Original Article

Structured training curricula for robotic colorectal surgery in China: does laparoscopic experience affect training effects?

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Background: Robotic surgery has been widely adopted for colorectal cancer (CRC). Many surgeons in China have completed structured training programs and have performed robotic colorectal surgeries. This multicenter study aimed to evaluate the training effects of structured training curricula in China for surgeons with different laparoscopic experiences during their initial implementation of robotic colorectal surgery.

Methods: Ten surgeons from five high-volume centers participated in this retrospective study. The baseline characteristics, perioperative data, and pathological outcomes were compared between the first 15 robotic surgeries performed by five surgeons with extensive laparoscopic experience (group A) and the first 15 robotic surgeries performed by five surgeons with limited laparoscopic experience (group B) at each center.

Results: Compared with group B, group A showed shorter operation time (200.9 *vs.* 254.2 min, P<0.001), less blood loss (100.0 *vs.* 150.0 mL, P=0.025), and a lower incidence of intraoperative complications (2.7% *vs.* 21.4%, P=0.015). The reoperation rate (1.3% *vs.* 5.3%, P=0.036) and postoperative complication rate (6.7% *vs.* 22.7%, P=0.025) were significantly lower in group A than in group B. There were no statistically significant differences in baseline characteristics (e.g., age, sex, and tumor location) and pathological information (e.g., tumor stage, lymph node count, and tumor size) between the two groups. Radical resection (R0) was performed in all cases.

Conclusions: In China, structured training curricula can help surgeons with extensive laparoscopic experience make a smooth transition from laparoscopic to robotic surgery. However, the higher intraoperative and postoperative complication rates indicate that structured training curricula still require further refinement for surgeons with limited laparoscopic experience.

Keywords: Short-term outcomes; colorectal tumors; structured training curricula; robotic colorectal surgery

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Introduction

The incidence of colorectal cancer (CRC) is gradually increasing; it is the second most common tumor in women and the third most common tumor in men. According to the statistics, CRC has the fourth highest mortality rate globally (1,2). Radical resection has always been the cornerstone of CRC treatment. Robotic surgery is widely used worldwide. Compared to laparoscopic surgery, robotic surgery possesses more advantages, such as a three-dimensional high-definition view, excellent operability and comfort in surgery, and better control of surgical instruments (3-7). Studies have shown that robotic surgery offers short-term and oncological outcomes comparable to those of laparoscopic surgery (8-11).

Owing to the lack of experience and technology during the initial implementation of robotic colorectal surgery, many centers have concerns about surviving the early learning curve period and reducing postoperative complications. Robotic colorectal surgery was introduced and performed in China almost simultaneously with that in Western countries. However, the first Da Vinci Surgical Robot International Training Center (DSRITC) was not established in China until 2016. Since then, hundreds of surgeons have completed structured training programs at this training center. Some of them have extensive laparoscopic experience and want to transit from laparoscopic surgery to robotic surgery, whereas others meet the minimum training requirements with limited laparoscopic experience. To date, few studies have evaluated the training effects of this structured training curricula on these two types of surgeons by comparing perioperative outcomes during their initial series of robotic colorectal surgeries.

The aim of this multicenter study was to investigate the short-term outcomes of robotic colorectal surgery performed by surgeons with or without extensive laparoscopic experience after the completion of structured training programs in China. We present the following article in accordance with the STROBE reporting checklist (available at https://jgo.amegroups.com/article/view/10.21037/jgo-22-1193/rc).

Highlight box

Key findings

- Robotic-structured training curricula in China can help surgeons with extensive laparoscopic experience to make a smooth transition from laparoscopic colorectal surgery to robotic colorectal surgery.

What is known and what is new?

- Robotic surgery has been widely adopted for colorectal cancer. Many surgeons in China have completed structured training programs and have performed robotic colorectal surgeries.
- The aim of this multicenter study was to investigate the short-term outcomes of robotic colorectal surgery performed by surgeons with or without extensive laparoscopic experience after the completion of structured training programs in China.

What is the implication, and what should change now?

- The perioperative outcomes of surgeons with limited laparoscopic experience were unsatisfactory in the initial implementation of robotic colorectal surgery. Our structured training curricula still have issues that need to be addressed.

Methods

Centers and patients

This multicenter retrospective study involves five high-volume centers (Shanghai Ruijin Hospital, Daqing Oilfield General Hospital, First Affiliated Hospital of China Medical University, First Affiliated Hospital of Zhengzhou University, and Shandong Provincial Hospital Affiliated with Shandong First Medical University). We selected two surgeons at each center who were trained and certified for robotic colorectal surgery by the DSRITC. Before enrolling in the structured training program, one had performed 300–500 laparoscopic colorectal surgeries, whereas the other had only performed 50–100 laparoscopic colorectal surgeries. The surgeon's surgical experiences were shown in Table S1. The first 15 robotic colorectal surgeries performed by surgeons with extensive or limited laparoscopic experience were included in groups A and B, respectively.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics committee of Ruijin Hospital (approval No. 2022-31). All participating hospitals were informed and agreed the study. The need for informed consent was waived because of the retrospective nature of this study.

Structured training curricula

The trainee requirements are as follows:

(I) Experience and proficiency in laparoscopic surgery with the completion of more than 30 laparoscopic colorectal surgeries as the first operator.

The prerequisites for proctors consist of the following:

(I) More than five years of experience in laparoscopic colorectal surgery.
(II) Completion of at least 150 robotic cases.
(III) Experience with fresh frozen cadaver surgical training.
(IV) Publication of at least two academic research papers on robotic surgery annually.

The structured training curricula included virtual learning tests, on-site simulations, and animal experiments. After the trainee completes the first robotic surgery independently, a qualification for robotic colorectal surgery is issued.

Outcomes

Perioperative and pathological data were recorded. Intraoperative complications included vessel, intestinal, and adjacent organ injuries. Postoperative complications included anastomotic leakage, abdominal abscess, lung infection, intestinal obstruction, lymphatic leakage, and incisional complications. Only Clavien–Dindo grade II or higher postoperative complications were recorded and analyzed in this study. Pathological information included the lymph node count, positive lymph node count, pathological stage, maximum tumor diameter, cancerous nodule, intravascular tumor thrombus, and resection margins.

Statistical analysis

Statistical analyses were performed using SPSS (version 26; IBM Corp., Armonk, NY, USA). Continuous data were recorded as the mean (± standard deviation) or median (range), while categorical data were summarized as percentages. Student's *t*-test was used to determine group differences in continuous factors, while either Pearson's χ^2 test or Fisher's exact test was applied to analyze categorical values. Wilcoxon rank-sum test was used for continuous variables that were not normally distributed. A two-sided P value <0.05 was considered significant statistically.

Results

The baseline characteristics of all the patients are shown in *Table 1*. There were no statistically significant differences in age, sex, tumor location, or preoperative stage. The most common type of surgery was low anterior resection (43.3%), followed by right hemicolectomy (31.3%), left hemicolectomy (14.0%), and abdominoperineal resection or Hartmann's procedure (11.3%) (*Table 1*).

Compared with group B, group A showed shorter operation time (200.9 *vs.* 254.2 min, P<0.001), less blood loss (100.0 *vs.* 150.0 mL, P=0.025), and shorter postoperative hospital stay (7.9 *vs.* 9.6 days, P=0.002). There were statistically significant differences in the incidence of vessel injury (2.7% *vs.* 14.7%, P=0.009) and intestinal injury (0.0% *vs.* 6.7%, P=0.023) between the two groups. The reoperation rate (1.3% *vs.* 5.3%, P=0.036), postoperative complication rate (6.7% *vs.* 22.7%, P=0.025), and total cost (68,646.5 *vs.* 83,834.0 CNY, P <0.001) were significantly lower in group A than in group B. In group A, we had only one case of reoperation for anastomotic leakage. In group B, a total of four patients underwent reoperation, including two cases of anastomotic leakage, one case of abdominal abscess, and one case of intestinal obstruction (*Table 2*).

The lymph node count, positive lymph node count, pathological stage, maximum tumor diameter, cancerous nodule, and intravascular tumor thrombus were comparable between the two groups. The margins were negative in all the specimens. Radical resection (R0) was performed in all cases (*Table 3*).

Discussion

In this study, we found that surgeons with extensive laparoscopic experience in China provided better perioperative data than those with limited laparoscopic experience during the initial implementation of robotic colorectal surgery. We speculate that this discrepancy might be caused by the different training effects of the structured training curricula for these two types of surgeons.

Surgeons with extensive laparoscopic experience performed better intraoperatively. The operative time and blood loss in group A were comparable to those reported in a large-scale nationwide observational study of robotic colorectal surgery in China (192 min and 100 mL) (12). This result suggests that surgeons with extensive laparoscopic experience adapted quickly to robotic surgery after completing the structured training program. We speculated that the satisfactory performance in robotic surgery was mainly attributed to the sense of space, feeling of distance, and recognition of anatomical landmarks obtained in previous laparoscopic surgeries. Some studies have shown that better performance in robotic surgery might be possible with an experienced laparoscopic surgeon, because the operative procedure and working platform of robotic surgery in the abdominal cavity are similar to those

Table 1 patients baseline characteristics

Baseline characteristics	Group A (n=75)	Group B (n=75)	P value
Sex (n, %)			0.87
Male	40 (53.3)	39 (52.0)	
Female	35 (46.7)	36 (48.0)	
Age (n, %)			0.275
<70	57 (76.0)	51 (68.0)	
≥70	18 (24.0)	24 (32.0)	
ASA grade (n, %)			0.806
I–II	66 (88.0)	64 (85.3)	
III	9 (12.0)	11 (14.7)	
Tumor location (n, %)			0.216
Mid-low rectum	14 (16.0)	21 (37.3)	
High rectum	22 (46.7)	25 (25.4)	
Colon	39 (37.3)	29 (37.3)	
Type of surgery (n, %)			0.38
APR/Hartmann	8 (10.7)	9 (12.0)	
LAR	28 (37.3)	37 (49.3)	
Right hemi-colectomy	28 (37.3)	19 (25.4)	
Left hemi-colectomy	11 (14.7)	10 (13.3)	
Preoperative staging (n, %)			0.623
1	24 (32.0)	19 (25.3)	
2	30 (40.0)	31 (41.4)	
3	21 (28.0)	25 (33.3)	

ASA, American Society of Anesthesiologists; APR, abdominoperineal resection; LAR, low anterior resection.

of laparoscopy (13-15). Moreover, compared with group B, group A showed a lower incidence of intraoperative complications (2.7%), which was similar to the results reported by Odermatt *et al.* (4%) and Shaw *et al.* (4%) (16,17). The main intraoperative complications recorded in our study included intestinal and vessel injuries, which may be related to the lack of tactile feedback in robotic surgery. When the intestine was exposed or stretched, the operating force was determined based on vision and experience alone. Thus, the lack of tactile feedback might cause an excessive operating force, leading to intestinal damage (18-20). Ielpo *et al.* also reported that excessive traction without tactile feedback may lead to vessel injury during robotic surgery (21). We believe that surgeons with extensive laparoscopic experience were able to quickly overcome the lack of tactile feedback in robotic surgery after the structured training program and keep the incidence of intraoperative complications within an acceptable range. In contrast, the extremely high incidence of intraoperative complications in group B (21.4%) raised concerns regarding the effectiveness of the structured training curricula for surgeons with limited laparoscopic experience.

We should not overlook the fact that the incidence of postoperative complications in group B (22.7%) was much higher than that in other studies (6.3–10.1%) (22-24). Notably, the incidence of anastomotic leakage (14.7%) was also higher than that reported by Guend *et al.* (5.1%), Kang *et al.* (7.3%), and Bokhari *et al.* (7.5%) (25-27). Moreover, the postoperative complications caused serious consequences, such as a longer postoperative hospital stay

Table 2 Intraoperative data and postoperative recovery

Intraoperative data and postoperative recovery	Group A (n=75)	Group B (n=75)	P value
Operation time (min)※	200.9±38.9	254.2±29.9	<0.001
Blood loss (mL)*	100 [30–200]	150 [30–220]	0.025
Vessel injury (n, %)	2 (2.7)	11 (14.7)	0.009
Intestinal injury (n, %)	0 (0.0)	5 (6.7)	0.023
Adjacent organ injury (n, %)	0 (0.0)	0 (0.0)	1.000
Postoperative hospital stay (days)※	7.9±2.1	9.6±4.1	0.002
Postoperative complications (n, %)	5 (6.7)	17 (22.7)	0.025
Anastomotic leakage	4 (5.3)	11 (14.7)	
Abdominal abscess	1 (1.3)	2 (2.7)	
Lung infection	0 (0.0)	2 (2.7)	
Intestinal obstruction	1 (1.3)	3 (4.0)	
Lymphatic leakage	0 (0.0)	2 (2.7)	
Incisional complications	0 (0.0)	1 (1.3)	
Reoperation within 30 days (n, %)	1 (1.3)	4 (5.3)	0.036

※, values are mean ± standard deviation; *, values are medium (range).

Table 3 Pathological information

Pathological information	Group A (n=75)	Group B (n=75)	P value
Lymph node count※	14.1±6.5	14.5±5.9	0.703
Positive lymph node count※	1.2±0.6	1.6±0.8	0.327
Pathological staging (n, %)			0.630
High-grade intraepithelial neoplasia	3 (4.0)	1 (1.3)	
1	21 (28.0)	17 (22.7)	
2	26 (34.7)	27 (36.0)	
3	25 (33.3)	30 (40.0)	
Maximum tumor diameter (mm) ※	4.5±1.8	4.3±1.6	0.662
Cancerous nodule (n, %)			0.785
No	67 (89.3)	68 (90.7)	
Yes	8 (10.7)	7 (9.3)	
Intravascular tumor thrombus (n, %)			0.806
No	66 (88.0)	65 (86.7)	
Yes	9 (12.0)	10 (13.3)	
Negative Margins (n, %)			1.000
No	0	0	
Yes	75	75	

※, values are mean ± standard deviation.

(+1.7 days) and higher total costs (+15,187.5 CNY) in group B. These results prompted us to doubt whether the structured training curricula set proper training courses and qualification assessments for surgeons with limited laparoscopic experience. Trainees might pay more attention to surgical skills (e.g., dissection of the correct anatomical plane and high ligation of the blood-supply vessels) during the training courses rather than training in tissue suturing and anastomotic skills. Meanwhile, trainees might be incapable of dealing with various types of tumors (different locations and stages) because of the limited experience with actual cases during the training. Furthermore, trainees tend to select a patient with an early-stage tumor or a simple type of tumor (e.g., sigmoid colon tumor) because they only need to complete one case to pass the qualification assessment. Thomas *et al.* (28) reported that surgeons with limited laparoscopic experience should complete at least 10 cases under supervision, which could help trainees learn the appropriate skills to deal with different types of tumors and reduce the incidence of postoperative complications. In contrast, our study showed that surgeons with extensive laparoscopic experience could provide satisfactory postoperative outcomes after the structured training program. Our existing structured training curricula and assessment difficulty could help them make a smooth transition from laparoscopic surgery to robotic surgery.

No statistically significant differences were found between the two groups in terms of specimen quality (lymph node count and resection margins). This indicates that after the structured training program, both types of surgeons could perform robotic surgery according to the oncological requirements. However, surgeries carried out by surgeons with limited laparoscopic experience showed longer operative time, more blood loss, and a higher incidence of intraoperative and postoperative complications. Hence, the existing structured training curricula are far from efficient in training them to perform robotic surgery.

We compared our robotic-structured training curricula with those of Europe and America. The European Academy of Robotic Colorectal Surgery (EARCS) curricula have been reported to reduce intraoperative complications, postoperative complications, and postoperative hospital stay (29,30). This training program has in addition a 2-day trainer-led course that includes animal experiments, cadaveric training, and real clinical training (the trainee conducts 10 robotic surgeries under supervision). The proctor scores each trainee's operation using a GAS form to assess robotic docking, colonic dissection, total mesorectal excision, and anastomosis during training. Trainees are allowed to perform robotic surgery alone when they reach the level of competence required by the EARCS curricula (29,30). In addition, Shellito *et al.* reported that adding cadavers and actual case surgical training in low anterior resection and ascending colectomy to the American Society of Colon and Rectal Surgeons curricula could help trainees make a rapid transition from the first assistant to the first operator (31). Therefore, we would like to make some suggestions to the existing structured training curricula in China for surgeons with limited laparoscopic experience: (I) set up some courses related to tissue suturing and anastomotic skills, (II) add cadavers and actual case surgical training, including different types of CRC, (III) increase the number of cases to be assessed (at least 10 cases), and (IV) establish corresponding scoring standards.

Our study has some limitations. First, the level of evidence was limited by the retrospective nature of this study. Second, the study's sample size was small, with only 10 surgeons from five centers, which limited its representation of Chinese colorectal surgeons. Third, we could not compare the long-term oncological outcomes between the two groups because of the lack of follow-up data.

Conclusions

Robotic-structured training curricula in China can help surgeons with extensive laparoscopic experience to make a smooth transition from laparoscopic colorectal surgery to robotic colorectal surgery. However, the perioperative outcomes of surgeons with limited laparoscopic experience were unsatisfactory in the initial implementation of robotic colorectal surgery. Our structured training curricula still have issues that need to be addressed.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jgo.amegroups.com/article/view/10.21037/jgo-22-1193/rc

Data Sharing Statement: Available at https://jgo.amegroups.com/article/view/10.21037/jgo-22-1193/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jgo.amegroups.com/article/view/10.21037/jgo-22-1193/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics committee of Ruijin Hospital (approval No. 2022-31). All participating hospitals were informed and agreed the study. The need for informed consent was waived because of the retrospective nature of this study.

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Supplementary

Table S1 Surgeon's surgical experiences

	Total number of surgeries (n)	Number of laparoscopic surgeries (n)	Number of open surgeries (n)
Group A (n)			
Surgeon 1	800	400	400
Surgeon 2	700	300	400
Surgeon 3	900	450	450
Surgeon 4	900	500	400
Surgeon 5	1,000	500	500
Group B (n)			
Surgeon 1	130	80	50
Surgeon 2	150	100	50
Surgeon 3	100	60	40
Surgeon 4	100	70	30
Surgeon 5	120	80	40

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