ORIGINAL RESEARCH

Efficacy of Serious Game Training in Comparison with the Traditional Training in Learning the Laparoscopic Cholecystectomy Skills: An Interventional Analytic Study

Zohrehsadat Mirmoghtadaie[1], Mansour Bhahrdoust[2], Adnan Tizmaghz[3], Ghazaal Shabestanipour[4]

Abstract

Background: Performing a laparoscopic cholecystectomy (LC) surgery requires a high level of experience, and complementary training methods are demanded. In this study, we evaluated the efficacy of serious game LC training compared to the traditional LC training in laparoscopic cholecystectomy skills of junior residents.

Materials and methods: Forty-four junior residents with no history of LC performance were assigned to either the serious game training group (case group, $n = 22$) or the traditional (Zollinger's Atlas of Surgical Operations) training group (control group, $n = 22$). Participants were allowed to perform the operation only when they achieved a score of more than 80% in the theory checklist.

Results: The mean LC skills score based on the pre-surgery theory checklist was 84.5 ± 11.1% in the case group and 68.2 ± 17.6% in the control group ($p = 0.021$). The total number of attempts needed to reach an 80% score in the theory checklist was 2.97 ± 1.40 in the case and 4.17 ± 2.03 in the control group ($p = 0.001$). The mean operation time and the number of attempts needed to complete the operation without complications were significantly lower in the case group ($p = 0.028$ and $p = 0.041$, respectively). The final skills score was 90.8 ± 9.2% in the case group and 80.1 ± 14.2% in the control group ($p = 0.012$).

Conclusion: Serious game training was more effective than traditional training in all aspects of LC performance. Therefore, broader usage of the serious game for LC training is recommended.

Keywords: Laparoscopic cholecystectomy, Serious game, Touch Surgery™.

World Journal of Laparoscopic Surgery (2022): 10.5005/jp-journals-10033-1523

Introduction

Traditionally, surgical learning and teaching are largely based on the use of animals and cadavers. The advent of minimal invasive surgeries (MIS) has led to decreased surgical morbidity.[1] Meanwhile, MIS techniques are associated with an increased demand for education and training because of a very small workspace and lack of a direct view of the organs under operation.[1] Therefore, the development of new learning and teaching approaches are of considerable value to improve surgical skills such as eye-hand coordination in the context of MIS procedures.[1]

Laparoscopic cholecystectomy is a widely used MIS technique that is associated with significant improvement in patient outcomes and considerable reduction in the healthcare burden for patients with biliary tract disease.[2,3] Despite these advantages, similar to the other MIS techniques, LC requires a high level of experience to result in satisfactory outcomes.[3] Therefore, extra education of surgeons through an attractive alternative way of learning is of critical importance.

Currently, training using computer simulation, also known as virtual reality (VR) training, is widely used for laparoscopic training and has proved to be an effective tool for improving laparoscopic skills, particularly for those surgical residents who underutilize traditional simulation training.[4] Serious games are referred to the games with the primary purpose of teaching and learning instead of entertainment. These innovative VR training applications contain a high simulation potential for skills that are required for specific surgeries. The complex interactive context of serious games engages the trainees, thereby offering a challenging yet motivational opportunity to learn due skills.[5]

Touch Surgery™ is considered as a serious gaming mobile application designed for surgical training, and its validity for cognitive training and assessment of key LC steps has been demonstrated.[6] In this study, we evaluate how it affects the clinical skills of surgical assistants when compared with the traditional training modality.

[1]Department of e-Learning, Virtual School of Medical Education and Management, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[2]Department of Epidemiology, School of Public Health, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[3]Department of General Surgery, Iran University of Medical Sciences, Tehran, Iran

[4]Iran University of Medical Sciences, Tehran, Iran

Corresponding Author: Adnan Tizmaghz, Department of General Surgery, Iran University of Medical Sciences, Tehran, Iran, Phone: +98 2164352215, email: adnan_ti@yahoo.com

How to cite this article: Mirmoghtadaie Z, Bhahrdoust M, Tizmaghz A, *et al*. Efficacy of Serious Game Training in Comparison with the Traditional Training in Learning the Laparoscopic Cholecystectomy Skills: An Interventional Analytic Study. World J Lap Surg 2022;15(2): 99–102.

Source of support: Nil

Conflict of interest: None

Table 1: Comparison of the baseline characteristic features between the two study groups

	Group		
Variable	*Serious game LC education (n = 22)*	*Traditional LC education (n = 22)*	*p-value*
Age (year)	29.75 ± 6.11	30.46 ± 4.8	0.89
Sex			
Male	18 (81.8%)	17 (77.2%)	0.12
Female	4 (18.2%)	5 (22.8%)	
History of participation or laparoscopic surgery (number)	1.92 ± 1.2	2.21 ± 1.4	0.65
Watching training videos before surgery (min/day)	19.2 ± 8.30	21.3 ± 6.8	0.58
Experience in using computer games and educational, social networks (min/day)	43.18 ± 20.84	45.11 ± 26.11	0.54

Data are presented as mean ± SD or number (%). p <0.05 is considered significant. LC, laparoscopic cholecystectomy

Materials and Methods

This interventional analytical study was approved by the Review Board of our institute. Participants were general surgery residents of the two educational hospitals in their second years of clinical education. Detailed information about the study design and purpose was provided for all participants. The residents were included if they had never been in the LC operating room. The residents of one hospital were randomly assigned into the serious game LC training group (n = 22), and the residents of the other hospital were included in the traditional LC training group (n = 22). Group matching was performed for age, sex, last promotion score, experience in using computer games, educational social networks, and history of participation in laparoscopic surgery variables between the two groups. Normally, there was no communication between the residents of the two hospitals.

Serious Game Design and Implication

The serious LC game was checked by nine professors of general surgery and laparoscopy and corrected according to their suggestions. Then, the game was installed on the dedicated tablets and delivered to the participants of the serious game group the day before the surgery.

Measurements

On the day of the surgery, first, the amount of time and the number of times that the participants successfully completed all stages of the game were extracted from the game software memory and recorded in the checklist. In the next step, we asked the participants to express the steps of surgery in theory, and the result was entered in the checklist designed by the nine involved professors of general surgery and laparoscopy. This checklist was designed based on the scoring to have the necessary skills to perform different stages of surgery and included six main subheadings, including Port insertion and gallbladder exposure, Dissection of Calot's triangle, Critical view of safety, Ligation of cystic duct and artery, Gallbladder dissection, and Specimen removal and closure. According to the theory checklist, participants were allowed to perform the operation only when they achieved a score of more than 80%. Patients with uncomplicated cholelithiasis or simple biliary colic were selected based on these criteria: age: 30–45 years, BMI:25–30, and gallstone size ≤1 cm for being operated by the residents of two studied groups.

The operation was performed under the supervision of a senior surgeon who was not informed of the assignment group of the participants. This surgeon also scored the performance of participants, in addition to recording the duration and accuracy of performing different stages of surgery without asking for help. The performance was checked using the same checklist that was designed for checking the participants' competency to perform LC. The final scores were compared between the participants of the serious game training group and the traditional training group.

Statistical Analysis

We used SPSS for Windows version 16 (SPSS Inc., Chicago, IL, USA) for statistical evaluations. Descriptive data were presented with the mean ± standard deviation (SD) or number and percentage. The Shapiro–Wilk test was used to evaluate the normality of distribution. A comparison of the mean difference between the two study groups was made with an independent t-test or its nonparametric counterpart (Mann–Whitney U test). Correlation between the variables was checked with a Pearson's or Spearman's correlation coefficient test. A p <0.05 was considered statistically significant.

Results

The two study groups were not significantly different in the baseline characteristic features, including age, gender, history of participation or laparoscopic surgery, and experience of using computer games and educational, and social networks (Table 1).

Laparoscopic cholecystectomy skills score based on the pre-surgery theory test was 84.5 ± 11.1% in the serious game training group and 68.2 ± 17.6% in the traditional training group (p = 0.021). The total number of attempts needed to reach an 80% score in theory checklist was 2.97 ± 1.40 in the serious game training group and 4.17 ± 2.03 in the traditional training group (p = 0.001). The total LC performance score for the first attempt was 61.2 ± 36.2% in the serious game training group and 48.37 ± 14.5 in the traditional training group (p = 0.021). The mean operation time and the number of attempts needed to complete the operation without complications were significantly lower in the serious game training group (p = 0.028 and p = 0.041, respectively). The final skills score was 90.8 ± 9.2%in the serious game training group and 80.1 ± 14.2% in the traditional training group (p = 0.012). Comparison of clinical scores between two study groups is demonstrated in more detail in Table 2.

The mean duration of playing the game was 62.3 ± 41.1 minutes. The mean obtained score was 69.6 ± 28.2. A significant positive correlation was found between the duration of playing the game

Table 2: Comparison of clinical scores between two study groups

	Group		
Variable	*Serious game LC training (n = 22)*	*Traditional LC training (n = 22)*	*p-value*
Skills score based on the pre-surgery theory test	84.5 ± 11.1	68.2 ± 17.6	0.021
Number of attempts needed to reach an 80% score			
	2.51 ± 1.22	4.11 ± 2.2	
	2.8 ± 1.40	3.9 ± 1.9	0.001
	3.61 ± 1.58	4.5 ± 2.01	
	2.97 ± 1.40	4.17 ± 2.03	
For the first attempt skill score			
	50.1 ± 16.2	43.2 ± 12.1	
	66.3 ± 11.1	50.33 ± 13.5	0.021
	67.2 ± 8.9	51.6 ± 17.6	
	61.2 ± 36.2	48.37 ± 14.5	
Speed operation time (m)	46.5 ± 10.12	63.31 ± 12.25	0.028
Number of attempts needed to complete the operation without complications	2.11 ± 0.99	2.81 ± 1.2	0.041
Final skills score gained in performing surgery	90.8 ± 9.2	80.1 ± 14.2	0.012

Data are presented as mean ± SD. $p < 0.05$ is considered significant. LC, laparoscopic cholecystectomy

Table 3: Correlation between the final skills score and characteristics features of the participants

Variable	*Pearson correlation*	*p-value*
Age	−0.12	0.65
Sex	0.085	0.91
History of participation in laparoscopic surgery	0.51	0.029
Experience in using computer games and educational social networks	0.11	0.59
Duration of surgery	−0.66	0.001

and the final skills score ($r = 0.061$, $p = 0.001$), as well as between the mean obtained score and final skills score ($r = 0.87$, $p = 0.001$). A significant negative correlation was found between the final skills score and duration of surgery ($r = -0.66$, $p = 0.001$). The history of participation in laparoscopic surgery was also positively correlated with the final skills score ($r = 0.51$, $p = 0.029$). The correlation of the final skills score with the characteristics features of the participants is demonstrated in more detail in Table 3.

Discussion

In this study, we compared the surgical LC skills between the residents who were trained via the serious game and those who were trained traditionally. Based on our results, the serious game training group had a higher skill score on the pre-surgical theory test, a lower number of attempts needed to reach an 80% skill score, shorter surgical duration, lower number of attempts needed to complete the operation without complications, and higher final skills score. The final skills score was significantly correlated with the duration of serious game playing and the mean obtained score.

The learning efficacy of serious games for a variety of health professions education has been evaluated in earlier studies.[7–12] Haoran et al. reviewed the studies evaluating the efficacy of serious game training from 1996. A total of 25 studies were included in their review, all of which reported significant improvement in learning scores following the use of serious games. In 14 out of 18 publications with a controlled experiment, post-test scores were significantly higher after serious games training compared to the conventional teaching methods. They concluded that health professions training using serious games seems efficacious, at least in the short term.[13] Similarly, the surgical skill score was significantly more in the serious game training group of the present study compared with the traditional training group.

Laparoscopic procedures are acknowledged as a significant source of surgical errors, and therefore, demand special training to obtain the required experience. There is an expanding trend in studies evaluating the efficacy of serious games in laparoscopic training. Graafland et al. investigated whether serious game training improves residents' skills to solve equipment-related problems during laparoscopic surgery. Thirty-one surgical residents without laparoscopic experience were randomly assigned into either the serious game group ($n = 16$) or the traditional curriculum. The laparoscopy task was performed in a pig model, during which three scenarios of standardized equipment malfunction occurred. The serious game group solved more equipment-related problems than the traditional training group (55 vs 33%).[7] We did not evaluate the skills of residents in solving the equipment malfunctions. However, residents of the serious game group outperformed the surgery compared to the traditional training group, which was demonstrated by a higher final skill score of LC performance.

Ijgosse et al. evaluated the construct validity of the serious game *Underground* for laparoscopic skills. The performance was compared between the novices (less than ten prior laparoscopic experiences), intermediates (10–100 prior laparoscopic experiences), and experts (>100 prior laparoscopic experiences). Prior laparoscopic experiences showed a significant effect on the time variable. The experts and intermediates outperformed novices regarding the speed task. The rate of gameplay errors showed a similar trend between different groups. Male gender and prior video game experience were associated with better performance. Accordingly, the construct validity was established for the serious game *Underground*.[14] In comparison with traditional

training, the serious game training group of the present study had significantly shorted operation and a lower number of attempts needed to complete the operation without complications. However, no significant correlation was found between gender and performance.

Kowalewski et al. evaluated the validity of a mobile serious game application named Touch Surgery™ for training and assessment of LC skills. Fifty-four surgeons and 51 medical students completed the study. Surgeons outperformed the medical students in all three modules, including patients' preparations, access and laparoscopy, and LC skills. All the participants agreed that the application was realistic and useful. The students took 2–4 attempts to achieve a 100% score of the serious game. They concluded that Touch Surgery™ contains acceptable construct, face, and content validity in learning cognitive LC aspects and could accompany virtual reality training in a multimodal LC training approach.[6] The serious game design in the present study was based on the Touch Surgery system. Similarly, we observed acceptable content validity and reliability.

The results of the present study, adjunct with the results of earlier investigations, reveal that using serious games could help the junior residents in mastering basic LC skills. However, the present study was not without limitations. The main limitation of the study was the small number of participants. The proportion of female participants was also significantly smaller than the male population. Therefore, future investigations should focus on resolving these limitations to unlock the full potential of serious games for training LC skills.

Conclusion

Touch Surgery™-based serious game contain acceptable content validly in training LC skills. Compared to traditional training, it results in higher skill scores on the pre-surgical theory test, lower number of attempts needed to reach an 80% skill score, shorter surgical duration, lower number of attempts needed to complete the operation without complications, and higher final skills score. Therefore, broader usage of serious games for LC training is recommended.

Acknowledgments

The authors would like to thank all residents of the Iran University of Medical Sciences for their contribution to the study.

References

1. De Paolis LT, editor Serious game for laparoscopic suturing training. IEEE Sixth International Conference on Complex, Intelligent, and Software Intensive Systems; 2012.
2. Hassler KR, Collins JT, Philip K, et al. Laparoscopic cholecystectomy. StatPearls 2022.
3. Hori T, Oike F, Furuyama H, et al. Protocol for laparoscopic cholecystectomy: is it rocket science? World J Gastroenterol 2016;22(47):10287–10303. DOI: 10.3748/wjg.v22.i47.10287.
4. 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(3):272–283. DOI: 10.1016/s1072-7515(00)00339-2.
5. Graafland M, Ten Cate O, van Seventer JP, et al. Mapping the demand for serious games in postgraduate medical education using the entrustable professional activities framework. Games Health J 2015;4(5):381–386. DOI: 10.1089/g4h.2014.0129.
6. Kowalewski KF, Hendrie JD, Schmidt MW, et al. Validation of the mobile serious game application Touch Surgery™ for cognitive training and assessment of laparoscopic cholecystectomy. Surg Endosc 2017;31(10):4058–4066. DOI: 10.1007/s00464-017-5452-x.
7. Graafland M, Bemelman WA, Schijven MP. Game-based training improves the surgeon's situational awareness in the operation room: a randomized controlled trial. Surg Endosc 2017;31(10):4093–4101. DOI: 10.1007/s00464-017-5456-6.
8. Haubruck P, Nickel F, Ober J, et al. Evaluation of app-based serious gaming as a training method in teaching chest tube insertion to medical students: randomized controlled trial. J Med Internet Res 2018;20(5):e195. DOI: 10.2196/jmir.9956.
9. Knight JF, Carley S, Tregunna B, et al. Serious gaming technology in major incident triage training: a pragmatic controlled trial. Resuscitation 2010;81(9):1175–1179. DOI: 10.1016/j.resuscitation.2010.03.042.
10. Middeke A, Anders S, Schuelper M, et al. Training of clinical reasoning with a serious game versus small-group problem-based learning: a prospective study. PLoS One 2018;13(9):e0203851. DOI: 10.1371/journal.pone.0203851.
11. Dankbaar MEW, Richters O, Kalkman CJ, et al. Comparative effectiveness of a serious game and an e-module to support patient safety knowledge and awareness. BMC Med Educ 2017;17(1):30. DOI: 10.1186/s12909-016-0836-5.
12. Cain J, Piascik P. Are serious games a good strategy for pharmacy education? Am J Pharm Educ 2015;79(4):47. DOI: 10.5688/ajpe79447.
13. Haoran G, Bazakidi E, Zary N. Serious games in health professions education: review of trends and learning efficacy. Yearb Med Inform 2019;28(1):240–248. DOI: 10.1055/s-0039-1677904.
14. Ijgosse W, van Goor H, Rosman C, et al. Construct validity of a serious game for laparoscopic skills training: validation study. JMIR Serious Games 2020;8(2):e17222. PMID: 32379051.