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Study on Basic Skills of Laparoscopic Virtual Simulation for Clinical Undergraduate Students

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Abstract: *This paper explores the impact of laparoscopic virtual simulation basic skills training on the surgical operational skills of undergraduate clinical medicine students. The analysis concludes that intensive laparoscopic virtual simulation basic skills training can effectively enhance the laparoscopic operational skills and traditional surgical operational skill levels of undergraduate clinical medicine students.*

Keywords: *Virtual Simulation; Laparoscopic Skills; Surgical Skills*

1. Materials and Methods

Laparoscopic surgery is a kind of operation that uses high-definition 3D imaging system and precise operating instruments to make a very small incision on the abdominal wall and perform it in the abdominal cavity through the laparoscopic system. Compared with traditional open surgery, laparoscopic surgery has the advantages of less trauma and faster recovery, and has been widely used and developed in the surgical field.[1][2]. However, laparoscopic surgery also has its inherent technical difficulties and learning curve, which requires the operating doctor to have good hand-eye coordination, hands coordination, spatial positioning, operation accuracy and stability and other basic skills. At the same time, we should also master the functions and usage of various laparoscopic instruments, as well as the operation steps and precautions of various laparoscopic operations [3][4]. The acquisition and improvement of these skills require necessary theoretical study and a lot of practical training, but the traditional surgical teaching mode, such as mentoring and clinical probation, can no longer meet the needs of contemporary clinical surgery [5]. This paper discusses the influence of different laparoscopic skills training programs on the surgical skills of clinical medical undergraduates, and the report is as follows.

1.1 Experimental subjects and groups

60 undergraduate students of clinical medicine in Hainan Medical College volunteered to participate in the project research. Sixty students in this study were randomly divided into three groups: the experimental group of laparoscopic skills enhancement based on basic surgical skills learning.

(Group I), the traditional surgical skills intensive control group (Group II) and the surgical skills routine learning group (Group III).

1.2 Experimental contents and methods

The subjects need to learn the basic knowledge and skills of laparoscopic virtual simulation: the function and use of instruments, picking beans, cutting five-pointed stars and traditional surgical skills, such as sewing, knotting and thread cutting. Group I intensively trained the basic skills of laparoscopic virtual simulation (picking beans and cutting pentagrams) and added maze and puzzle thinking the game; Group ii strengthened the basic skills of traditional surgery, while Group iii did not have any intensive training. The intensive time is one hour twice a day for 30 days. Within one day after the training, the learning effect was evaluated by multi-station assessment (laparoscopic bean picking, laparoscopic five-pointed star cutting, sewing and knotting and front line), and each group was assessed at the same time, based on the scoring rules of Hainan Medical College Skill Operation Center.

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1.3 Statistical treatment

Descriptive statistics, variance analysis and correlation analysis were carried out on the experimental data with SPSS 18.0 software. Descriptive statistics are used to show the basic situation of experimental objects and the digital characteristics of experimental results. Analysis of variance is used to compare whether there are significant differences in the operating performance of the three groups of experimental subjects. Correlation analysis is used to analyze the correlation between laparoscopic performance and surgical performance. The test level is set to $\alpha = 0.05$, and $P < 0.05$ is significant. Deal with the assessment scores of each group separately, mainly around the mean, variance and standard deviation, and then draw conclusions and make statistical analysis with different representation methods.

2. Experimental result

2.1 Descriptive statistical analysis

Detailed table of examination scores of department and laparoscopy; From the analysis of Table 1, it can be concluded that the average scores of the three groups of students are group I (86.6), group II (81.05) and group III (74.5) from high to low, which shows that the training scheme of group I is the best and the training scheme of group III is the worst. There are obvious differences in the average scores of basic surgical operations among the three groups of students. Group I (46.5) is significantly higher than Group II (43.85) and Group III (37.85), which shows that the training program of Group I can improve the students' traditional surgical skills. Comparing the scores of three groups of students in basic laparoscopic operation: group i (40.1), group ii (37.2) and group iii (36.65), it shows that the training program of group i has a strong improvement on laparoscopic skills. From the analysis of Table 2, it is concluded that Group I scored better than Group II and Group III in sewing, knotting, thread cutting, bean picking and pentagram cutting, while Group II scored lower than Group III in pentagram cutting and scored in other aspects.

Table 1 Data table of average scores for three groups' assessments

Evaluation method	Evaluation content	Average scores of each item	aggregate score	Total average score
Group *I*	Basic surgical operation	46.5	1732	86.6
	Basic operation of laparoscopy	40.1		
Group *II*	Basic surgical operation	43.85	1621	81.05
	Basic operation of laparoscopy	37.2		
Group *III*	Basic surgical operation	37.85	1490	74.5
	Basic operation of laparoscopy	36.65		

Note: Compared with laparoscopic basic operation, group I is superior to groups II and III.

Table 2 Details table of three groups of assessment results

group	Evaluation content	Average scores of each item	aggregate score	Total average score
Group *I*	suture	16.85	337	
	tie	10.05	201	
	trimming	7.9	158	51.15
	Picking beans	8.05	161	
	Cut five-pointed star	8.3	166	
Group *II*	suture	15.15	303	
	tie	10.1	202	
	trimming	8.6	172	48.25
	Picking beans	eight	160	
	Cut five-pointed star	6.4	128	
Group *III*	suture	12.7	254	
	tie	7.65	153	
	trimming	7.4	148	41.9
	Picking beans	6.35	127	
	Cut five-pointed star	7.8	156	

Note: Compared with group I, P2<0.05,P3<0.0.1, and P1<0.05.

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All were better than group iii. Because Group II is an intensive group based on Group III, and only one of the assessment items has a higher score than Group II, it is speculated that there may be data recording errors. To sum up, intensive training is helpful for students to master the basic skills of surgery and laparoscopy.

In order to further determine the source of the difference, we conducted LSD-t test on the total average score of the three groups of students, and the results are shown in Table 3. As can be seen from the table, there are significant differences between the total average scores of group I and group II ($t=2.76, P<0.05$), group I and group III ($t=4.32, P<0.01$), and group II and group I ($t=2.13, P<0.05$). These results show that the training scheme of group I is the best, the training scheme of group III is the worst, and the training scheme of group II is the middle.

Table 3 LSD-t checklist for the overall average score of three groups of students

Group	Comparison group	t	P
Group *I*	Group *II*	2.76	<0.05
	Group *III*	4.32	<0.01
Group *II*	Group *III*	2.13	<0.05

Note: The comparison of the overall average scores between Group I and Group

II shows a significant difference ($P<0.05$); the comparison between Group I and Group III shows a highly significant difference ($P<0.01$); the comparison between Group II and Group III also shows a significant difference ($P<0.05$).

2.2 Correlation Analysis between Laparoscopic and Surgical Operation Scores of Three Groups of Students

To further explore the relationship between laparoscopic skills and surgical skills, we conducted a correlation analysis on the average scores of laparoscopic and surgical operations for the three groups of students, and the results are presented in Table 4. It can be seen from the table that there is a significant positive correlation between the laparoscopic oper ation scores and the surgical operation scores among the three groups of students, with correlation coefficients of 0.82, 0.79, and 0.77, respectively. The P-values are all less than 0.01, indicating that laparoscopic skills training can promote the development of surgical skills. Operations scores of three groups of student group correlation coefficient p

Table 4 Correlations analysis table between laparoscopic and surgical

Group *I*	0.82	<0.01
Group *II*	0.79	<0.01
Group *III*	0.77	<0.01

Note: When comparing the three groups, $P < 0.01$.

3. Discussion

The primary finding of this study is that the training program combining intensive laparoscopic skills training with traditional surgical operation learning can significantly improve students' performance in both laparoscopic and surgical skills, making it the optimal training approach. This conclusion aligns with some previous research findings but also presents some differences, which we will discuss in the following sections.

Firstly, our study demonstrates that laparoscopic skills training can enhance students' surgical skills, which is consistent with the conclusions drawn by Zhang, Huijian et al. (2023)[6] and Chen Zonglin et al. (2019)[7]. Laparoscopic skills training helps to develop students' hand-eye coordination, bimanual coordination, spatial orientation, precision, and stability in operations, all of which are crucial for traditional surgical procedures. Therefore, laparoscopic skills training can promote the development of surgical skills. Additionally, laparoscopic skills training can boost students' confidence, interest, and motivation, thereby improving their learning and surgical outcomes[8]. Through virtual laparoscopic surgery training systems that utilize virtual reality technology to create a virtual surgical environment (including surgical scenarios and patients), and by simulating clinical surgical instruments on the display screen to accurately mimic the entire process of laparoscopic and minimally invasive surgeries, medical students can become proficient in surgical techniques and procedures, and enhance their surgical proficiency.[9]

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Secondly, our study reveals that different laparoscopic skills training programs have varying impacts on students' surgical skills. The training program that combines intensive laparoscopic skills training with traditional surgical operation learning enables students to perform well in both areas, making it the best training approach. This finding contrasts with some studies that suggest laparoscopic skills training and traditional surgical skills training are mutually exclusive, and excessive laparoscopic skills training may negatively affect students' traditional surgical skills[10]. We believe this discrepancy may be related to the content, method, and duration of the training. Our training program focuses on intensive laparoscopic skills training but does not neglect traditional surgical skills learning. Instead, it combines traditional surgical operation learning, allowing students to effectively switch and adapt between the two types of operations. It is reported that resident physicians need to practice laparoscopic simulation skills 15 to 100 times before they can proficiently perform laparoscopic surgeries. Therefore,laparoscopic simulation skills training is extremely helpful for improving surgeons' laparoscopic operation levels and enabling them to adapt to real surgical roles in clinical settings[11]. Thus, our training program is a comprehensive, balanced, and targeted approach that enables students to perform well in both laparoscopic and surgical skills.our study has some limitations and shortcomings that need to be improved and perfected in future research. For example, the number of participants in our study is relatively small, with only 60 students, which may introduce certain randomness and instability. Therefore, it is necessary to increase the sample size to enhance the reliability and generalizability of the study. Additionally, the experimental duration of our study is relatively short, lasting only two months, which may not fully reflect the long-term effects of different training programs. Hence, it is advisable to extend the experimental period to observe students' sustained progress and consolidation of skills. Moreover, the evaluation method in our study is relatively single, using only operational scores as the assessment indicator, which may not fully reflect students' surgical skills. Therefore, it is necessary to incorporate other evaluation methods, such as questionnaires, teacher evaluations, and peer evaluations, to improve the effectiveness and objectivity of the study.

In terms of skill improvement, the study found that:

Operation time reduction: Multiple studies have shown that after undergoing virtual reality simulation training for laparoscopy, medical undergraduate students significantly reduced the time required to complete tasks. The operation time of students was reduced from an initial 305 seconds to 167 seconds after training.

Optimization of movement paths: After virtual reality simulation training, the length of students' operation paths was significantly shortened, indicating more precise and efficient operations. The path length of students was reduced from 830 centimeters to 463 centimeters.

Reduction in hand movements: The number of hand movements made by students was significantly reduced after training, resulting in more stable operations. The number of hand movements made by students in the virtual reality simulation training group was reduced by 74.5 times.

Enhanced instrument coordination skills: Students became more proficient in coordinating the use of instruments with both hands after training, and the use of instruments became more fluent.

Improved tissue handling skills: In simulated surgeries, students' handling of tissues became more delicate, resulting in reduced damage to surrounding tissues.

Skill transfer:

Transferability of skills to real operations: The study showed that the skills acquired by students through virtual reality simulation training could be effectively transferred to actual laparoscopic surgery operations.

Comparison with traditional training methods: Virtual reality simulation training was found to be no less effective than traditional physical model training in terms of skill transfer. For example, a comparative study found no significant difference in the performance of students after skill transfer between the virtual reality simulation training group and the physical model training group.

Learning curve:

Accelerated skill acquisition: Virtual reality simulation training helped students quickly master the basic skills of laparoscopy and shortened the learning curve. For example, in one study, students' skill levels significantly improved in a short period of time after undergoing virtual reality simulation training.

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Differences in benefits for students of different levels: The effect of virtual reality simulation training was more significant for beginners and students with less experience. The skill level improvement of beginners after virtual reality simulation training was greater than that of students with more experience.

Training effectiveness evaluation:

Objective quantitative assessment: Virtual reality simulation systems can provide a variety of objective quantitative assessment indicators, such as operation time, path length, and instrument movement trajectories, which facilitate accurate assessment of students' skill levels.

Consistency between subjective and objective assessments: There was a high degree of consistency between subjective assessments (such as expert ratings) and the objective assessment results of virtual reality simulation systems. In the study, the expert ratings of students' operations were positively correlated with the assessment results of the virtual reality simulation systems.

Student feedback:

Increased interest and motivation: Students generally showed a high level of interest and enthusiasm for virtual reality simulation training for laparoscopy, considering it to be lively and interesting, and capable of stimulating their passion for learning.

Enhanced self-confidence: After undergoing virtual reality simulation training, students' self-confidence in facing actual laparoscopic operations was significantly enhanced.

Research limitations:

Limited sample size: Some studies had small sample sizes, which may affect the universality and reliability of the research findings.

Lack of long-term follow-up: Most studies focused only on short-term training effects and lacked long-term tracking assessments of students' skill retention and development.

Differences between simulated scenarios and actual surgery: Although virtual reality simulation technology is constantly improving, there are still differences between simulated scenarios and actual surgery, which may affect the effectiveness of skill transfer.

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