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A modified multi-angle suture training module for laparoscopic training curriculum on emergency intestinal surgery

Jiliang Shen[1,2†], Chengcheng Wu[3†], Xiaochen Zhang[3], Yaoting Xue[4] and Jin Yang[1,2*]

Abstract

Background Intestinal perforation and intestinal obstruction are common emergency surgeries in clinics which often require intestinal resection and anastomosis. Most intestinal anastomosis can be completed by laparoscopy. The wound closure module In the Fundamentals of Laparoscopic Surgery (FLS) program is traditionally used for laparoscopic suture and knotting training. However, many young surgeons tend to focus on practicing suture techniques from certain or a limited range of angles. This narrow approach increases the difficulty of complex suturing and knotting in clinical scenarios such as laparoscopic intestinal anastomosis.

Methods To address this issue, we designed a multi-angle suture module specifically for suture and knotting training. Thirty-six second-year surgical residents were recruited for the study. Twelve residents were randomly divided at a 1:1 ratio into the traditional suture group and the multi-angle suture group according to their basic laparoscopic surgical ability. After training, they were required to perform laparoscopic end-to-end anastomosis surgery on isolated swine intestines.

Results The operation times, goal scores and surgical performance scores of the surgeries were collected and compared. Trainees who used the multi-angle suture training module shortened the operation time (3375.7 ± 1000 s vs. 4678.2 ± 684.7, $p = 0.008$) and achieved better surgical effects (operation performance score: 8.2 ± 1.5 vs. 6.83 ± 1.3, $p = 0.041$) in end–end intestine anastomosis surgery than did those who used the traditional suture training module.

Conclusions The multi-angle suture training module effectively improved the laparoscopic suture skills of trainees and is therefore a better choice for laparoscopic suture and knotting training before doing laparoscopic intestinal anastomosis.

Keywords Laparoscopic, Intestinal anastomosis, Multi-angle, Suture and knotting, Training curriculum

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Introduction

Laparoscopic surgery has been widely performed because it is less traumatic, facilitates a faster recovery, and causes only mild pain [1–3]. However, laparoscopic surgery is difficult to perform and requires surgeons to have excellent technical skills and extensive experience. Intestinal perforation, intestinal obstruction, or intestinal tumor resection often require intestinal anastomosis [4–7]. Laparoscopic manual intestinal anastomosis is one of the classic surgical methods and the basis of many anastomosis surgeries [8, 9]. To ensure the safety and success of surgery, surgical students and young surgeons need to undergo strict training and several practical exercises [10–13]. In recent years, we have been focusing on simulation training of abdominal surgery [14–16]. In laparoscopic surgery training, suturing and knotting are crucial skills. The Fundamentals of Laparoscopic Surgery (FLS) program is a comprehensive, educational module containing suture and knotting training [17–19]. Many trainees tend to focus on practicing suture and knotting techniques from certain or a limited range of angles using traditional modules, which, to some extent, limits the trainees' adaptability to different surgical scenarios and their ability to improve their skills. To overcome this limitation, we designed a multi-angle suture training module to provide trainees with a more comprehensive and realistic suture training curriculum to improve their laparoscopic suturing and knotting skills. The aim of this study is to compare the specific uses of an ordinary laparoscopic suture training module and a multi-angle suture training module among trainees performing animal end-to-end small intestine anastomosis surgery in animals and to provide a scientific basis for the optimization of laparoscopic surgery training methods.

Table 1 Baseline characteristics of these 2 groups

		Performance score		
NO.	Subgroup	Transfer	Positioning	Normal suturing
Group 1	Normal suture	B	A	A
	Special suture	B	A	A
Group 2	Normal suture	B	B	A
	Special suture	B	B	A
Group 3	Normal suture	C	B	A
	Special suture	C	B	A
Group 4	Normal suture	B	B	B
	Special suture	B	B	B
Group 5	Normal suture	A	A	B
	Special suture	A	A	B
Group 6	Normal suture	B	C	B
	Special suture	B	C	B

Methods

IRB approval

This study was approved by the Ethics Committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine (No. 2025-2141-01).

Participants

Thirty-six second-year surgical residents at Sir Run Run Shaw Hospital were recruited. Twelve residents were ultimately included in the entire study.

Research route

The 36 surgical residents were required to first conduct suture and knotting training on the traditional suture module. Surgical performance was ranked from excellent to poor according to the evaluation scale. The top one-third were evaluated as A, the middle one-third as B, and the bottom one-third as C. Those evaluated as C were excluded from the subsequent study. It is believed that these patients might have difficulty completing laparoscopic intestinal anastomosis surgery, as they still lack basic suture skills. The remaining residents were required to further complete the transfer training and precise positioning training tasks. They were given evaluations of A, B, and C according to the above evaluation methods. On the basis of the scores of the above three tests, these residents were matched 1:1 in terms of scores and assigned to the wound closure suture and knotting training group (normal suture group) or the multi-angle suture and knotting training group (special suture group), with 6 residents included in each group (Table 1). The members of these two groups underwent the same duration of ordinary suture training and multi-angle suture training (Training on the model designed by Yaoting Xue [20], Fig. 2: **special suture and knotting training model**). Finally, after completing the training, they were required to complete the end-to-end anastomosis surgery on the isolated swine intestine (Fig. 1). The operation time and surgical performance scores of the patients were recorded.

Training time

After the residents were matched 1:1 in terms of scores and assigned to the wound closure suture and knotting training groups (normal suture group), they were required to perform suture and knotting training for 90 min on their respective modules.

Surgical time and surgical performance score

The operation time was calculated from the start of the operation to the end of the surgery. The surgical performance score consists of two parts: the anastomotic repair score and the anastomotic stenosis or torsion score. Each part is evaluated by two experts according to a Likert scale. A higher score indicates higher anastomotic

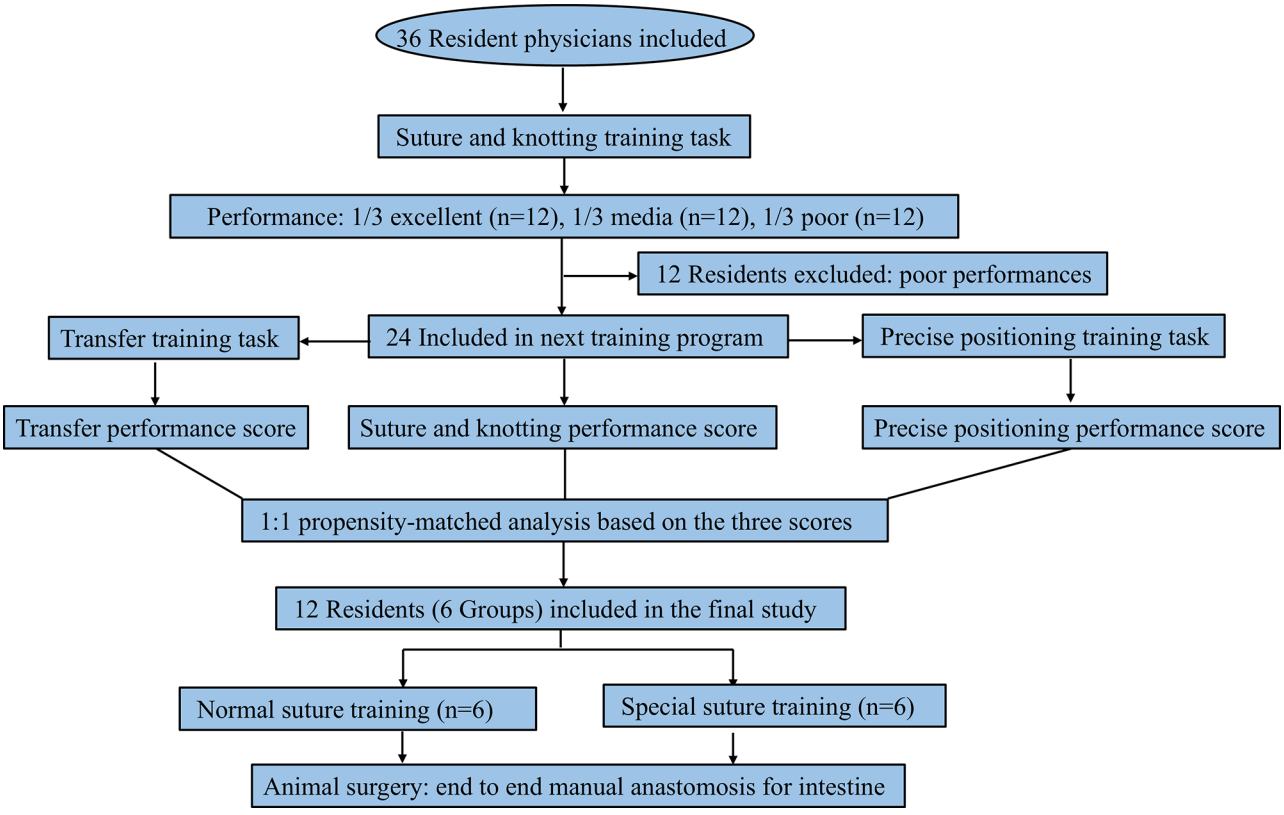

Fig. 1 Participant recruitment flowchart

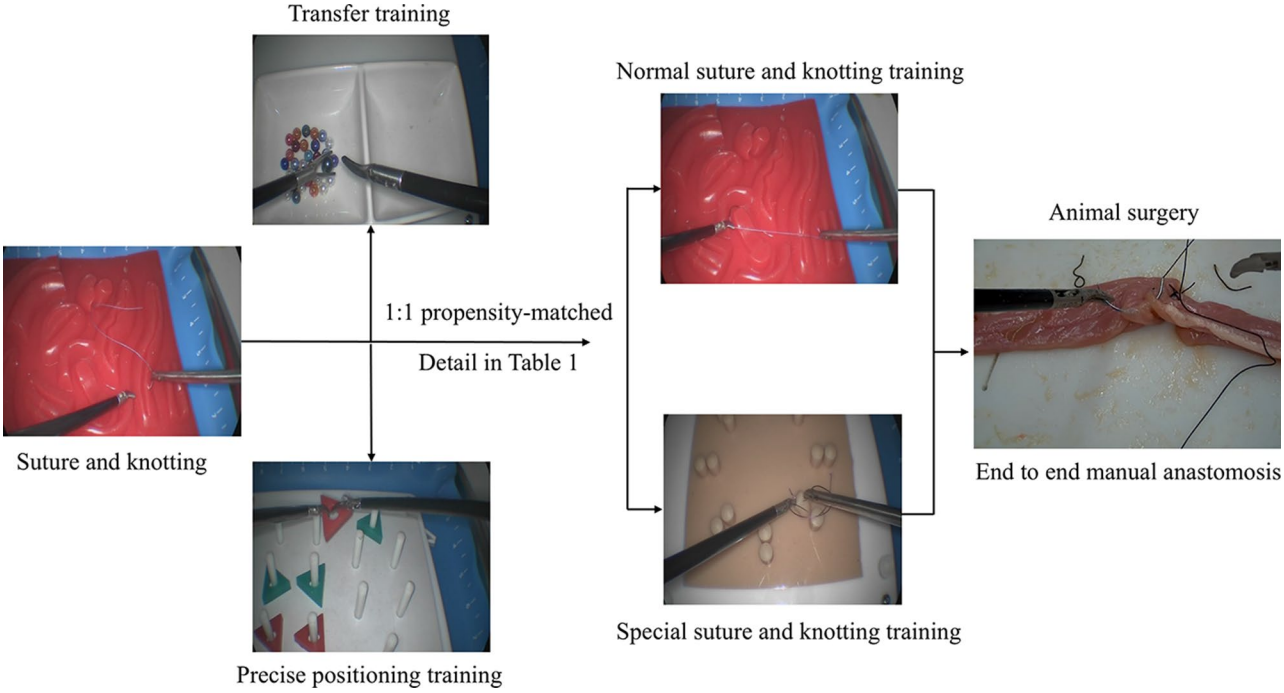

Fig. 2 Training task flowchart

quality. The maximum score for each part is 5 points, and the maximum surgical performance score is 10 points.

Data analyses

All the data were analyzed using SPSS software (version 20.0; SPSS Inc., Chicago, IL, USA). All the charts were designed via GraphPad Prism software (version 7.0). Descriptive statistics are presented as follows: continuous data are presented as the means ± standard deviations. All t tests were two-tailed and paired, and P values < 0.05 indicated statistical significance.

Results

Baseline characteristics

The individuals' baseline characteristics are illustrated in Table 1. The scoring methods of suture and knotting training, transfer training and precise positioning training were introduced. Twelve residents were matched 1:1 and assigned to two groups (normal suture group: wound closure suture and knotting training group; special suture group: multi-angle suture and knotting training group) according to the scores of these three training tasks. After the grouping was completed, there was no significant difference in the two groups' baseline characteristics.

Operation time

The operation times for isolated swine intestine surgery from the two training groups are recorded and compared in Table 2 (special group vs. normal group: 3375.7 ± 1000 s vs. 4678.2 ± 684.7 s, $p = 0.008$). The results clearly show that the average operation time of trainees who use the multi-angle suture training module is significantly shorter than that of trainees who use the ordinary wound closure module (Fig. 3A, B).

Goals score

The goal score was used to quantitatively evaluate laparoscopic surgical skills. There were no significant differences in the average Goals score between these two groups, as shown in Table 2 (special group vs. normal group: 14 ± 2.0 vs. 13 ± 2.1, $p = 0.504$) (Fig. 3C, D).

Table 2 Operation time, goal score and operation performance in these 2 groups

	Operation Time (s)	Goals Score	Operation performance Score
Special	3375.7 ± 1000	14 ± 2.0	8.2 ± 1.5
Normal	4678.2 ± 684.7	13 ± 2.1	6.8 ± 1.3
P value	0.008	0.504	0.041

Surgical performance

The surgical performance score consists of two parts: the anastomotic repair score and the anastomotic stenosis or torsion score (Fig. 4A). The results clearly show that the average operation performance score of trainees using the multi-angle suture training module is significantly higher than that of trainees using the ordinary wound closure module, as shown in Table 2. (Special group vs. normal group: 8.2 ± 1.5 vs. 6.8 ± 1.3, $p = 0.041$) (Fig. 4B).

Discussion

Laparoscopic surgery has been widely used in gastrointestinal [21–23], hepatobiliary [24, 25] and other surgeries [26, 27]. Laparoscopic training is essential for the growth of young doctors. The FLS program is a classic laparoscopic training method [12–14]. Ordinary laparoscopic suture training modules are limited by their training angles, and the skills obtained via such training are not applicable in complex surgical scenarios. In actual surgery, the angles and positions can vary. Only through comprehensive training can surgeons make correct judgments and operate quickly. The multi-angle suture training module was designed to overcome this limitation by providing suture training at multiple different angles, enabling trainees to master laparoscopic suture technology comprehensively.

The operation time is an important indicator for measuring surgical efficiency [28]. The results of this study show that the operation time of trainees using the multi-angle suture training module in animal end-to-end small intestine anastomosis surgery is significantly shorter. This is mainly due to the multi-angle training enabling trainees to master suture techniques more proficiently and reduce the time allotted for mistakes and adjustments during surgery. In actual surgery, every minute that the surgical duration can be reduced may have a positive impact on the patient's safety and recovery. In addition, improving surgical efficiency can reduce medical waste and improve hospital efficiency. The multi-angle suture training module serves as a solid foundation for efficient operations by allowing trainees to continuously improve their skill level and operation speed during training.

Anastomosis quality is one of the key factors for surgical success [28, 29]. Good anastomosis can reduce the occurrence of postoperative complications and promote patient recovery [30]. The multi-angle suture training module can enable trainees to better master suturing from different angles, thereby improving anastomotic quality. In actual surgery, the sealing and stability of the anastomosis are crucial. If sutured improperly, it may lead to serious complications such as bleeding, infection, and intestinal fistula. The multi-angle suture training module simulates the real surgical environment, allowing trainees to continuously adjust their suture techniques

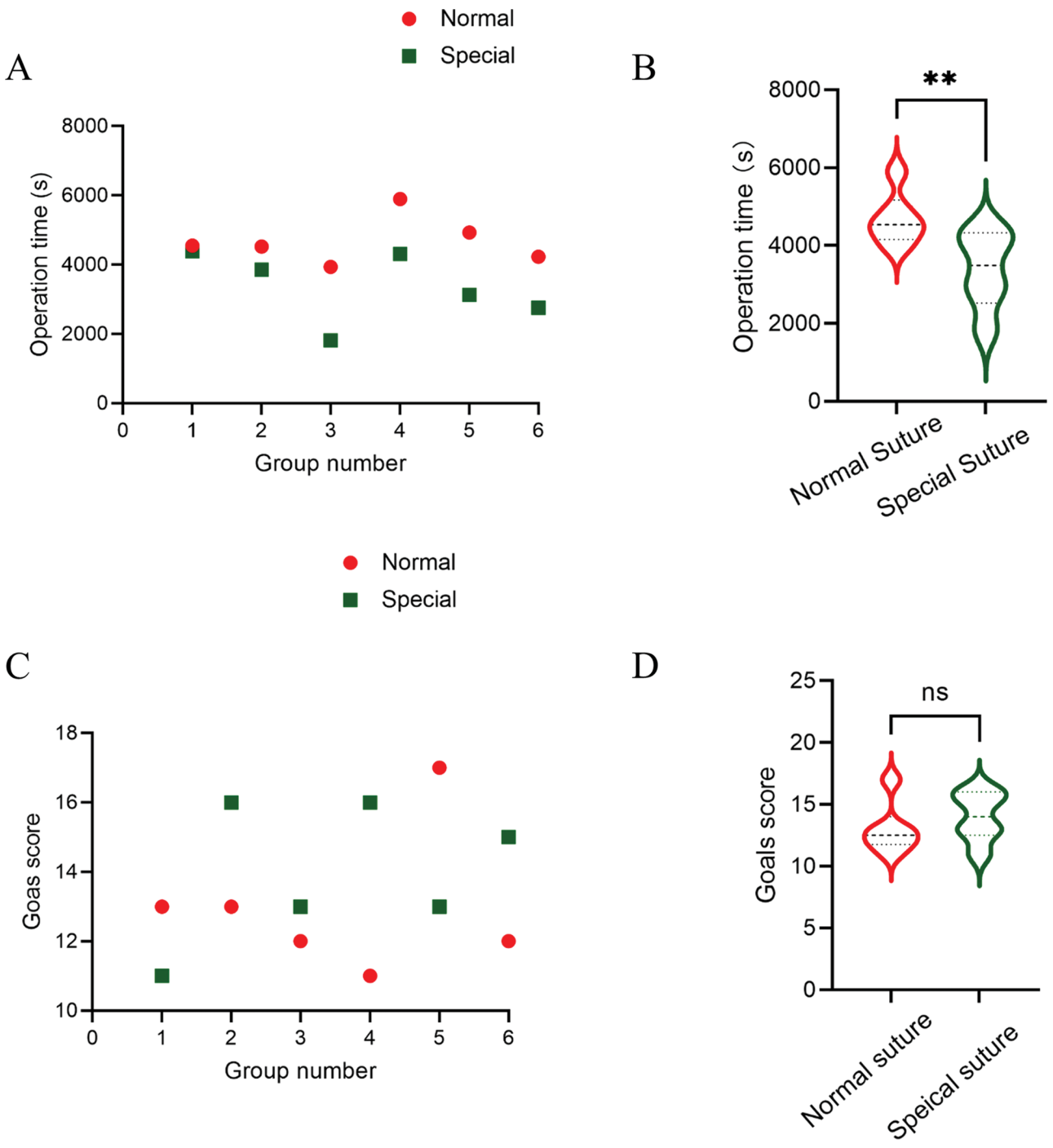

Fig. 3 The operation time and goal score for trainers in the two modules are shown, and the surgical time can be significantly reduced by training on the multi-angle module (special suture group). (**a**) The operation time of the six trainers in the end-to-end intestine anastomosis task; (**b**) the operation time was significantly reduced by training on the multi-angle module (special suture group) compared with training on the wound-closure module (normal suture group); (**c**) the goal score of the six trainers in the end-to-end intestine anastomosis task; (**b**) there was no significant difference in the goal score between the trainees from these two groups. (**$p < 0.01$)

during training to achieve the best anastomotic effect. In addition, this module can improve surgical judgment and operation precision. This finding indicates that the multi-angle suture training module can effectively improve the operation efficiency of trainees during actual surgery.

The Global Operative Assessment of Laparoscopic Skills (GOALS) is a tool specifically designed for evaluating laparoscopic surgical skills [31]. It quantitatively assesses the operator's performance from multiple dimensions, including the fluency of surgical operations

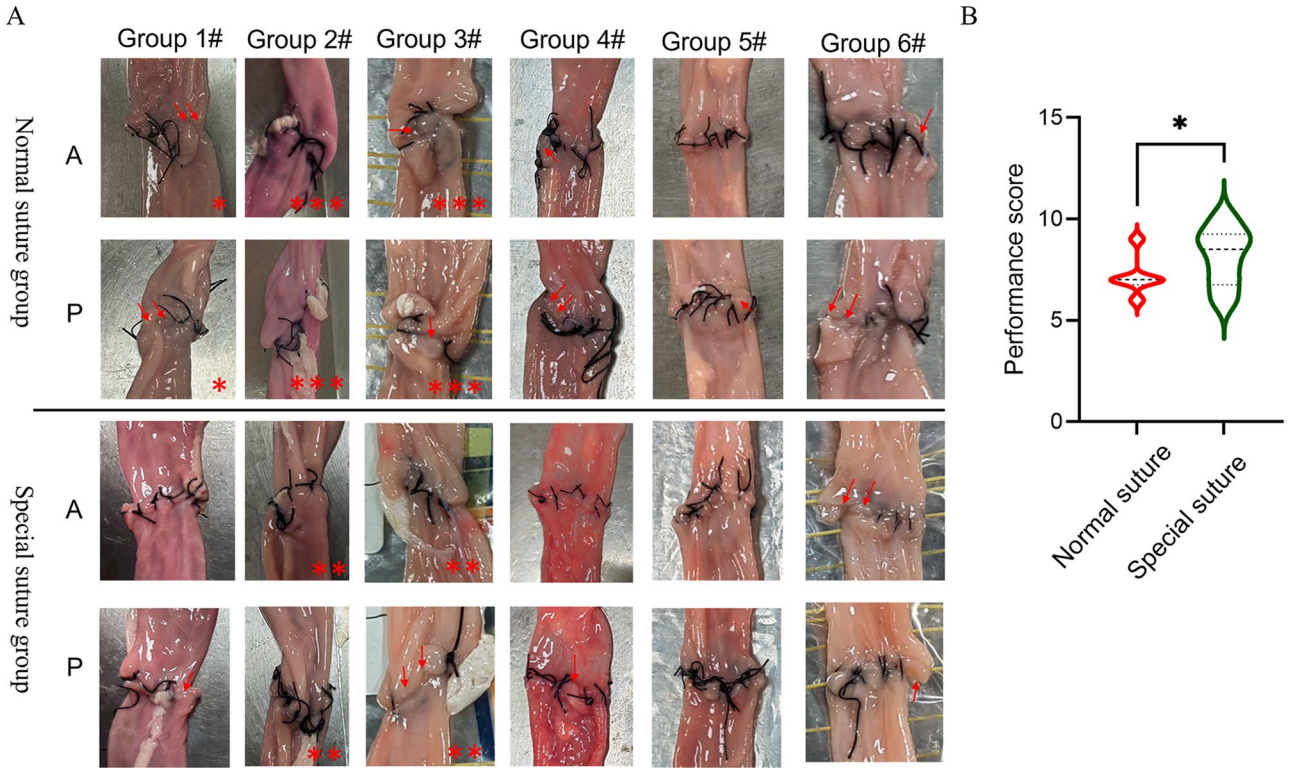

Fig. 4 The operation performance scores for trainers in the two groups are shown, and the operation performance score can be significantly improved by training on the multi-angle module. (**a**) The operation performance score was evaluated by the anastomotic repair score and the anastomotic stenosis or torsion score. The red arrows in the figure refer to the positions where the degree of anastomosis repair is poor. The more arrows there are, the lower the repair score. The red asterisks (*) in the figure indicate the severity of stenosis or torsion at the anastomosis. The more asterisks there are, the lower the stenosis score. (**b**) The operation performance score was better in the special suture group than in the other groups. (*: $p < 0.05$)

and tissue handling, to measure the operator's proficiency and operational quality in laparoscopic surgery. In our study, there was no difference in the GOALS score between the two groups. However, the multiangle suture training group presented more obvious advantages in terms of operation time and anastomotic quality. In end-to-end intestinal anastomosis surgery, adequate spacing between sutured tissues is important, as is whether both ends of the intestinal tubes are aligned during suturing, whether there is torsion, and whether the anterior and posterior walls will be sewn together during suturing and therefore result in anastomotic stenosis or closure. However, the GOALS score is highly subjective and is calculated on the basis of the fluency of the operation and tissue damage, so there may be no significant difference in this regard.

The multi-angle suture training module is a new and effective method for laparoscopic surgery training. In traditional laparoscopic surgery training, theoretical knowledge and basic skills are often prioritized, whereas complex scenarios and multi-angle operations in actual surgery are often ignored. The emergence of the multi-angle suture training module compensates for this deficiency. It can allow trainees to train in a more realistic environment and improve their practical operation ability and ability to deal with complex situations. In future laparoscopic surgery training, the multi-angle suture training module is expected to become an important training tool and contribute to the cultivation of better laparoscopic surgeons. With the continuous popularization of laparoscopic surgery, the requirements for surgeons' surgical skills are increasing. The multi-angle suture training module can help surgeons continuously improve their skill levels and improve surgical quality in daily work. In some complex laparoscopic surgeries, such as gastrointestinal tumor surgery and hepatobiliary surgery.

This study also has several limitations. This was a single-center study, and the sample size was limited. It examines the impact of short-term training (90 min) on intestinal anastomosis surgery with different training models. Potential differences or more obvious differences between different models after long-term training warrant further study. Future studies should incorporate longitudinal assessments with multiple training intervals to determine the optimal duration and frequency of multi-angle suture training. Moreover, our research results confirm that multi-angle training can help residents

improve intestinal anastomosis in animal surgery. However, whether this approach is effective for more difficult surgeries, such as bile-enteric anastomosis and pancreaticojejunostomy anastomosis, is still unknown. Lastly, while we attempted to control for baseline skills through stratified matching, the inherent variability in residents' prior laparoscopic experience remains an unavoidable confounding factor. Larger-scale multicenter trials with standardized pre-assessment protocols would help mitigate this limitation.

Conclusion

In conclusion, compared with the traditional FLS module, the multi-angle suture training module significantly improved both operative efficiency and anastomotic quality in end-to-end intestinal anastomosis. This innovative approach addresses critical gaps in conventional laparoscopic training by simulating complex spatial challenges encountered in real surgeries. While our findings demonstrate promising short-term outcomes, future research should focus on establishing competency-based learning curves through longitudinal training programs and validating clinical translation in live animal models and human surgeries. The cost-effectiveness and scalability of this module position it as a viable alternative to expensive virtual reality simulators for laparoscopic suturing education.

Abbreviations

FLS	Fundamentals of Laparoscopic Surgery
GOALS	Global Operative Assessment of Laparoscopic Skills

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Author contributions

Jiliang Shen had the idea of using the model as a simulator, critically read the literature, wrote the manuscript, and approved its final version. Jin Yang participated in the idea, helped in refining the simulator, critically read the manuscript, and approved its final version. Yaoting Xue helped in making the multi-angle training model.Chengcheng Wu and Xiaochen Zhang helped in collecting data and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine (No. 2025-2141-01).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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