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Peer Reviewer of *World Journal of Gastrointestinal Surgery*, Deven Juneja, DNB, FNB, EDIC, FCCP, Director, Department of Critical Care Medicine, Max Super Speciality Hospital, New Delhi 110017, India. devenjuneja@gmail.com

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The primary aim of *World Journal of Gastrointestinal Surgery* (*WJGS*, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, *etc*.

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ORIGINAL ARTICLE

Retrospective Cohort Study

Efficacy of laparoscopic low anterior resection for colorectal cancer patients with 3D-vascular reconstruction for left coronary artery preservation

Ye Wang, Zhi-Sheng Liu, Zong-Bao Wang, Shawn Liu, Feng-Bo Sun

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Abstract

BACKGROUND

Laparoscopic low anterior resection (LLAR) has become a mainstream surgical method for the treatment of colorectal cancer, which has shown many advantages in the aspects of surgical trauma and postoperative rehabilitation. However, the effect of surgery on patients' left coronary artery and its vascular reconstruction have not been deeply discussed. With the development of medical imaging technology, 3D vascular reconstruction has become an effective means to evaluate the curative effect of surgery.

AIM

To investigate the clinical value of preoperative 3D vascular reconstruction in LLAR of rectal cancer with the left colic artery (LCA) preserved.

METHODS

A retrospective cohort study was performed to analyze the clinical data of 146 patients who underwent LLAR for rectal cancer with LCA preservation from January to December 2023 in our hospital. All patients underwent LLAR of rectal cancer with the LCA preserved, and the intraoperative and postoperative data were complete. The patients were divided into a reconstruction group (72 patients) and a nonreconstruction group (74 patients) according to whether 3D vascular reconstruction was performed before surgery. The clinical features, operation conditions, complications, pathological results and postoperative recovery of the two groups were collected and compared.

RESULTS
A total of 146 patients with rectal cancer were included in the study, including 72 patients in the reconstruction group and 74 patients in the nonreconstruction group. There were 47 males and 25 females in the reconstruction group, aged (59.75 ± 6.2) years, with a body mass index (BMI) (24.1 ± 2.2) kg/m^2, and 51 males and 23 females in the nonreconstruction group, aged (58.77 ± 6.1) years, with a BMI (23.6 ± 2.7) kg/m^2. There was no significant difference in the baseline data between the two groups (P > 0.05). In the submesenteric artery reconstruction group, 35 patients were type I, 25 patients were type II, 11 patients were type III, and 1 patient was type IV. There were 37 type I patients, 24 type II patients, 12 type III patients, and 1 type IV patient in the nonreconstruction group. There was no significant difference in arterial typing between the two groups (P > 0.05). The operation time of the reconstruction group was 162.2 ± 10.8 min, and that of the nonreconstruction group was 197.9 ± 19.1 min. Compared with that of the reconstruction group, the operation time of the two groups was shorter, and the difference was statistically significant (t = 13.840, P < 0.05). The amount of intraoperative blood loss was 30.4 ± 20.0 mL in the reconstruction group and 61.2 ± 26.4 mL in the nonreconstruction group. The amount of blood loss in the reconstruction group was less than that in the control group, and the difference was statistically significant (t = -7.930, P < 0.05). The rates of anastomotic leakage (1.4% *vs* 1.4%, P = 0.984), anastomotic hemorrhage (2.8% *vs* 4.1%, P = 0.672), and postoperative hospital stay (6.8 ± 0.7 d *vs* 7.0 ± 0.7 d, P = 0.141) were not significantly different between the two groups.

CONCLUSION
Preoperative 3D vascular reconstruction technology can shorten the operation time and reduce the amount of intraoperative blood loss. Preoperative 3D vascular reconstruction is recommended to provide an intraoperative reference for laparoscopic low anterior resection with LCA preservation.

Key Words: Laparoscopic low anterior resection; 3D vascular reconstruction; Coronary artery; Colorectal cancer; Retrospective cohort study

Core Tip: Through the observation of left coronary artery three-dimensional vascular reconstruction in patients with colorectal cancer after laparoscopic low anterior resection, the effect of surgery on the vascular system and its curative effect were discussed. The preservation of the left coronary artery and its possible effects were evaluated by comparing preoperative and postoperative vascular remodeling. The results of this study will help to deeply understand the impact of laparoscopic surgery on the cardiovascular system of patients with colorectal cancer, and provide an important reference for postoperative management and clinical treatment, and improve the safety and effect of surgery.

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INTRODUCTION

Colorectal cancer is a malignant tumor of the digestive system with a high incidence worldwide, and surgical treatment has always been one of the main treatment methods[1-3]. In terms of surgical methods, low anterior resection is favored because of its lower trauma and faster recovery speed[4]. However, with improvements in surgical techniques, the need for preoperative evaluation is also increasing. As an accurate preoperative evaluation method, 3D vascular reconstruction imaging provides clearer anatomical information for the surgical process, especially for patients with left coronary artery preservation, which has unique value[5]. In recent years, with the continuous development of laparoscopic technology, colorectal cancer surgery has gradually evolved into a minimally invasive and individualized approach[6-8]. In this context, low anterior resection, a common surgical method, has attracted much attention. The purpose of this retrospective cohort study was to investigate the efficacy of laparoscopic low anterior resection (LLAR) for colorectal cancer and 3D vascular reconstruction imaging in patients with left coronary artery preservation and to further analyze the effects of surgical modalities and angiography on patient recovery and survival.

LLAR to preserve the left colic artery (LCA) is a surgical procedure for rectal cancer. Its advantages include a good blood supply for anastomosis and better protection of autonomic nerves, especially for elderly patients with diabetes, hypertension, and extensive arterial disease[9]. Although there is still controversy and debate about the preservation of the LCA, many surgeons have chosen to perform this procedure to dissect and preserve the LCA while thoroughly clearing the regional lymph nodes[10]. The enlarged field of view and fine anatomy provided by laparoscopic surgery make it relatively easier and more feasible to preserve the LCA than open surgery. Preoperative computed tomography

(CT) angiography and 3D reconstruction can provide 3D visual reconstruction of the inferior mesenteric artery (IMA) and its branches and provide the necessary reference for colorectal cancer surgery. However, the effect of preoperative 3D vascular reconstruction on LCA-preserving rectal surgery is inconclusive[11-13].

Therefore, we conducted this study to evaluate the clinical application of 3D vascular reconstruction technology in the surgical and postoperative outcomes of LLAR of rectal cancer patients with left colon preservation, to provide new ideas and evidence supporting the individualized treatment of colorectal cancer surgery and to promote the wider application of minimally invasive technology in clinical practice.

MATERIALS AND METHODS

General clinical data of the patients

A total of 146 patients with left colon-preserved LLAR who underwent gastrointestinal surgery at the National University Hospital of Singapore from January to December 2023 were included in this retrospective cohort study. The inclusion criteria for patients were as follows: (1) Had a diagnosis of colonoscopy-confirmed and pathological biopsy-confirmed colorectal adenocarcinoma; (2) Had a tumor location 7 cm–15 cm from the anal margin; (3) Underwent LLAR of rectal cancer with the LCA preserved; and (4) Had a pathological stage of I–III. The exclusion criteria were as follows: (1) Had a diagnosis of stage IV rectal cancer; (2) Had a previous history of abdominal surgery; (3) Had intestinal obstruction, bleeding, perforation, *etc.*, or needed emergency surgery; and (4) Had incomplete relevant case data and data. The main indications include large tumors, high surgical difficulty, and a need to improve surgical feasibility. In the pretreatment evaluation, we paid attention to the joint decision-making of the medical team and comprehensively considered preoperative chemotherapy, radiotherapy, and other treatment methods according to individual conditions.

Enhanced CT and 3D vascular reconstruction

A Philips or GE 64-slice CT scanner was used for enhanced CT. The tube voltage was 120 kV, the tube current was automatic MA, the layer thickness was 1.25 mm, the interval was 0.8 mm, and the detector collimation was 320 mm × 0.5 mm. The samples were fasted for 4 h before the examination. The patient was supine and scanned from the apex of the diaphragm to the level of the ischial tubercle. After a normal scan, 85 mL of the enhancer (iodohydramol, iodiproamine, *etc.*, at a concentration of 350-370 mg/mL) was applied. Intravenously, 2 to 5 mL/s. The delay time of arterial phase scanning was 30 s, and 3D vascular reconstruction was performed using a Philips or GE workstation.

Mode of operation

Patients in both groups were given general anesthesia with tracheal intubation, lithotomy at the head lower and foot higher, and 3D laparoscopic surgery. A 1 cm incision was made at the upper edge of the navel to establish a CO_2 pneumoperitoneum, and the pressure was maintained at 12 mmHg-14 mmHg (1 mmHg = 0.133 kPa). The five-hole method was used. The whole abdominal cavity, location and size of the tumor and whether there was distant metastasis were investigated. Through the middle approach, the sigmoid colon is traversed with an ultrasound knife or electrotome.

The serous membrane at the yellow-white junction of the mesangial root was opened to fully nip the IMA to avoid nerve injury. From the inside to the outside and from the head to the side, the IMA roots reach the Toldt space to skeletonize the IMA and protect the submesenteric plexus. The IMA branch was clearly dissected, and the lymph nodes and adipose tissue of Group 253 were completely cleared to the LCA branch. After completing the lymph node dissection in Group 253, the IMA branches were clearly dissected, ligation was performed below the bifurcation of the LCA, the LCA was retained, and the other branches were ligated and severed (Figure 1).

The Toldt space was fully extended, and the pelvic nerve plexus was fully protected. The submesenteric vein was separated to the left, and the surrounding fat and lymph nodes were removed. The mesosigmoid was trimmed along the LCA branch, preserving the marginal vascular arch. The intestinal tube was cut at a distance of more than 2 cm from the tumor, and all the specimens were removed from the lower abdomen in a sterile specimen bag. End-to-end anastomosis was performed to reconstruct the digestive tract. After the abdominal cavity was cleaned, the drainage tube was placed and fixed, and the operating hole was sutured.

Statistical analysis

SPSS software package 25.0 was used for the statistical analysis. Clinical and pathological data are presented as the mean ± SD, and statistical data are presented as the quantity and percentage. The t test was used for measurement data, and the chi-square test or Fisher's exact test was used for counting data. A P value (bilateral) < 0.05 was considered to indicate statistical significance.

RESULTS

Analysis of general data and basic patient information

Between January 2023 and December 2023, we enrolled 146 patients who underwent LLAR-preserving LCA based on the inclusion criteria. In our study, preoperative treatment included chemotherapy, radiotherapy, or other related treatments to reduce tumor volume, improve surgical feasibility, and improve patients' postoperative quality of life. In particular, we observed that a subset of patients in the retrospective cohort received radiation therapy, and this decision was based on a

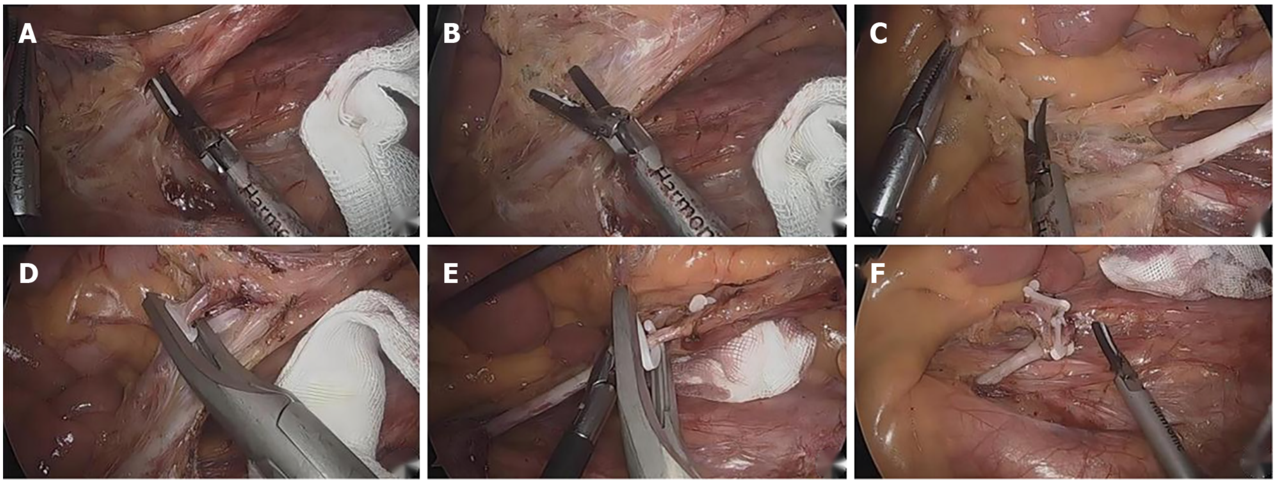

Figure 1 The left colic artery was preserved. A: Isolation of the main naked inferior mesenteric artery; B: Isolatedisolation of the naked left colic artery; C: Clearance of the lymph nodes in group 253; D: Ligation and dissection of the sigmoid artery; E: Ligation of the severed superior rectal artery; F: Operation.

comprehensive assessment of the individual's condition and the clinical team. Table 1 summarizes the basic information and clinical features of the patients in the reconstruction group (n = 72, 49.3%) and the nonreconstruction group (n = 74, 50.7%). There were 47 males and 25 females in the reconstruction group, aged (59.75 ± 6.2) years, with a body mass index (BMI) (24.1 ± 2.2) kg/m^2, and 51 males and 23 females in the nonreconstruction group, aged (58.77 ± 6.1) years, with a BMI (23.6 ± 2.7) kg/m^2. There was no significant difference in the baseline data between the two groups (P > 0.05). There were no statistically significant differences between the two groups in terms of sex, age, BMI, American Society of Anesthesiology (ASA) score, or neoadjuvant therapy.

Preoperative 3D vascular reconstruction and intraoperative vascular anatomy observation

Preoperative 3D vascular reconstruction or surgery was used to study the IMA and its branches in a total of 146 patients. Four IMA blood vessel types were identified in our study. The four blood vessel types are as follows: Type I (Figures 2A and 3A), the LCA alone from the IMA, the sigmoid artery (SA) and the superior rectal artery (SRA) together; Type II (Figures 2B and 3B), the LCA and the SA originate together from a single backbone, and the SRA originates independently from the IMA. In type III (Figures 2C and 3C), all three branches of the IMA emanated at the same level; in type IV and type IV (Figures 2D and 3D), there was no LCA, and only the LCA and SA branched out from the IMA. There was no significant difference in blood vessel types between the two groups (χ^2 = 0.092, P = 0.993) (Table 2).

In the reconstruction group, there were 35 cases of IMA type I, 25 cases of type II, 11 cases of type III, and 1 case of type IV. There were 37 type I patients, 24 type II patients, 12 type III patients, and 1 type IV patient in the nonreconstruction group. There was no significant difference in arterial typing between the two groups (χ^2 = 0.092, P = 0.993). In terms of branch type, both the reconstructed group and the nonreconstructed group were classified as type I (35 patients in the reconstructed group, 48.6% *vs* 37 patients (50.0%) in the nonreconstruction group and type II (25 patients (34.7%) in the reconstruction group *vs* 24 patients (32.4%) in the nonreconstruction group), followed by type III and type IV.

Surgery-related data and complication analysis

The surgical data and related surgical complications are shown in Tables 2 and 3. According to our results, the operation time for LLAR to retain the LCA was shorter in the reconstructive group (162.2 ± 10.8 min *vs* 197.9 ± 19.1 min, t = -13.840; P < 0.05). Intraoperative blood output was also significantly lower in the reconstruction group than in the nonreconstruction group (30.4 ± 20.0 *vs* 61.2 ± 26.4 mL, t = -7.930, P = 0.000). All procedures in both groups were performed by the same group of experienced surgeons specializing in colorectal cancer. There was no conversion to laparotomy in either group. There was no significant difference in postoperative complications, including anastomotic leakage (1 case, 1.4% *vs* 1 case, 1.4%, χ^2 = 0.000, P = 0.984) or anastomotic hemorrhage (2 cases, 2.8% *vs* 3 cases, 4.1%, χ^2 = 0.180, P = 0.672), between the two groups. All of these complications were successfully resolved. There was no significant difference in postoperative recovery between the reconstruction group (6.8 ± 0.7) and the nonreconstruction group (7.0 ± 0.7) (t = 1.480, P = 0.141).

Pathological analysis

The pathological results of the surgical patients are summarized in Table 4. The tumor size (3.1 ± 0.8 *vs* 2.9 ± 0.9 cm, t = 1.309, P = 0.193), differentiation degree (χ^2 = 0.085, P = 0.958) and TNM stage (χ^2 = 0.248, P = 0.958) of the two groups were evaluated. P = 0.883, and there was no significant difference (P > 0.05). In terms of lymph node dissection, the number of lymph nodes in the reconstruction group (18.3 ± 2.7) was slightly greater than that in the nonreconstruction group (17.6 ± 2.1), but the difference was not statistically significant (t = 1.720, P = 0.088).

Table 1 Baseline data of included patients [mean ± SD, *n* (%)]

Clinical features	3D vascular reconstruction group (*n* = 72)	Non-3D vascular reconstruction group (*n* = 74)	*t* value	*P* value
Gender			0.219	0.64
Male	47 (65.3)	51 (68.9)		
Female	25 (34.7)	23 (31.1)		
Age (year)	59.75 ± 6.2	58.77 ± 6.1	0.961	0.338
BMI (kg/m^2)	24.1 ± 2.2	23.6 ± 2.7	1.123	0.263
Neoadjuvant therapy	12 (16.7)	13 (17.6)	0.021	0.885
ASA score			0.174	0.917
ASA I	24 (33.3.0)	23 (31.3)		
ASA II	37 (51.4)	38 (51.4)		
ASA III	11 (15.3)	13 (17.6)		

BMI: Body mass index; ASA: American Society of Anesthesiology.

Table 2 Submesenteric artery branch types [*n* (%)]

Arterial classification	3D vascular reconstruction group (*n* = 72)	Non-3D vascular reconstruction group (*n* = 74)	χ^2	*P* value
Branch type			0.092	0.993
Type I	35 (48.6)	37 (50.0)		
Type II	25 (34.7)	24 (32.4)		
Type III	11 (15.3)	12 (16.2)		
Type IV	1 (1.4)	1 (1.4)		

Table 3 Data analysis of surgery and complications (mean ± SD)

Intraoperative and postoperative indicators	3D vascular reconstruction group (*n* = 72)	Non-3D vascular reconstruction group (*n* = 74)	χ^2	*P* value
Operation time (min)	162.2 ± 10.8	197.9 ± 19.1	-13.84	0.001
Conversion to laparotomy	0	0		
Intraoperative blood loss (mL)	30.4 ± 20.0	61.2 ± 26.4	-7.93	0.001
Anastomotic leak	1 (1.4%)	1 (1.4%)	0.001	0.984
Anastomotic hemorrhage	2 (2.8%)	3 (4.1%)	0.18	0.672
Postoperative hospital stay	6.8 ± 0.7	7.0 ± 0.7	1.48	0.141

DISCUSSION

Colorectal cancer is the third most commonly diagnosed cancer internationally, and laparoscopic colorectal cancer surgery has been widely accepted worldwide[14-16]. Preserving the LCA means that the IMA ligation is located far from the origin of the LCA, which is one of the surgical options for rectal cancer[17]. Our study showed that preoperative 3D vascular reconstruction can provide a preoperative reference for LCA-sparing rectal cancer surgery and can shorten the operation time and reduce the amount of intraoperative blood loss.

3D vascular reconstruction technology has been widely used in a variety of diseases, such as coronary artery disease, lower limb artery stenosis, aortic aneurysm, aortic dissection, and hepatic artery variation. Coronary CT and 3D reconstruction of blood vessels have become the gold standard noninvasive methods for detecting coronary artery disease in clinical practice[18-20]. Previous studies[21-24] have shown that 3D vascular reconstruction techniques are 100% accurate at identifying variations and stenoses in the arteries that supply the lower limbs and the liver, respectively.

With regard to submesenteric artery branch types, we identified four submesenteric artery types using 3D vascular reconstruction techniques and surgical dissection[25]. In our study, both the reconstructed and nonreconstructed groups included four types, of which types I and II were the most common, type III was the most common, and type IV was the

Table 4 Postoperative pathological results [mean ± SD, n (%)]

Pathological index	3D vascular reconstruction group (n = 72)	Non-3D vascular reconstruction group (n = 74)	χ^2	P value
Tumor size (cm)	3.1 ± 0.8	2.9 ± 0.9	1.309	0.193
Number of lymph nodes	18.3 ± 2.7	17.6 ± 2.1	1.72	0.088
Degree of differentiation			0.085	0.958
Low	20 (27.8)	19 (25.7)		
Middle	39 (54.2)	41 (55.4)		
High	13 (18.1)	14 (18.9)		
Pathological stage			0.248	0.883
Stage I	14 (19.4)	13 (17.6)		
Stage II	35 (48.6)	39 (52.7)		
Stage III	23 (31.9)	22 (29.7)		

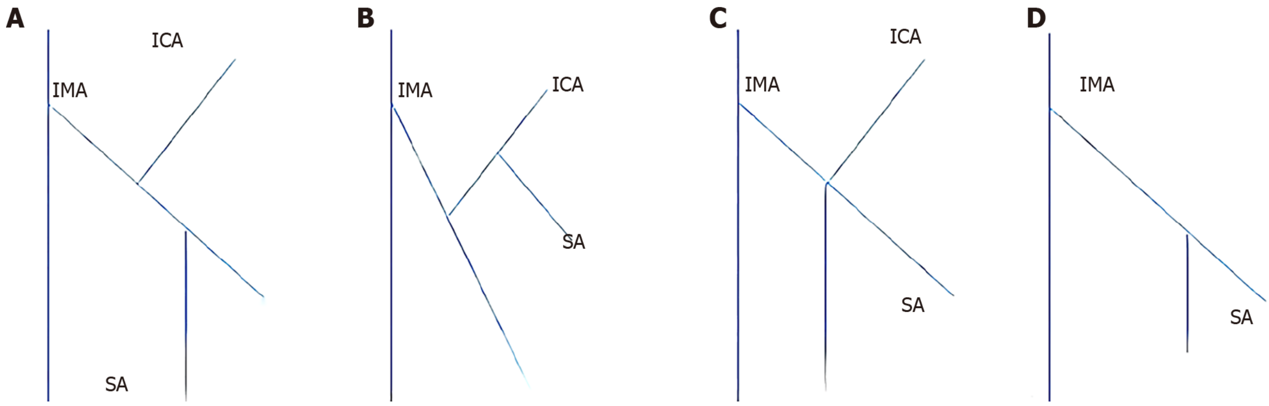

Figure 2 Submesenteric artery classification model. A: Type I; B: Type II; C: Type III; D: Type IV. IMA: Inferior mesenteric artery; LCA: Left colic artery; SA: Sigmoid artery.

least common. In type IV patients, the LCA could not be maintained, but it was impossible to determine whether the patients in the nonreconstruction group would not have the LCA ahead of time[26-28]. This could only be proven by separating the organs along the main IMA during surgery[29]. Therefore, for strict control between the two groups, type IV patients were included in the study. This type of study also highlights the important reference significance of preoperative 3D vascular reconstruction technology for surgical planning and design.

Our study showed that surgical time was shorter in the reconstruction group than in the nonreconstruction group. Although there are no studies that have compared the use of 3D vascular reconstruction in LCA-sparing rectal surgery, a study involving 112 patients who underwent right hemicolectomy, left hemicolectomy, or prerectal resection reported similar results and shortened the time required for surgery for colon and rectal cancer. One study showed that in colorectal cancer surgery, the surgery time in the reconstruction group was significantly shorter than that in the control group[30-32]. According to their experience, preoperative 3D vascular reconstruction may show significant advantages in identifying blood vessels, even in special cases of vascular anatomical variation or obesity[33]. Because less time is spent dissecting blood vessels and looking for aberrant or missing blood vessels, this approach can help surgeons shorten the operation time. Another study showed that in laparoscopic right hemicolectomy, the surgical time in the reconstruction group was shorter than that in the control group (154.7 ± 25.9 min and 177.6 ± 24.4 min, respectively).

In terms of operation time, according to our experience, the application of preoperative vascular reconstruction has shortened the operation time for the following reasons. First, 3D vascular reconstruction helps to accurately plan surgical strategies and programs before surgery. Similarly, many scholars have proposed similar effects of 3D reconstruction technology on surgical planning and design in stomach and liver operations[34]. Second, 3D reconstruction of blood vessels can help clinicians predict the type of blood vessels before surgery, find blood vessels during surgery, and correctly anatomize blood vessels. This is especially helpful for people who are very overweight, have experienced major changes in their anatomy, or have severe abdominal adhesions[35]. Third, 3D vascular reconstruction technology may help avoid some intraoperative complications, such as visceral damage, vascular damage, and bleeding, which are some of the main reasons for prolonged surgical time. Preoperative 3D vascular reconstruction can provide surgeons with basic information on arterial classification and variation before surgery, which is of great help and important reference significance for safe and effective colorectal cancer surgery[36-38]. Compared with digital subtraction angiography, 3D

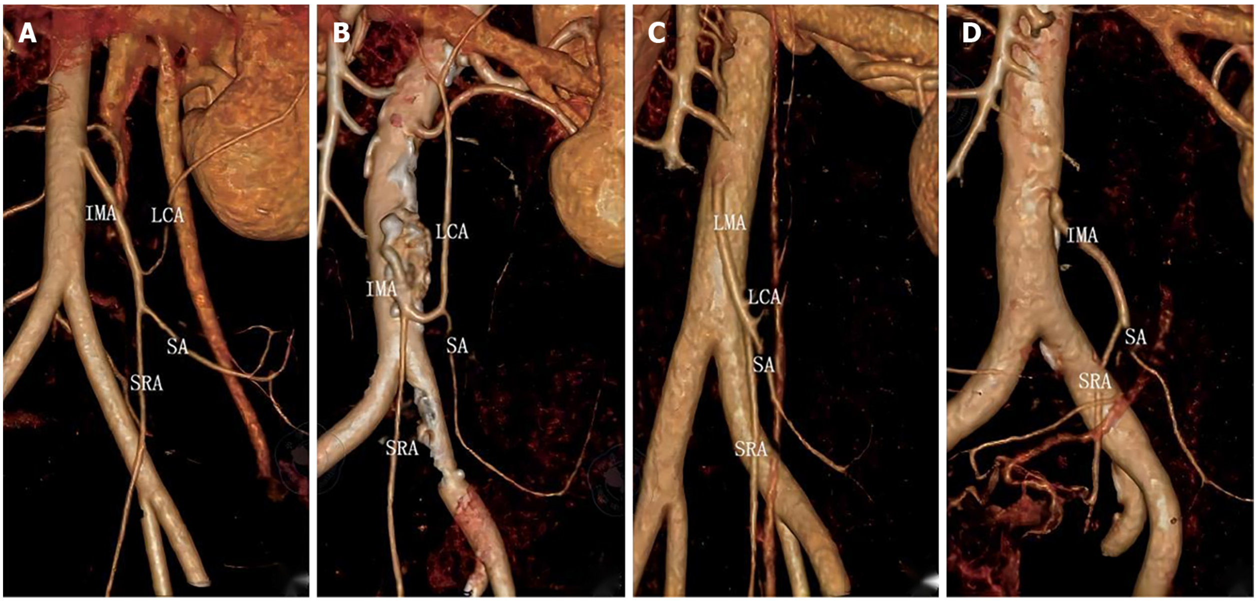

Figure 3 3D reconstruction of submesenteric artery typing. A: Type I; B: Type II; C: Type III; D: Type IV. IMA: Inferior mesenteric artery; LCA: Left colic artery; SA: Sigmoid artery; SRA: Superior rectal artery.

vascular reconstruction is a better way to quickly reconstruct IMA branching patterns with less damage[39]. Moreover, with the rapid development of CT technology, 3D reconstruction of blood vessels can now be performed more quickly and at a lower cost. In terms of postoperative pathology, there was no significant difference in tumor size, number of lymph nodes, degree of differentiation, or pathological stage between the reconstructed group and the nonreconstructed group. Some studies[40-42] have shown that vascular reconstruction technology may have a positive impact on the number of lymph nodes because vascular reconstruction can help surgeons better cut the blood vessels at the root and clean the lymph nodes at the root of the blood vessels to clear the local lymph nodes more thoroughly. Although the number of lymph nodes in the reconstructed group was slightly greater than that in the nonreconstructed group (18.3 ± 2.7 *vs* 17.6 ± 2.1), the difference was not statistically significant in our study. This may be related to the fact that we were the same group of surgeons who performed the operation, and the location of the vessel ligation and the scope of regional lymph node dissection were the same. Whether vascular reconstruction techniques have a positive effect on the number of lymph nodes obtained in colorectal cancer surgery is also a hot issue, and multicenter, prospective clinical studies may provide a greater amount of evidence[43-45].

Our study also has several limitations. First, the study design was retrospective in nature. Prospective studies may better confirm future results. Second, the study represents the experience of a single center, which may limit its external validation validity. Therefore, conducting large-scale, multicenter studies is the direction of further research to better verify the conclusions of this study.

CONCLUSION

Our study suggested that preoperative 3D vascular reconstruction can shorten the operative time and reduce intraoperative blood loss during LLAR of rectal cancer while preserving the LCA. Therefore, for LCA-sparing rectal cancer surgery, preoperative 3D vascular reconstruction is recommended.

FOOTNOTES

Author contributions: Wang Y wrote the manuscript; Liu ZS, Wang ZB, and Liu S collected the data; Sun FB guided the study. All authors reviewed, edited, and approved the final manuscript and revised it critically for important intellectual content, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

Institutional review board statement: This study has been approved by the Clinical Medical Ethics Committee of National University Hospital of Singapore.

Informed consent statement: This study has obtained the informed consent of the patients and their families, and has signed the informed consent for relevant surgical treatment.

Conflict-of-interest statement: The authors declare no conflicts of interest.

Data sharing statement: The technical appendix, statistical code, and dataset are available from the corresponding author at sunfengbo1983@163.com.

STROBE statement: This study has strictly complied with the STROBE statement and met the relevant conditions and requirements of the STROBE statement.

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