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EFFICACY OF SIMULATION BASED TRAINING FOR LAPAROSCOPIC CHOLECYSTECTOMY IN IMPROVING SURGICAL SKILLS

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ABSTRACT

Background: Laparoscopic cholecystectomy, a minimally invasive procedure for gallbladder removal, is widely regarded as the gold standard for treating symptomatic cholelithiasis. However, simulation-based training significantly improves the acquisition of laparoscopic skills compared to traditional methods

Method: It is a randomized control conducted at department of general surgery, Jinnah international hospital, Abbottabad from April 2023 to April 2024. A total of 50 residents from 1st, 2nd and 3rd year with minimal to no experience of laparoscopic surgery were included in this study. A pre-test assessing GOAL score, time duration and complication rate was conducted followed by a post-test after 12 weeks of training. The results were analyzed using SPSS 24. P-values of ≤0.05 will be significant

Result: The mean age of participants in Group A was 25.1 ± 6.9 years, while in Group B was 24.9 ±7.2 years. In Group A, mean pre-test GOAL score was 5.36 ± 0.89, which increased significantly to 15.84 ± 1.93 post-training. In Group B mean pre-test GOAL score of 5.61 ± 0.73 and in post-test score was 9.83 ± 1.85($p < 0.01$). Group A's mean time decreased from 26.73 ± 5.72 minutes to 22.81 ± 4.96 minutes, while Group B's duration changed from 26.15 ± 6.11 minutes to 25.89 ± 7.91 minutes. Group A saw a decrease from 7 (28%) complications pre-test to 2 (8%) post-test, whereas Group B had a reduction from 8 (32%) to 5 (20%)

Conclusion: Simulation-based training for laparoscopic cholecystectomy shows promise in improving surgical skills and reducing procedural time, though ongoing research is needed to optimize training protocols and assess long-term outcomes in surgical practice.

INTRODUCTION

Laparoscopic cholecystectomy, a minimally invasive procedure for gallbladder removal, is widely regarded as the gold standard for treating symptomatic cholelithiasis. Despite its advantages over open surgery, including reduced recovery time and minimized surgical trauma, the technique demands high levels of dexterity and precision. Simulation in surgical training has evolved significantly from basic mechanical models to advanced computer-based systems. Box Trainers offer a tangible method for practicing hand-eye coordination and basic laparoscopic skills [1]. It has been discovered that box trainers can actually refine skills in simple procedures like suturing and knot-tying that are basic in laparoscopic surgery. Sophisticated Virtual Reality (VR) simulates high fidelity environments that are suitable for practicing intricate surgeries. Detailed anatomical models along with haptic feedback found in these devices make it possible to simulate whole surgery including its complications [2]. Hybrid Simulators combine physical and virtual elements by allowing trainees to practice tactile skills on physical models while interacting with a virtual environment, enhancing their ability to perform realistic laparoscopic procedures.

According to research, use of simulation-based training has been found to enhance the acquisition of laparoscopic skills in comparison with standard methods. This low in cost, space saving, movable, versatile training environment closely duplicates the feel of doing real live laparoscopic surgery, thereby assisting residents and fellows. Those who utilized simulators had higher performance levels in both simulation and genuine operating room environments [3]. Residents trained on VR simulators performed laparoscopic cholecystectomy faster and with fewer errors than those who received traditional training. Hence, it helps to reduce the clinical impacts of learning curve [4]. It improves manual dexterity and decreases intellectual tension during surgery. Spiliotis et al.'s systematic review revealed that simulation-trained participants outperformed conventionally-trained ones in terms of surgical performance, duration of operation, precision, rate of intraoperative errors, and enduring consequences of an operation [5].

In addition, a meta-analysis was performed by Humm et al that used Objective Structured Assessment of Technical Skill (OSATS) to assess the performance of residents surgeon performing laparoscopic cholecystectomy. It has revealed that the OSATS score (mean difference (MD) 6.22, 95%CI 3.81 to 8.36, $P < 0.001$) and time to completion of task (MD −8.35 min, 95%CI 13.10 to 3.60, $P = < 0.001$) significantly improved after virtual reality training as compared with conventional training programs [6]. Inbuilt assessment tools from simulation platforms help learners to get fast response on their performance, which is very necessary as far as learning process is concerned. This information ensures that people going through trainings can spot their shortcomings then take necessary steps to rectify them without worrying about any risks involved hence making their knowledge better [7].

Many training institutions find the high prices of advanced simulators and low accessibility as great obstacles in their work. Simulation-based training programs have no common standards now, which may result in dissimilarity of training quality. There is ongoing debate on effectiveness of simulation trainings in this regard; however, nobody knows how much these acquired skills help after all [8]. It is suggested by some researchers that simulating is useful for improving technical competence but does not fully mimic the stresses or intricacies involved in live operations. It has been argued that combining AR with simulated training is likely to make such programs even more efficient. Furthermore, progress in artificial intelligence and data mining might offer an opportunity for designing customized personalised training courses that fit every single learner who participates in them competition [9]. The expansion of remote training and tele-simulation can increase accessibility to high-quality training, especially in underserved areas.

The purpose of this study is to assess whether simulation-based training can improve the surgical skills necessary for performing laparoscopic cholecystectomy. The study specifically aims at investigating the increase in technical competence in trainees who receive simulation-based training vis-à-vis others who receive the conventional training methods.

Method

It is a randomized control conducted at department of general surgery, Jinnah international hospital, Abbottabad after taking approval from the ethical review committee from April 2023 to April 2024. A total of 50 residents from 1st, 2nd and 3rd year with minimal to no experience of laparoscopic surgery were included in this study after taking informed consent. Participants with extensive prior experience in laparoscopic cholecystectomy or undergone extensive simulation-based training for laparoscopic procedures were excluded from this study. The participants were divided into two groups after randomization from a computer generated table. It was made sure that each group has equal number of training year wise residents to remove any discrepancy. Group A was given simulation training with box trainers while Group B was control group received traditional patient based training of laparoscopic cholecystectomy. A specific task of dissection of gall bladder from the liver bed and clip application was given to the residents. A pretest was conducted and every participant was asked to perform he specific task and video of whole procedure was recorded. Two consultant surgeons were enrolled as training supervisors. These supervisors assessed the pretest video of each resident by using validated global operative assessment of laparoscopic skills (GOAL) score. The average of scores given by the two supervisors was entered.

After the pretest, Group A was given training with the help of box simulator. Each candidate was given a session of 90 minutes with 2 sessions in a week. The whole training program lasted 12 weeks. On the other hand, Group B received traditional patient based training in operation theaters for 12 weeks while assisting laparoscopic cholecystectomies with consultant surgeons. After 12 weeks a post test was conducted and each resident was given the same task to separate the gall bladder from liver bed and clip application. The post-test videos were again assessed by the training supervisors using GOAL score. In addition, the time taken to complete the pre-test and post-test by each resident was also noted. The complications such as bile duct injury, bile leak and trocar injury were also noted

Data was entered and analyzed using SPSS (Statistical Package for the Social Sciences) version 24. It was presented as mean, standard deviation, and percentages. P-values of ≤0.05 will be considered statistically significant. The findings were interpreted in the context of the study objectives and existing literature.

RESULT

In this study the demographics of Group A and Group B, each consisting of 25 participants, several parameters were evaluated. The mean age of participants in Group A was 25.1 ± 6.9 years, while Group B had a slightly younger mean age of 24.9 ±7.2 years. Gender distribution has shown that in Group A, there were 16 males (64%) and 9 females (36%), whereas Group B had 14 males (56%) and 11 females (44%). Regarding the distribution by year of residency, both groups exhibited similar proportions across the categories of first, second, and third-year residents. In Group A, 8 participants (32%) were in their first year, 10 (40%) in their second year, and 7 (28%) in their third year of residency. Similarly, Group B mirrored these proportions exactly, with 8 (32%), 10 (40%), and 7 (28%) participants in the first, second, and third years of residency, respectively (Table 1, Figure 1).

Firstly, in terms of cognitive skills assessed using the GOAL (Global Operative Assessment of Laparoscopic Skills) score, Group A showed a mean pre-test score of 5.36 ± 0.89, which increased significantly to 15.84 ± 1.93 post-training. In contrast, Group B started with a slightly higher mean GOAL score of 5.61 ± 0.73 in the pre-test, but their post-test score also increased significantly to 9.83 ± 1.85($p < 0.01$). The difference in post-test scores between the groups was statistically significant, indicating that both groups improved their cognitive skills after the training, but Group A showed a more substantial improvement. Regarding the procedural efficiency measured by the duration to complete the task, both groups demonstrated reductions in time from pre-test to post-test. Group A's mean time decreased from 26.73 ± 5.72 minutes to 22.81 ± 4.96 minutes, while Group B's duration changed from 26.15 ± 6.11 minutes to 25.89 ± 7.91 minutes. In terms of complication rates, both groups experienced reductions in complications from pre-test to post-test. Group A saw a decrease from 7 (28%) complications pre-test to 2 (8%) post-test, whereas Group B had a reduction from 8 (32%) to 5 (20%) (Table 2, Figure 2).

Parameter	Group A (n=25)	Group B(n=25)
Age	25.1 ± 6.9	24.9 ± 7.2
Gender Male Female	 16 (64%) 09 (36%)	 14 (56%) 11 (44%)
Year of residency First Second Third	 8 (32%) 10 (40%) 7 (28%)	 8(32%) 10 (40%) 7 (28%)

Table 1: Demographic data of study population

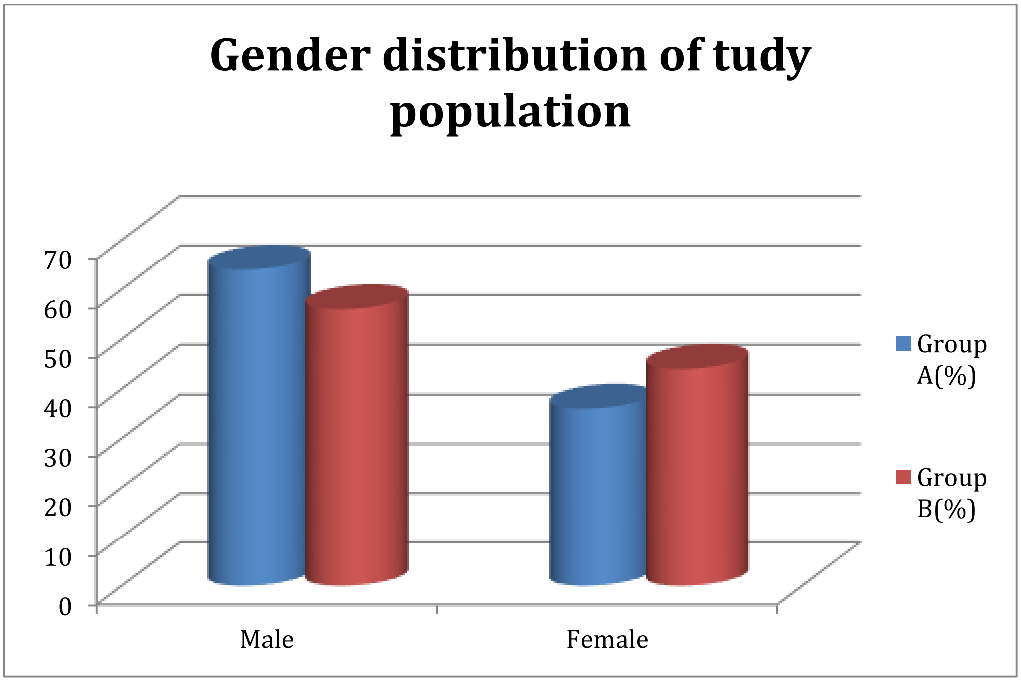

Figure 1: Gender distribution of study sample

Variable	Group A (n=25)	Group B(n=25)	p value
GOAL score Pre-test Post-test	 5.36 ± 0.89 15.84 ± 1.93	 5.61 ± 0.73 9.83 ± 1.85	 0.079 <0.01
Duration to complete the task Pre-test (minutes) Post-test (minutes)	 26.73 ± 5.72 22.81 ± 4.96	 26.15 ± 6.11 25.89 ± 7.91	 0.082 <0.01
Complication rate Pre-test Post-test	 7 (28%) 2 (8%)	 8 (32%) 5 (20%)	 0.89 <0.01

Table 2: comparison of outcomes in Group A and Group B

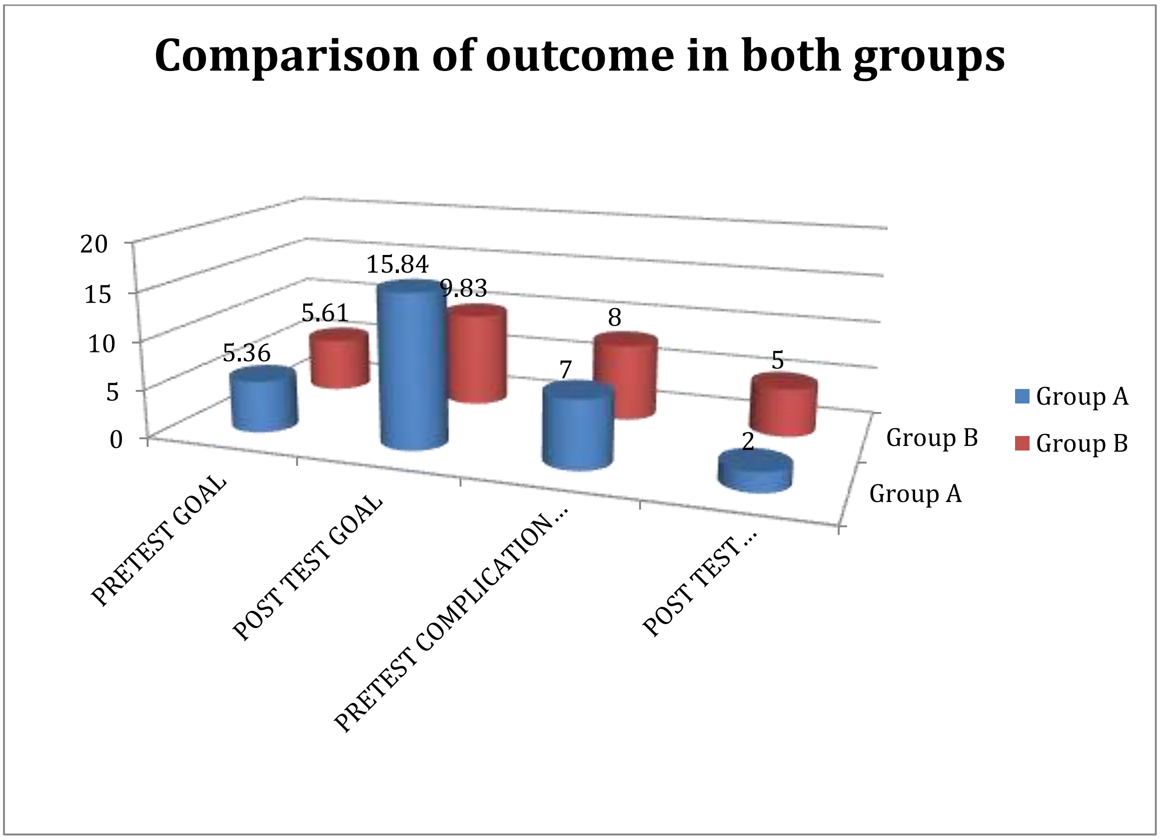

Figure 2: Comparison of outcome in both groups

DISCUSSION

The present study aimed to evaluate the effectiveness of simulation-based training for laparoscopic cholecystectomy by comparing outcomes between Group A and Group B across multiple variables: GOAL scores (cognitive skills), duration to complete the task (procedural efficiency), and complication rates. Both Group A and Group B showed improvements in their GOAL scores from pre-test to post-test. Group A started with a mean GOAL score of 5.36 ± 0.89, which significantly increased to 15.84 ± 1.93 post-training ($p < 0.01$). Group B, with a slightly higher mean pre-test score of 5.61 ± 0.73, also improved significantly to 9.83 ± 1.85 post-training ($p < 0.01$). Although the p-value (0.079) for the comparison between post-test scores of Group A and Group B suggests a trend towards significance, the absolute difference in post-test scores indicates that both groups benefited significantly from the training. Group A exhibited a more substantial improvement in cognitive skills compared to Group B, suggesting that the simulation-based training was particularly effective in enhancing their laparoscopic skills [10].

Similarly, the duration required to complete the task was significantly reduced in post-test in Group A as compared to Group B. These findings correlated with the observations of randomized control trial conducted by Nilsson et al. it shows that procedural group who received simulation training for laparoscopic surgery using LASTT model completed the task (167 seconds; 95% CI, 117–216) as compared to the control group that took (307 seconds; 95% CI, 202–412)($p=0.018$) [11] . Moreover, this study has observed significant reduction ($p<0.01$) in complication or error rate in post-test in Group A (8%) as compared to Group B (20%). The systematic review conducted by Hong et al analyzed 43 different simulation training program for minimally invasive surgery. It has stated that simulation training programs enhance the surgeon’s efficiency and improves patient safety [12].

The hybrid augmented reality simulator for laparoscopic cholecystectomy provides accurate training for identifying and isolating Calot's triangle, with potential applications in other surgical procedures. Moreover, Virtual reality simulators like TIPS are more effective in teaching laparoscopic surgical techniques to medical students than videos, with greater confidence in reproducing procedural steps [13]. Hands-on training allows surgeons-in-training to develop skills in a controlled environment

before performing procedures on actual patients. This training includes familiarizing oneself with the laparoscopic equipment, trocar placement, handling of instruments, and manipulation of tissues under direct visualization. The randomized control trial by Lesch et al has compared the efficacy of virtual reality simulator TIPS with videos learning. It has found that videos are simple to use but TIPS leads to greater percentage of replication of steps and procedural precision [14]. Hence, it is indispensable for acquiring technical proficiency, improving patient outcomes, and maintaining high standards of surgical practice in the field of minimally invasive surgery.
The study on the efficacy of simulation-based training for laparoscopic cholecystectomy offers valuable insights by recommending Incorporation of simulation-based training in the curriculum for surgical residents. It can help in accelerating their learning curve and ensuring competence in laparoscopic cholecystectomy [15]. Moreover, Surgeons better equipped to handle potential complications can mitigate risks and improve surgical outcomes for patients. The study contributes to the body of evidence supporting simulation-based training as an effective educational method in surgical education in local context. Virtual and augmented reality simulations can bridge gaps in training resources, ensuring more equitable access to high-quality surgical education worldwide [16]. This study also has certain limitations. The study was conducted with a relatively small sample size (n=25 per group), which may limit the generalizability of the findings. Long-term retention of skills beyond immediate post-training assessment was not assessed. Future studies could explore skill retention over time. Factors such as prior surgical experience, learning styles, and individual variations were not fully explored but could influence training outcomes.

CONCLUSION

In conclusion, the study highlights significant improvements in cognitive skills (measured by GOAL scores) and procedural efficiency (measured by task completion time) following simulation based training for laparoscopic cholecystectomy. However, while both groups improved, Group A showed greater cognitive skill enhancement. These findings underscore the efficacy of simulation-based training in enhancing surgical skills across various metrics, contributing valuable insights into the training methodologies for laparoscopic procedures.

AUTHOR’S CONTRIBUTION

All the authors have read and agreed to findings of the manuscript

CONFLICT OF INTEREST

None

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