laparoscopic surgery and simulation-based training indicates a translation of the surgical skills to the operating theatre ensuring a good quality patient safety [13]. In 2010 there was an 80% increase of emergency gynecological patients at Danderyd hospital resulting in more surgical cases during nights and weekends. The doctors covering the shifts were residents and specialists either with an obstetric or gynecological profile. At the time of the study there were no national guidelines in laparoscopy training for neither residents nor for consultants. To ensure patient safety a clinical education model focusing on basic laparoscopic skills was needed. The purpose of this study was to develop a structured curriculum for residents in obstetrics and gynecology and the primary outcome to investigate if VR simulation combined with animal model training can improve psychomotor skills after 6 months.

Materials and Methods

Fifty-three doctors working in the Department of Obstetrics and Gynecology, Danderyd Hospital, Stockholm, Sweden were recruited. They were residents and specialists in obstetrics and gynecology. In step 1 they participated, on five different occasions, in an interactive lecture on laparoscopy (Figure 1). This was directly followed by step 2, where they performed attempts on open entry technique as well as box-training with moving objects in a box, cutting, lifting and grasping for two hours. Thereafter they were schemed to perform VR simulator sessions in step 3. The VR simulator was a LapSim (Surgical Science, Gothenburg, Sweden) with Software Version 2010 and proven construct validity. The participants were introduced to the program by a technician and support was available during their training. They performed 16 different exercises on a LapSim Simulator including psychomotor skills measuring camera navigation, coordination, grasping, lifting and grasping as well as cutting and clip applying. These psychomotor skills were in detailed analyzed with the total score for the exercise, the total procedure time, the path length (which is the shortest distance between two sites), the angular path length measuring tremor, stretch damage, tissue damage and blood loss. Approximately one month later all participants had a whole day of surgical procedures on an animal model. The procedures included hysterectomy, dissection of ureter and bladder and voluntary suturing on a non-survivable animal model with female crossbreed pigs 30 kg under general anesthesia. During the procedure veterinary personnel monitored and journalized the depth of anesthesia, pain and physiological parameters. Ethical approval was obtained from Stockholm Ethical Committee N320/10. Subsequently, approximately six months later, participants repeated the simulator exercises in step 5. Measurements on step 3 were compared to step 5 and analyzed by Wilcoxon Matched Pairs test and Sign test.

Results

The study group consisted of 40 females and 13 males. Twenty-

Table 2: Advanced skills at step 3 and 5 presented as median values (interquartile range).

Task	Overall score	Time (sec)	Path Length (mm)	Angular Path (mm)	Stretch damage (%)	Tissue damage (score)	Blood loss (liters)	P values (comparison between step 3 and 5)
Cutting 1 Step 3	88 (81–95)	119 (94–142)	1.1 (.7–1.6)	300 (211–409)	82 (51–100)	3 (1–5)	NA	
Cutting 1 Step 5	96 (87-100)	98 (86-133)	1.0 (0.8-1.4)	274 (208-381)	55 (14-100)	2 (0.5-4)	NA	0.05 (score) 0.02 (stretch damage)
Cutting 2 Step 3	88 (79–88)	94 (77–113)	0.9 (2.7-.7)	244 (189–335)	100	3 (1–4)	NA	
Cutting 2 Step 5	88 (82-91)	98 (70-119)	0.9 (0.6-1.6)	223 (133-306)	100 (78-100)	2 (1-4)	NA	ns
Cutting right Step 3	91 (86–100)	104 (84–135)	0.8 (0.6–1.0)	209 (161–296)	83 (41–100)	1 (0–2)	NA	
Cutting right Step 5	89 (87-92)	116 (86-132)	0.8 (0.7-1.2)	203 (169-278)	100 (56-100)	0.5 (0-2)	NA	0.02 (stretch damage)
Cuttingleft Step 3	91 (88–100)	95 (74–111)	0.7 (0.6–1.0)	194 (144–260)	100 (39–100)	1 (0–3)	NA	
Cuttingleft Step 5	97 (88-100)	81 (65-97)	0.7 (0.5-0.9)	168 (123-232)	48 (29-100)	0.5 (0-2)	NA	002 (time) 0.03 (path length)
Grasping 1 Step 3	92 (76–98)	36 (27–61)	1.0 (0.8–1.4)	258 (179–385)	NA	3 (1–6)	NA	
Grasping1 Step 5	93 (83-97)	43 (26-54)	1.0 (0.8-1.2)	238 (173-280)	NA	1 (0-4)	NA	0.02 (tissue damage)
Grasping 2 Step 3	80 (65–88)	59 (45–79)	1.2 (1.0–1.7)	292 (229–409)	NA	6 (3–16)	NA	
Grasping 2 Step 5	87 (78-93)	44 (38-67)	1.1 (0.9-1.4)	252 (205-309)	NA	5 (3-16)	NA	0.02(score) 0.02 (time) 0.003 (path length) 0.009 (angular path length)
Lifting and grasping 1 Step 3	89 (72–95)	94 (81–127)	1.4 (1.2–2.0)	353 (301–458)	NA	6 (3–10)	NA	
Lifting and grasping 1 Step 5	93 (83-98)	80 (68-101)	1.4 (1.2-1.6)	318 (283-400)	NA	5 (2.5-8.5)	NA	0.04 (score) 0.02 (time) 0.04 (angular path length)
Lifting and grasping 2 Step 3	96 (92–99)	75 (63–98)	1.3 (1.2–1.5)	305 (275–353)	NA	3 (2–5)	NA	
Lifting and grasping 2 Step 5	97 (93-99)	68 (62-91)	1.3 (1.2-1.5)	299 (279-349)	NA	2.5 (1-5)	NA	ns
Lifting and grasping 3 Step 3	95 (89–98)	84 (71–109)	1.3 (1.1–1.5)	294 (252–354)	NA	3 (1–5)	NA	
Lifting and grasping 3 Step 5	96 (89-98)	80 (69-97)	1.3 (1.1-1.4)	287 (247-333)	NA	2 (1-6)	NA	ns

NA: Not Applicable; ns: Not Significant

four were residents and 29 specialists either with an obstetric or gynecological profile. Median age was 41 years (range 28-65). Thirty-nine doctors completed the curriculum. The dropouts were due to maternity leave, change of specialty and loss of motivation. There was a significant improvement in psychomotor skills measuring camera navigation (p=0.001), coordination (p=0.03), grasping (p=0.02), lifting and grasping (p=0.02), cutting and clip applying (p<0.05) at step 5 compared to step 3 (Table 1 and 2, Figure 2 and 3).

Discussion

Our study demonstrates that virtual reality simulation combined with animal model training can significantly improve psychomotor skills after six months. There was significant improvement in 10 out of 16 different categories; both basic skills such as camera navigation and more advanced skills such as lifting and grasping were ameliorated. The majority enhanced in score and time, indicating that even after some period the most basic psychomotor skills remain. Likewise, in the more advanced procedures such as clip applying, lifting and grasping as well as grasping there were significant development in domains such as instrument path length and angular path length. This study included participants with different abilities and experience of laparoscopic surgery which illustrates the reality at a district general hospital in Sweden. In coordination with a clinical skills center, a laparoscopic training program can be created and ensure sufficient training [14-16]. The strength of this study is a relative high number of participants and despite some dropouts the majority (74%) completed the curriculum. Earlier studies on validation of curriculum have had

Figure 1: Shows the study curriculum.

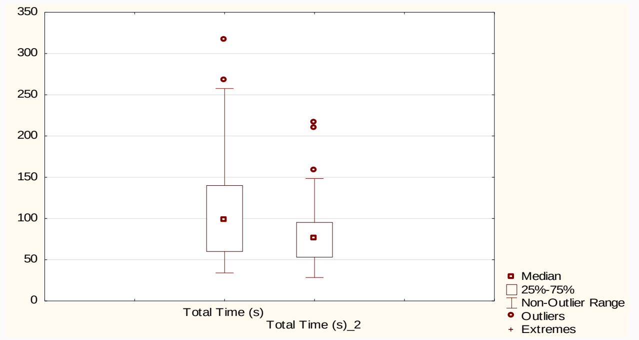

Figure 2: Shows significant reduction in total time (seconds) of camera navigation in step 3 compared to step 5.

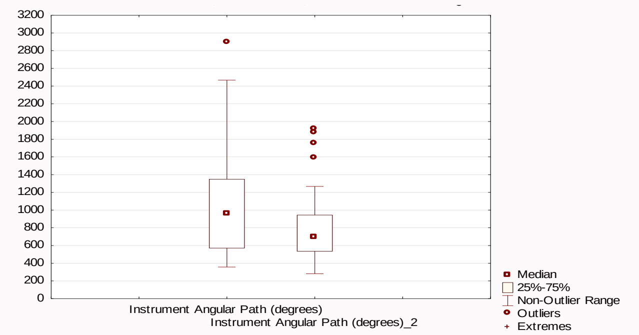

Figure 3: Shows significant improvement in instrument angular path length (degrees) in step 3 compared to step 5.

fewer completions [17]. Shore et al. [18] developed a standardized laparoscopy curriculum for gynecological residents using Delphi consensus methodology. In our curriculum we combined validated methods to maximize learning. This can be further improved by adding procedural training in VR simulators since this also has resulted in shorter time to reach proficiency [19]. Paschold et al. [20] showed how preconditioning by performing VR simulation directly prior to a live surgery such as laparoscopic appendectomy and Cholecystectomy augments the postoperative results. Another perspective is to add the effects of competition to the box and/or VR simulator training which might lead to improved dexterity and enhanced performance [21]. A standardized assessment of the interactive lecture and box training in step 1 and 2 would also have made the study more replicable. One limitation of this study is the lack of randomization. There are some randomized controlled trials in gynecological laparoscopy, but the majority compares box training and VR simulation [9,12,22]. However, a randomization at our clinic would have resulted in several small groups and consequently less ability to show statistical differences. Another limitation is the combination of various methods. We cannot rule out that the improved psychomotor skills can be due to the animal model training which occurred at step 4. Another perspective is the possibility of increasing amount of real laparoscopic procedures between step 2 and step 5. Nonetheless, by performing different modalities in training and establishing a standardized assessment of these further increases patient safety [23]. By testing procedures on an animal model followed by training with or without VR simulator Nickel et al. could not show any benefit from VR training [24]. An RCT on laparoscopic salpingectomy on live patients, where the intervention group completed simulation procedures on a porcine cadaver prior to patient surgery, showed improved surgical technique [25]. Since development of surgical skills also is dependent on judgment and competence this has not been measured in our curriculum. In conclusion, this prospective cohort study shows that VR simulation combined with animal model training can significantly improve laparoscopic psychomotor skills after 6 months. By using our curriculum patient safety may increase in larger clinics where there is a need for emergency gynecological laparoscopy. Further studies are required to measure the duration and quality of improvement.

Conclusion

Laparoscopic virtual reality simulation combined with animal model training may significantly improve psychomotor skills after 6 months.

References

1. Gaitán HG, Reveiz L, Farquhar C, Elias VM. Laparoscopy for the management of acute lower abdominal pain in women of childbearing age. Cochrane Database Syst Rev. 2014;(5):CD007683.
2. Wong JMK, Bortoletto P, Tolentino J, Jung MJ, Milad MP. Urinary Tract Injury in Gynecologic Laparoscopy for Benign Indication: A Systematic Review. Obstet Gynecol. 2018;131(1):100-8.
3. Llarena NC, Shah AB, Milad MP. Bowel injury in gynecologic laparoscopy: A systematic review. Obstet Gynecol. 2015;125(6):1407-17
4. Larsen CR, Grantcharov T, Aggarwal R, Tully A, Sørensen JL, Dalsgaard T, et al. Objective assessment of gynecologic laparoscopic skills using the LapSimGyn virtual reality simulator. Surg Endosc. 2006;20(9):1460-6.
5. Vapenstad C, Buzink SN. Procedural virtual reality simulation in minimally invasive surgery. Surg Endosc. 2013;27(2):364-77.
6. Larsen CR, Soerensen JL, Grantcharov TP. Effect of virtual reality training on laparoscopic surgery: Randomised controlled trial. BMJ. 2009;338:b1802.
7. Larsen CR, Oestergaard J, Ottesen BS, Soerensen JL. The efficacy of virtual reality simulation training in laparoscopy: a systematic review of randomized trials. Acta Obstet Gynecol Scand. 2012;91(9):1015-28.
8. Gurusamy KS, Nagendran M, Toon CD, Davidson BR. Laparoscopic surgical box model training for surgical trainees with limited prior laparoscopic experience. Cochrane Database Syst Rev. 2014;(3):CD010478.
9. Akdemir A, Sendag F, Oztekin MK. Laparoscopic virtual reality simulator and box trainer in gynecology. Int J Gynaecol Obstet. 2014;125(2):181-5.
10. La Torre M, Caruso C. The animal model in advanced laparoscopy resident training. Surg Laparosc Endosc Percutan Tech. 2013;23(3):271-5.
11. Lim CP, Roberts M, Chalhoub T, Waugh J, Delegate L. Cadaveric surgery in core gynecology training: A feasibility study. Gynecol Surg. 2018;15(1):4.
12. Shore EM, Grantcharov TP, Husslein H, Shirreff L, Dedy NJ, McDermott CD, et al. Validating a standardized laparoscopy curriculum for gynecology residents: A randomized controlled trial. Am J Obstet Gynecol. 2016;215(2):204.e1-204.e11.
13. Vanderbilt AA, Grover AC, Pastis NJ, Feldman M, Granados DD, Murithi LK, et al. Randomized controlled trials: A systematic review of laparoscopic surgery and simulation-based training. Glob J Health Sci. 2014;7(2):310-27.
14. Burden C, Oestergaard J, Larsen CR. Integration of laparoscopic virtual-reality simulation into gynaecology training. BJOG. 2011;118:5-10.
15. Burden C, Appleyard TL, Angouri J, Draycott TJ, McDermott L, Fox R. Implementation of laparoscopic virtual-reality simulation training in gynaecology: A mixed-methods design. Eur J Obstet Gynecol Reprod Biol. 2013;170(2):474-9.

16. Ahlborg L, Hedman L, Nisell H, Fellander-Tsai L, Enochsson L. Simulator training and non-technical factors improve laparoscopic performance among OBGYN trainees. Acta Obstet Gynecol Scand. 2013;92(10):1194-201.

17. Strandbygaard J, Bjerrum F, Maagaard M, Rifbjerg Larsen C, Ottesen B, Sorensen JL. A structured four-step curriculum in basic laparoscopy: development and validation. Acta Obstet Gynecol Scand. 2014;93(4):359-66.

18. Shore EM, Lefebvre GG, Husslein H, Bjerrum F, Sorensen JL, Grantcharov TP. Designing a Standardized Laparoscopy Curriculum for Gynecology Residents: A Delphi Approach. J Grad Med Educ. 2015;7(2):197-202.

19. Bjerrum F, Maagaard M, Led Sorensen J, Rifbjerg Larsen C, Ringsted C, Winkel P, et al. Effect of instructor feedback on skills retention after laparoscopic simulator training: Follow-up of a randomized trial. J Surg Educ. 2015;72(1):53-60.

20. Paschold M, Huber T, Kauff DW, Buchheim K, Lang H, Kneist W. Preconditioning in laparoscopic surgery--results of a virtual reality pilot study. Langenbecks Arch Surg. 2014;399(7):889-95.

21. Hashimoto DA, Gomez ED, Beyer-Berjot L, Khajuria A, Williams NN, Darzi A, et al. A Randomized Controlled Trial to Assess the Effects of Competition on the Development of Laparoscopic Surgical Skills. J Surg Educ. 2015;72(6):1077-84.

22. Gala R, Orejuela F, Gerten K, Lockrow E, Kilpatrick C, Chohan L, et al. Effect of validated skills simulation on operating room performance in obstetrics and gynecology residents: A randomized controlled trial. Obstet Gynecol. 2013;121(3):578-84.

23. Shore EM, Lefebvre GG, Grantcharov TP. Gynecology resident laparoscopy training: present and future. Am J Obstet Gynecol. 2015;212(3):298-301.

24. Nickel F, Bintintan VV, Gehrig T, Kenngott HG, Fischer L, Gutt CN, et al. Virtual reality does not meet expectations in a pilot study on multimodal laparoscopic surgery training. World J Surg. 2013;37(5):965-73.

25. Patel NR, Makai GE, Sloan NL, Della Badia CR. Traditional Versus Simulation Resident Surgical Laparoscopic Salpingectomy Training: A Randomized Controlled Trial. J Minim Invasive Gynecol. 2016;23(3):372-7.