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The impact of virtual reality training on laparoscopic surgical skills; A prospective blinded controlled trial

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ABSTRACT

Background. Laparoscopic surgery has gained popularity in the last few decades replacing open standard techniques in several procedures. While its use and scope expand, a standardized method of training and assessment in laparoscopic skills is lacking. Aim. To assess the effect of virtual reality (VR) training on laparoscopic surgical skills. Materials and Methods. It is a prospective, controlled study conducted at Sagar Hospital's skill lab and Shanthi Hospital and Research Centre (SHRC). We included 27 post graduates in general surgery. They were divided into two groups. One group underwent training in VR Simulator for one week, 30 minutes each day. The second group received no training. Their proficiency while mobilizing the Gallbladder from its liver bed was assessed using a validated scale by a single blinded observer. Results. The statistical analysis was done using a non-parametric test (Mann-Whitney U test). Residents who underwent training in VR simulator got better scores in Overall rating and also in individual parameters when compared with the control group (P = <0.05). Conclusions. Laparoscopic surgical skills can be increased by using proficiency-based VR simulator training and it can be transferred to actual operations. VR simulators are a valid tool for laparoscopic surgical skills training.

Category: Original Research Paper

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Introduction

Laparoscopic surgery has gained popularity in the last few decades replacing open standard techniques in several procedures [1-3]. This is mainly because of the advantages that laparoscopic surgery offers like minimal surgical trauma, early postoperative recovery, shorter hospitalization and better cosmetic results [4]. Learning laparoscopic surgical skills is different when compared to open surgical skills, as it requires hand eye coordination and accommodation for lack of depth perception with 2D vision. It requires proper and extensive training to become competent in laparoscopic surgery. Learning laparoscopic techniques at an actual surgery is time consuming and can be a safety concern for patients [5,6].

There are various training modules available to acquire laparoscopic skills outside the operation theatre like box trainer, Virtual Reality (VR) simulator, animal models, cadaver models, to name a few. Training on these modules helps in acquiring basic laparoscopic skills. Among them, only VR and Augmented Reality simulators provide objective metrics and real time feedback to trainees [7]. Although VR simulation offers many advantages to a trainee for developing new skills and learning new procedures, evidence on skill transfer from simulator to operation theatre is still limited [8,9]. We investigated the impact of VR simulator training on laparoscopic surgical skills in a commonly performed laparoscopic procedure, such as laparoscopic cholecystectomy. The investigation was carried out as a prospective, observer blinded, controlled trial, according to the guidelines of the consolidated standards of reporting trials (CONSORT), which is presented in Figure 1.

The aim of the present study was to investigate whether laparoscopic skills acquired in a virtual environment could be transferred to actual operations, and therefore to validate the role of VR simulation as a tool for surgical skills training.

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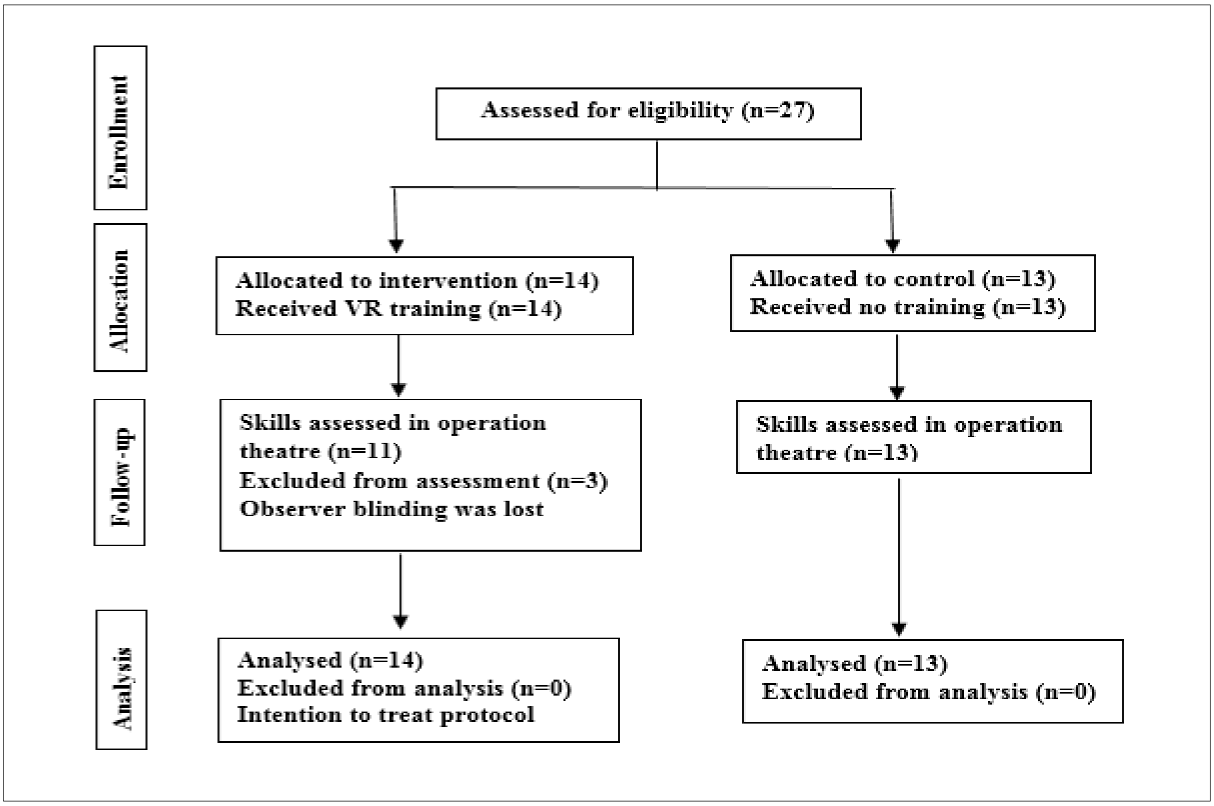


Figure 1. CONSORT diagram of the trial

Materials and Methods

It is a prospective, blinded, controlled study conducted at Sagar Hospital's skill lab and Shanthi Hospital and Research Centre (SHRC). The study was conducted between December 2019 and April 2020. The study protocol was approved by the hospital ethics committee.

We included in our study 27 residents from the department of General Surgery, with limited laparoscopic experience. We defined surgical residents with limited laparoscopic experience as those who have helped senior surgeons in laparoscopic operations by no more than holding the camera, with no experience in laparoscopic dissection. The residents were then allotted by the principal investigator to either an intervention group that received training in a VR simulator or a control group that did not receive any training. The randomization was not possible because of the practical difficulty in consistently getting residents for the study.

Simulator training

The residents in the intervention group were given an oral introduction to the VR simulator and a demonstration of the training exercises to be carried out. The intervention group undertook a specific training programme in the VR simulator (BIGSOLV Laparo simulator, Sri Dutt Technologies, Bengaluru, India). The programme comprised basic surgical skill tasks which are described in detail below. The tasks were of progressive complexity. The intervention group underwent training in VR Simulator for one week, 30 minutes a day. Figure 2 shows the images of the various tasks as seen in the VR simulator.

In Task 1, Pointing dots – trainee had to move the tool sequentially from 1 to 10. In Task 2, Joining straight lines – the tool had to be moved sequentially from 1 to 10 along the straight path provided. In Task 3, Joining curved lines – the tool had to be moved along the curved path provided. For Tasks 1, 2 and 3, a needle tool was used and these tasks were mainly aimed at improving the hand to eye coordination.

In Task 4, Picking objects - This task basically consisted of a couple of cubes and a bowl. The trainee was supposed to pick up the cube using the tool and transfer it into the bowl. In Task 5, Peg transfer – It consisted of a torus and a peg and the trainee was asked to pick up the torus using the tool and transfer it over the peg. For Tasks 4 and 5, a grasper tool was used and these tasks were aimed at giving the user a higher degree of hand to eye coordination, compared to Tasks 1 to 3, with respect to handling objects in a 3D space.

In Task 6, Tissue cutting – In this task, a section of the tissue highlighted in yellow had to be cut using a scissor. In Task 7, Tissue cauterization – this task was aimed at giving the trainee a feel of using both hands and feet while performing surgery. Needle and footswitch were used here. The tool tip was 'heated' by means of applying some pressure on a switch that was controlled by the surgeon's feet and the tooltip had to be moved over the marked area on a virtual tissue thus denoting cauterization.

In Task 8, Stone removal – This task involved the use of two tools, a grasper and an endobag. The grasper was used to pick the 'gallstone' and the endo bag was used to collect the gallstone that had been picked up. This task also provided an enhanced visualization of the environment that surgeons encounter within the human body. Various tools used in VR training were depicted in Figure 3.

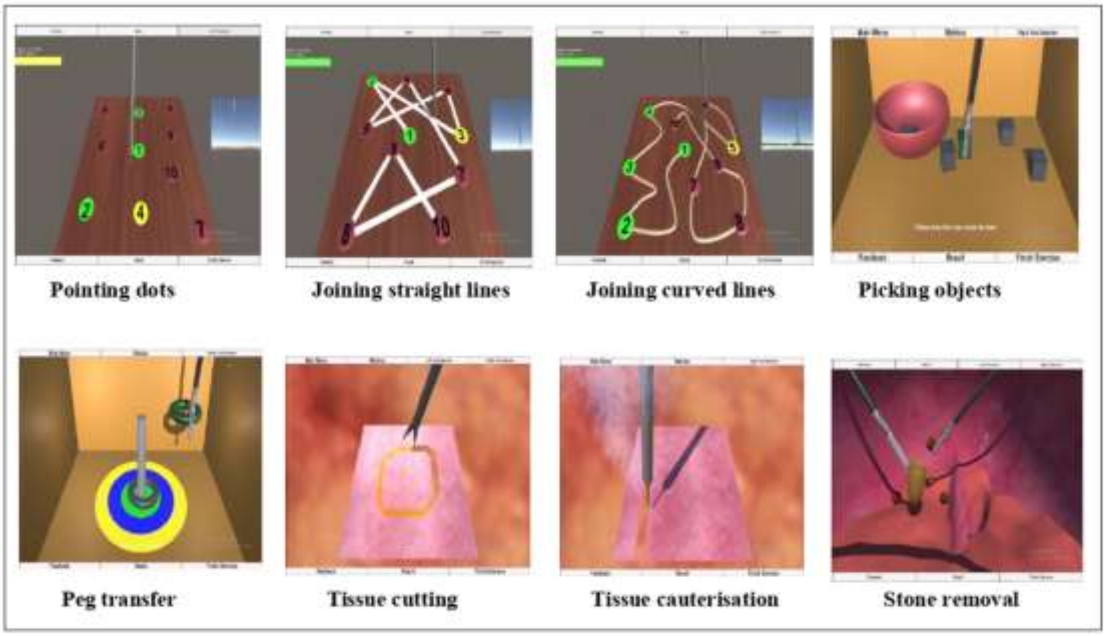


Figure 2. Images of the various tasks as seen in the VR simulator

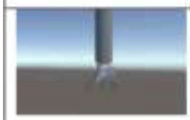
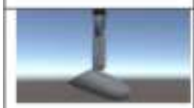
Tool	Name	Objective
	Needle	Pointing the object / Thermal Control.
	Grasper	Grasping the Object.
	Scissor	Cutting.
	Endo Bag	Remove the Stones.

Figure 3. Tools used in the VR training

Assessment

All the residents included in the study were assessed consistently by an experienced surgeon who was blinded to the training status of the residents. All the residents were shown the video of laparoscopic cholecystectomy before assessment. Their task of having to dissect the gallbladder off the liver bed was explained to them. This part of Laparoscopic Cholecystectomy following dissection of Calot's triangle and clipping and cutting the cystic duct and artery was chosen to maximize safety to the patient. The senior surgeon was always scrubbed in and supervised the novice closely during this dissection.

The assessment was done using the modified global rating scale of the OSATS (Objective Structured Assessment of Technical Skills) [10] which is shown in (Table 1). The candidates were given scores of 1-5 for each parameter based on his/her performance. Under time and motion parameter, to make scoring more objective, the scoring was based on 3 factors: 1. whether the candidate reached the intended point of dissection, 2. whether the path to the target was straight and 3. the speed of reaching the target. Each of these 3 factors was considered as a 5-point scale and the average of those three scores were taken as the time and motion parameter score.

Statistical analysis

Data was presented as cumulative scores as medians and compared using nonparametric analysis (Mann-Whitney U test). We considered a P value of 0.05 or less to be statistically significant. Data was analyzed using SPSS 20.0 (Statistical Package for the Social Sciences) software package for Windows.

Results

Out of 27 residents, 14 were allocated to the intervention group and 13 were allocated to the control group. All residents in both groups successfully completed the Gallbladder dissection from the liver bed. The observer blinding was lost in three residents from the intervention group because of the inadvertent disclosure of their training status. However, they were included in the final analysis to keep with the intention to treat protocol.

Table 1. The modified global rating scale of the OSATS (Objective Structured Assessment of Technical Skills)

Please circle the number corresponding to the candidate's performance in each category, irrespective of training level						
		1	2	3	4	5
Respect for Tissue		Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments		Careful handling of tissue but occasionally caused inadvertent damage		Consistently handled tissue appropriately with minimal damage
Time and Motion	**Reaching the intended point of dissection**	Struggles in reaching		Difficulty in reaching		Easily reaching
	Straight path to the target	Significant deviation		Slight deviation		No deviation
	Speed of reaching	Slow		Moderate speed		Good speed
Instrument Handling		Repeatedly makes tentative or awkward moves with instruments by inappropriate use of instruments		Competent use of instruments but occasionally appeared stiff or awkward		Fluid moves with instruments and no awkwardness
Knowledge of Instruments		Frequently asked for wrong instrument or used inappropriate instrument		Knew names of most instruments and used appropriate instrument		Obviously familiar with the instruments and their names
Flow of Operation		Frequently stopped operating and seemed unsure of next move		Demonstrated some forward planning with reasonable progression of procedure		Obviously planned course of operation with effortless flow from one move to the next
Use of Assistants		Consistently placed assistants poorly or failed to use assistants		Appropriate use of assistants most of time		Strategically used assistants to the best advantage at all time
Knowledge of Specific Procedure		Deficient knowledge. Needed specific instruction at most steps		Knew all important steps of operation		Demonstrated familiarity with all aspects of operation

The median total score obtained on the modified global rating scale of operative performance was 23 in the intervention group and 15 in the control group. The scores were statistically significant ($P = 0.001$). If we look at the individual parameters of the modified global rating scale, the intervention group performed well in all the parameters when compared with the control group and the results were statistically significant (P value <0.05). Figures 4 and 5 depict the comparison between the overall scores and individual parameters of the OSATS scale in the two groups respectively.

Discussions

Laparoscopic surgery has gained popularity in the last few decades replacing open standard techniques in several procedures because of the advantages well known to all of us. While its prevalence expands, the need for reliable training and assessment tools are lacking. Laparoscopic surgery requires a different set of skills when compared to open surgery due to the fact that laparoscopic surgery needs good hand eye coordination, good manual dexterity to use long instruments and also adjusting for lack of 3D vision [11]. It's always better to acquire these skills outside the operation theatre through training modules to avoid a steeper learning curve, save time in the operation theatre and also to lessen the risk to the patient.

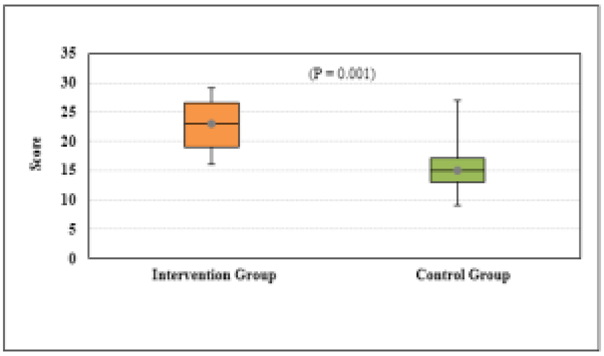


Figure 4. Box plot comparison between the overall scores of the OSATS scale in the two groups respectively

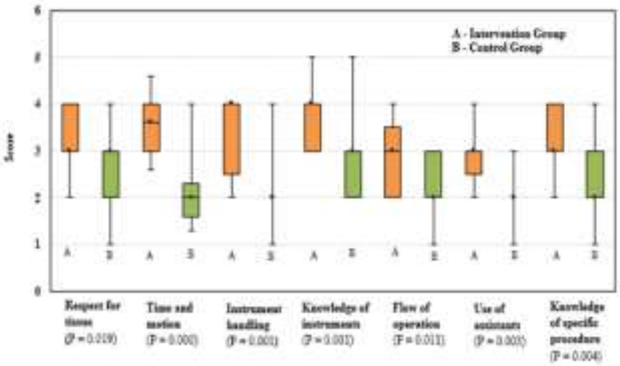


Figure 5. Box plot comparison between the individual parameters of the OSATS scale in the two groups respectively

There are various training modules available for laparoscopic surgery. VR simulator training is one such method of laparoscopic training which is aimed at improving basic and advanced surgical skills and also it provides objective assessment. Our study has shown that, at a novice level, VR simulator training does improve basic surgical skills and these skills can be transferred to tissue dissection capability at an operation. Other studies have shown that skills obtained through VR simulator training can be transferred to operating room [12-17]. A systematic review published by Gurusamy et al. involving 622 participants in 22 trials concluded that VR simulator training, when compared to other modules of training, improves standard surgical training in surgical trainees with limited or no previous experience [18].

A valid and reliable assessment tool is also needed to document surgical skills training programs. The OSATS shows promise as a tool for assessing the technical skill of surgical trainees [19]. The OSATS scale used in our study had 7 parameters. Among them 2 parameters, i.e, use of assistants and knowledge of the specific procedure had no relevance to training in a VR simulator as it doesn't help in acquiring those skills. But the intervention group scored better in these parameters as well. It was a surprise that the candidates did well even in those categories which were not influenced by the VR simulation and we can only surmise that this was secondary to a boost in confidence of the trainee and probably can be considered as a serendipitous advantage of a VR simulator training.

However, our study had some limitations. Scoring of performance in the operating room was subjective, although the impact of this was minimized by blinding the assessor and using the objective scoring criteria. In addition, our sample size was small and we may need a larger trial to confirm the present findings.

Conclusions

To conclude, our study provides objective evidence that training with the VR simulator does improve surgical operative performance. Thus, skills in laparoscopic surgery can be increased by using proficiency-based VR simulator training and it can be transferred to actual operations. VR simulators are a valid tool for laparoscopic surgical skills training and could be incorporated into surgical training programs.

Conflict of interest disclosure

There are no known conflicts of interest in the publication of this article. The manuscript was read and approved by all authors.

Compliance with ethical standards

Any aspect of the work covered in this manuscript has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

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References

1. Bruhat MA, Pouly JL. Endoscopic treatment of ectopic pregnancies. *Curr Opin Obstet Gynecol*. 1993; 5(2):260-6.

2. Keus F, Broeders IA, van Laarhoven CJ. Gallstone disease: Surgical aspects of symptomatic cholecystolithiasis and acute cholecystitis. *Best Pract Res Clin Gastroenterol*. 2006;20(6):1031-51. doi: 10.1016/j.bpg.2006.05.008
3. Rosenmüller M, Haapamäki MM, Nordin P, Stenlund H, Nilsson E. Cholecystectomy in Sweden 2000-2003: a nationwide study on procedures, patient characteristics, and mortality. *BMC Gastroenterol*. 2007;7:35. doi: 10.1186/1471-230X-7-35
4. Peters JD. Cutting the legal risks of laparoscopy. *OBG MANAGEMENT*. 2002;14(10):47-55.
5. Jordan JA, Gallagher AG, McGuigan J, McClure N. Virtual reality training leads to faster adaptation to the novel psychomotor restrictions encountered by laparoscopic surgeons. *Surg Endosc*. 2001; 15(10):1080-4. doi: 10.1007/s004640000374
6. Gallagher AG, Ritter EM, Champion H, Higgins G, Fried MP, Moses G, Smith CD, Satava RM. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. *Ann Surg*. 2005;241(2):364-72. doi: 10.1097/01.sla.0000151982.85062.80
7. Nagendran M, Gurusamy KS, Aggarwal R, Loizidou M, Davidson BR. Virtual reality training for surgical trainees in laparoscopic surgery. *Cochrane Database Syst Rev*. 2013;2013(8):CD006575. doi: 10.1002/14651858.CD006575.pub3
8. Issenberg SB, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Med Teach*. 2005;27(1):10-28. doi: 10.1080/01421590500046924
9. Sutherland LM, Middleton PF, Anthony A, Hamdorf J, Cregan P, Scott D, Maddern GJ. Surgical simulation: a systematic review. *Ann Surg*. 2006;243(3):291-300. doi: 10.1097/01.sla.0000200839.93965.26
10. van Hove PD, Tuijthof GJ, Verdaasdonk EG, Stassen LP, Dankelman J. Objective assessment of technical surgical skills. *Br J Surg*. 2010 Jul;97(7):972-87. doi: 10.1002/bjs.7115
11. Ahlberg G, Enochsson L, Gallagher AG, Hedman L, Hogman C, McClusky DA 3rd, Ramel S, Smith CD, Arvidsson D. Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies. *Am J Surg*. 2007;193(6):797-804. doi: 10.1016/j.amjsurg.2006.06.050
12. Kanumuri P, Ganai S, Wohaibi EM, Bush RW, Grow DR, Seymour NE. Virtual reality and computer-enhanced training devices equally improve laparoscopic surgical skill in novices. *JSLS*. 2008; 12(3):219-26.
13. Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, Satava RM. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Ann Surg*. 2002;236(4):458-63; discussion 463-4. doi: 10.1097/00000658-200210000-00008
14. Cosman PH, Hugh TJ, Shearer CJ, Merrett ND, Biankin AV, Cartmill JA. Skills acquired on virtual reality laparoscopic simulators transfer into the operating room in a blinded, randomised, controlled trial. *Stud Health Technol Inform*. 2007;125:76-81.
15. Youngblood PL, Srivastava S, Curet M, Heinrichs WL, Dev P, Wren SM. Comparison of training on two laparoscopic simulators and assessment of skills transfer to surgical performance. *J Am Coll Surg*. 2005;200(4):546-51. doi: 10.1016/j.jamcollsurg.2004.11.011
16. Palter VN, Grantcharov TP. Individualized deliberate practice on a virtual reality simulator improves technical performance of surgical novices in the operating room: a randomized controlled trial. *Ann Surg*. 2014;259(3):443-8. doi: 10.1097/SLA.0000000000000254
17. Palter VN, Orzech N, Reznick RK, Grantcharov TP. Validation of a structured training and assessment curriculum for technical skill acquisition in minimally invasive surgery: a randomized controlled trial. *Ann Surg*. 2013;257(2):224-30. doi: 10.1097/SLA.0b013e31827051cd
18. Gurusamy KS, Aggarwal R, Palanivelu L, Davidson BR. Virtual reality training for surgical trainees in laparoscopic surgery. *Cochrane Database Syst Rev*. 2009;(1):CD006575. doi: 10.1002/14651858.CD006575.pub2
19. Martin JA, Regehr G, Reznick R, MacRae H, Murnaghan J, Hutchison C, Brown M. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg*. 1997;84(2):273-8. doi: 10.1046/j.1365-2168.1997.02502.x