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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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ORIGINAL ARTICLE

Retrospective Study

Comparative analysis of the short and medium-term efficacy of the Da Vinci robot *versus* laparoscopic total mesangectomy for rectal cancer

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Abstract

BACKGROUND

The Da Vinci robot-assisted surgery technique has been widely used in laparoscopic mesangectomy for rectal cancer. However, the short-term efficacy of these procedures compared to traditional laparoscopic surgery remains controversial. The purpose of this study was to compare and analyze the short- and medium-term efficacy of Da Vinci robot and laparoscopic surgery in total mesangectomy (TME) for rectal cancer, so as to provide guidance and reference for clinical practice.

AIM

To investigate the safety and long-term efficacy of robotic and laparoscopic total mesorectal resection for the treatment of rectal cancer.

METHODS

The clinicopathologic data of 240 patients who underwent TME for rectal cancer in the Anorectal Department of People's Hospital of Xinjiang Uygur Autonomous Region from August 2018 to March 2023 were retrospectively analyzed. Among them, 112 patients underwent laparoscopic TME (L-TME) group, and 128 patients underwent robotic TME (R-TME) group. The intraoperative, postoperative, and follow-up conditions of the two groups were compared.

RESULTS

The conversion rate of the L-TME group was greater than that of the R-TME group (5.4% *vs* 0.8%, $\chi^2 = 4.417$, $P = 0.036$). The complication rate of the L-TME

group was greater than that of the R-TME group (32.1% *vs* 17.2%, χ^2 = 7.290, P = 0.007). The percentage of positive annular margins in the L-TME group was greater than that in the R-TME group (7.1% *vs* 1.6%, χ^2 = 4.658, P = 0.031). The 3-year disease-free survival (DFS) rate and overall survival (OS) rate of the L-TME group were lower than those of the R-TME group (74.1% *vs* 85.2%, χ^2 = 4.962, P = 0.026; 81.3% *vs* 91.4%, χ^2 = 5.494, P = 0.019); in patients with American Joint Committee on Cancer stage III DFS rate and OS rate in the L-TME group were significantly lower than those in the R-TME group (52.5% *vs* 76.1%, χ^2 = 5.799, P = 0.016; 65.0% *vs* 84.8%, χ^2 = 4.787, P = 0.029).

CONCLUSION

Compared with the L-TME group, the R-TME group had a better tumor prognosis and was more favorable for patients with rectal cancer, especially for patients with stage III rectal cancer.

Key Words: Rectal tumor; Robots; Laparoscopy; Total mesangectomy; Survival prognosis; Retrospective analysis

Core Tip: This study compared the short- and medium-term efficacy of Da Vinci robot-assisted surgery with traditional laparoscopic surgery in total mesangectomy for rectal cancer, involving indexes such as operation time, postoperative complications, postoperative pain, and postoperative rehabilitation. By comparing and analyzing the advantages and disadvantages of the two surgical methods, the influence on the treatment effect and quality of life of the patients was evaluated, and the scientific basis for clinical decision-making was provided.

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INTRODUCTION

With the continuous development of medical technology, Da Vinci robot technology and laparoscopic mesangectomy for the treatment of rectal cancer have gradually emerged[1]. Rectal cancer is a common malignant tumor, and continuous innovations in its treatment are essential for improving the survival rate and quality of life of patients[2]. Due to its precision and minimal invasiveness, Da Vinci robot technology has gradually become a popular choice for rectal cancer surgery[3]. Compared with traditional surgical methods, the Da Vinch robot is more flexible during surgery, allowing doctors to complete complex anatomical structure resection under a highly enlarged field of view, which is expected to reduce the incidence of surgical complications[4-6]. On the other hand, laparoscopic mesangectomy for rectal cancer, as a representative traditional surgical method, has achieved remarkable efficacy in the treatment of rectal cancer, but its limitations and invasiveness are still problems that cannot be ignored. Studies have shown that the Da Vinci robot may have better operability in rectal cancer surgery, but whether it is more effective than laparoscopic surgery in the short or medium term still needs further research[7-9]. Therefore, the aim of this study was to comprehensively compare the short- and medium-term treatment effects of the Da Vinci robot and laparoscopic total mesangectomy (L-TME) for rectal cancer, providing clinicians with a more scientific and objective basis to optimize the selection of rectal cancer surgical programs[10]. The purpose of this study was to provide patients with safer and more effective surgical treatment, promote continuous progress in the field of rectal cancer surgery, and contribute to patient rehabilitation and quality of life.

With the widespread application of L-TME for rectal cancer, people have begun to pay attention to its long-term oncological outcomes[11]. Previous studies have shown that the short-term efficacy of L-TME is better than that of open surgery, but the long-term efficacy is similar. At present, many studies have confirmed the short-term tumor prognosis of robotic TME (R-TME) for rectal cancer[12]. However, only a few studies have reported its long-term efficacy, and the long-term oncological outcomes of L-TME and R-TME are still controversial. This study analyzed and compared the safety and long-term efficacy of R-TME and L-TME.

MATERIALS AND METHODS

General patient data analysis

This study was a retrospective study. Clinicopathological data of 240 patients with rectal cancer undergoing TME were collected from August 2018 to March 2023 in the Anorectal Department of People's Hospital of Xinjiang Uygur Autonomous Region, including 112 patients undergoing L-TME and 128 patients undergoing R-TME. Laparoscopic model: CLV-S190.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) Colorectal adenocarcinoma confirmed by pathological biopsy. Preoperative computed tomography (CT) or magnetic resonance imaging (MRI) was performed to evaluate lymph node spread and determine the depth of tumor invasion. Tumor-node-metastasis (TNM) stages I-III were used. The tumor staging criteria used were the American Joint Committee on Cancer (AJCC)/Union International Against Cancer Colorectal Cancer TNM Staging System (8th edition); (2) Imaging examination ruled out liver, lung, and other distant metastases; and (3) Surgery was generally tolerated. The exclusion criteria for patients were as follows: (1) Had a tumor invading other adjacent organs; (2) Had serious underlying disease; (3) Had combined perforation, obstruction, or emergency surgery; (4) Had received neoadjuvant chemoradiotherapy before surgery; (5) Had undergone palliative resection; and (6) Had multiple colorectal cancers. All patients and their families signed informed consent before surgery. This study was approved by the Ethics Committee of the Cancer Hospital, Chinese Academy of Medical Sciences.

The following data were collected: (1) General information: Age, sex, body mass index (BMI), American Society of Anesthesiologists grade, preoperative serum carcinoembryonic antigen, tumor distance from the anal margin and distribution (as determined by electronic colonoscopy), clinical stage, comorbidities, NRS2002 score, low anterior rectal resection syndrome, International Questionnaire on Erectile Function-5, and follow-up A surname; (2) Perioperative indexes: Conversion rate of laparotomy, postoperative hospital stay, postoperative complications, and Clavien-Dindo grade; (3) Oncological results: The number of lymph nodes removed, pathological grade, AJCC stage, positive rate of annular margin, vascular and nerve invasion, and mesorectal excision (complete: Complete mesenteric tissue, smooth surface, defect depth ≤ 5 mm; nearly complete: The mesangial tissue surface was irregular, the defect depth was ≥ 5 mm; and the musculi propria was not reached). Incomplete: Small mesangial tissue defects as deep as the muscularis propria; and (4) Survival analysis: Disease-free survival (DFS), overall survival (OS), local recurrence, and distant metastasis. The 3-year DFS was defined as the percentage of patients who were free of disease recurrence within 3 years; the 3-year OS was defined as the percentage of patients who were still alive at 3 years of follow-up after surgery.

Surgical method

To facilitate the free anterior rectal space, the uterus was routinely suspended for female patients, and the bladder was suspended for male patients. As shown in Figure 1A, during the procedure, robotic arm II lifted the vascular ridge of the upper rectal artery to enter the Toldt space at the level of the sacral promontory and free it upward to the root of the inferior mesenteric artery. The left colic artery was found and preserved, the superior rectal artery and the sigmoid artery were cut off, the inferior mesenteric vein was cut off, the Toldt space continued to open to the head, and the descending colon and lateral peritoneum of the sigmoid colon were cut. With the continuation of the rectum from the pelvic floor to the hiatus of the levator anal muscle, the extreme attachment margin of the mesentery indicates that total mesentery resection has been completed, as shown in Figure 1B and C.

The separation sequence was lateral first, then posterior, and finally anterior to the rectum. Because the posterior ligament is shielded by the cluster of hiatal ligaments, it is not easy to access the sphincter space. However, gently pulling the puborectal muscle around the rectum from the left and right sides can easily enter the internal and external sphincter spaces. The sphincter gap is loose and without a vascular gap, and the robot's electric hook is delicate and flexible. The three-step separation method of the robot electric hook, which is combined with "a little bit of water burning", "blunt pushing", and "tracing line burning", is adopted to achieve sharp and accurate separation in the sphincter gap, accurately control the depth and depth of the operating plane, and progress layer by layer, as shown in Figure 1D and E. When separation reaches the dentate line level, the loose sphincter space disappears, and a cluster of venous plexuses can be seen in front of the rectum, as shown in Figure 1F.

Further distal separation is prone to damaging the intestinal tube and causing easy bleeding. This is the limit distance for complete abdominal path ionization of the robot and the scope of partial intersphincteric resection (ISR) resection, as shown in Figure 1G. For subtotal ISR or complete ISR, a combined transanal path is needed, as shown in Figure 1H. The reconstruction of the digestive tract was as follows: Part of the ISR was separated from the enterotomy tube through the pelvic cavity with a straight-line cutting and closing device, and the coloanal canal anastomosis was completed under an endoscope. Subtotal and complete ISR require a combined abdominal-transanal route to free the rectum, drag out the rectum and tumor through the anus, disentangle the enterotomy under direct vision, complete colo-anal anastomosis (Figure 1I), and complete a prophylactic ileostomy in the right lower abdomen.

Follow-up method

Follow-up was conducted according to the Guidelines for Colorectal Cancer Diagnosis and Treatment of the Chinese Society of Clinical Oncology. Patients with AJCC stage I disease were followed up every 6 months. Patients with AJCC stages II to III disease were treated once every 3 months. Follow-up included: (1) Physical examination, mainly digital rectal examination; (2) Blood collection and serum tumor marker analysis; (3) Abdominal ultrasound examination; (4) Electronic colonoscopy; and (5) Enhanced CT or MRI examination of the chest, abdominal cavity, and pelvic cavity once a year. The follow-up period ends in March 2023.

Statistical analysis

SPSS 26.0 statistical software was used for data analysis. Normally distributed measurement data are expressed as the mean ± SD, and a *t* test was used for comparisons between groups. The measurement data with a skewed distribution are expressed as the median (interquartile distance), and a nonparametric test (Mann-Whitney *U* test) was used for comparisons between groups. The χ^2 test or Fisher's exact probability test was used to compare the data between groups. The Kaplan-Meier method was used for survival analysis, and the log-rank test was used for comparisons between

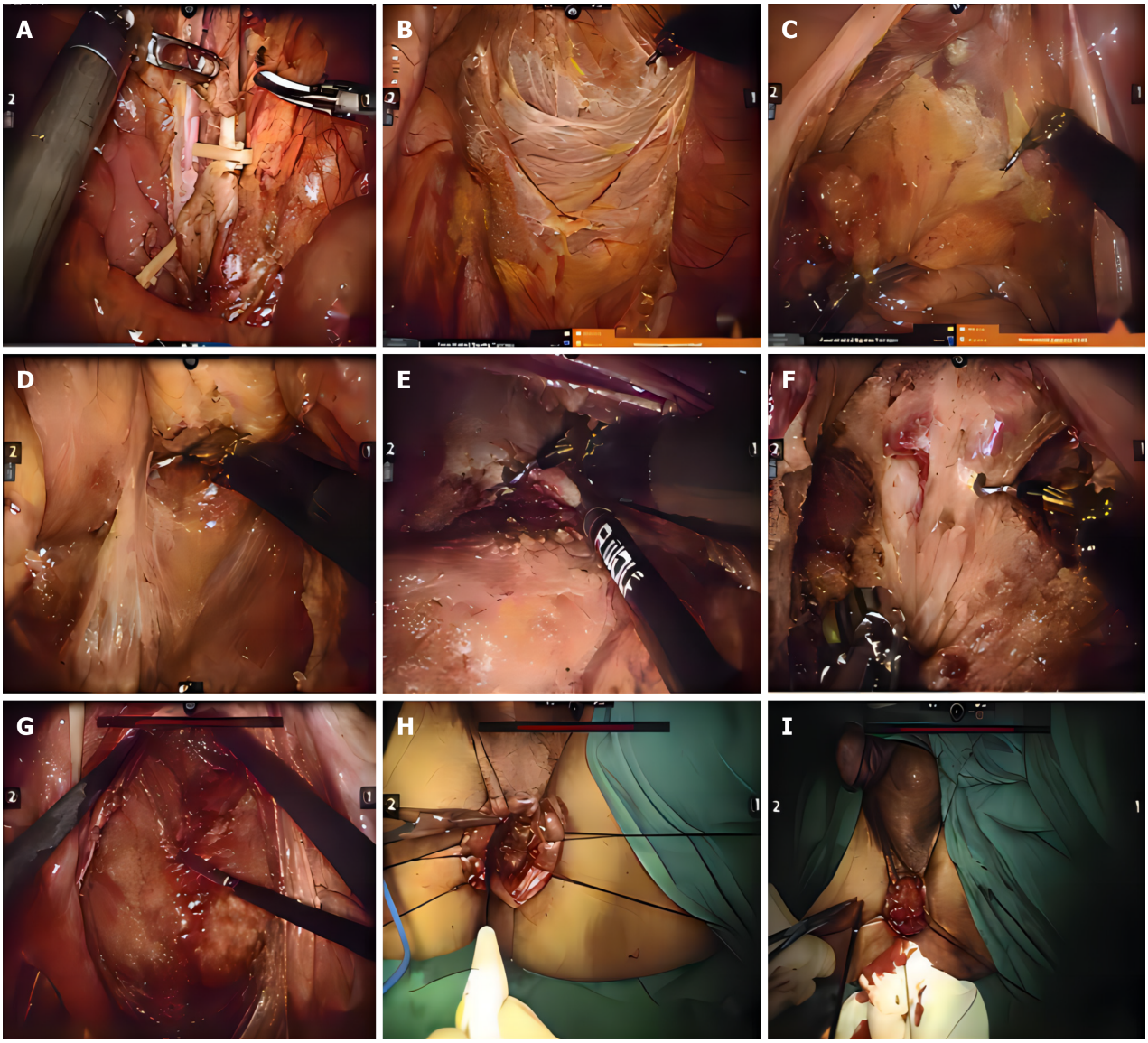

Figure 1 The surgical procedure for the Da Vinci robot diagram. A: The left colic artery was preserved, and the lymph nodes in group 253 were dissected; B: Free retrorectal space; C: Free anterior rectal space; D: Hiatal ligament; E: The puborectal muscle was redrawn to free the sphincter space through the abdominal path; F: Anterior wall venous plexus; G: Complete abdominal path intersphincter separation; H: Free the sphincter space *via* the anal route; I: Colo-anal end-to-end anastomosis.

groups. $P < 0.05$ was considered to indicate statistical significance.

RESULTS

General clinical data of the patients

A total of 240 patients with rectal cancer were included, including 151 males and 89 females. The mean age was 61 ± 9 years, ranging from 37 to 84 years. The average BMI was 23 ± 2.89 kg/m^2. There was no significant difference in the comparison of general data between the two groups (all $P > 0.05$), as shown in Table 1.

Analysis of surgical indexes

The intraoperative conversion rate of the L-TME group was greater than that of the R-TME group ($P < 0.05$). There were more postoperative complications in the L-TME group than in the R-TME group ($P < 0.05$). The hospital stay in the L-TME group was longer than that in the R-TME group ($P < 0.05$). In the L-TME group, 6 patients with anastomotic fistula were treated with enterostomy, 5 patients with intestinal obstruction were treated with adhesive release, 1 patient with urinary retention was treated with ultrasound-guided vesical puncture fistula, 2 patients with anastomotic stenosis were treated with balloon dilation, and 1 patient with sexual dysfunction was transferred to the urology department for treatment. In the R-TME group, 4 patients with anastomotic fistulas underwent enterostomy, 2 patients with intestinal obstruction underwent adhesion lysis, and 1 patient with pulmonary embolism was transferred to the intensive care unit

Table 1 Comparison of general data of rectal cancer patients between the two groups

Clinicopathological indicators	L-TME group (*n* = 112)	R-TME group (*n* = 128)	Statistical	*P* value
ASA grading			$\chi^2 = 0.006$	0.997
Class I	59	68		
Class II	39	44		
Class III	14	16		
Preoperative serum CEA	2.93 (6.06)	3.13 (4.78)	$Z = -0.005$	0.996
Tumor distance from anal margin (cm)	6 (6)	5 (6)	$Z = -0.963$	0.335
Distance distribution of tumor from anal margin			$\chi^2 = 0.592$	0.744
< 5 cm	29	34		
5-10 cm	65	69		
10-15 cm	18	25		
Comorbidities				
Diabetes	24	28	$\chi^2 = 0.007$	0.933
Dypertension	32	26	$\chi^2 = 2.223$	0.136
Chronic obstructive pulmonary disease	15	12	$\chi^2 = 0.966$	0.326
Emphysema	6	8	$\chi^2 = 0.087$	0.768
Varicose veins of the lower extremities	4	3	$\chi^2 = 0.318$	0.573
Deep vein thrombosis of the lower extremities	2	1	$\chi^2 = 0.488$	0.485
Sinus bradycardia	1	3	$\chi^2 = 0.767$	0.381
Atrial fibrillation	1	2	$\chi^2 = 0.217$	0.641
NRS2002 Score			$\chi^2 = 1.493$	0.222
0-2 points	99	106		
≥ 3 points	13	22		
TNM staging			$\chi^2 = 0.138$	0.933
Stage I	34	38		
Stage II	42	46		
Stage III	36	44		
LARS			$\chi^2 = 5.070$	0.079
None	89	115		
Mild	19	11		
Severe	4	2		
IIEF-5 score	112	128	$\chi^2 = 7.443$	0.059
Accessibility	90	118		
Mild impairment	13	5		
Moderate impairment	7	4		
Severe impairment	2	1		
Follow-up time (months)	43.5 (11.5)	42.0 (5.8)	$Z = -1.593$	0.111

L-TME: Laparoscopic total mesorectal resection; R-TME: Robotic total mesorectal resection; ASA: American Society of Anesthesiologists; CEA: Carcinoembryonic antigen; TNM: Tumor-node-metastasis; LARS: Low anterior rectal resection syndrome; IIEF-5: International Questionnaire on Erectile Function-5.

for treatment. The other complications all improved after conservative treatment without special treatment, as shown in Table 2.

Postoperative pathological findings

Compared with those in the L-TME group, the number of lymph nodes dissected was greater in the R-TME group, and the number of positive circumferential margins was lower in the R-TME group ($P < 0.05$). There were no significant differences in tumor diameter, pathological grade, AJCC stage, neurovascular invasion, or complete mesenteric resection rate between the two groups (all $P > 0.05$), as shown in Table 3.

Survival analysis and follow-up

The median follow-up time was 43 months, and the follow-up time ranged from 6 to 60 months. There were no severe complications, such as ostomy hernia, delayed anastomotic fistula, or death of the ostomy, in the two groups. There was no significant difference in the recurrence rate between the two groups ($P > 0.05$). The 3-year DFS and OS of AJCC stage III patients in the L-TME group were lower than those in the R-TME group (74.1% *vs* 85.2%, $P = 0.045$; 81.4% *vs* 91.4%, $P = 0.03$) (Figure 2 and Table 4).

DISCUSSION

L-TME has obvious advantages in terms of short-term efficacy, such as less trauma, faster recovery, and fewer complications[13]. However, due to the 2D laparoscopic surgical field of view, inflexibility of long straight-stem instruments, limited pelvic anatomical space, and complex anatomical levels, manual operation for low-position straight bowel cancer patients is more difficult[14-16]. In 2006, Pigazzi and others completed the first robotic rectal cancer surgery. The Da Vinci robotic surgery system is more suitable for accurate operation in narrow surgical spaces due to its high-definition 3D surgical field of view, automatic filtering of the operator's hand tremor, independent operating table, and high-degree-of-freedom robotic arm, which can reduce operator fatigue and ensure smooth operation[17]. The quality of surgical specimen removal should be improved, thereby reducing local recurrence and improving OS[18].

Switching to laparotomy not only increases the risk of death within 30 d but also affects local recurrence and OS in patients with rectal cancer during long-term follow-up[19]. In this study, the rate of conversion to laparotomy was 5.4% in the L-TME group and 0.8% in the R-TME group, and these differences were statistically significant. A recently published meta-analysis of randomized controlled trials of laparoscopic *vs* robotic rectal cancer surgery showed that the rate of conversion to laparotomy was lower in the robotic group than in the laparoscopic group, which is consistent with the results of this study. Technological advances in robotic systems have enabled surgeons to perform more precise dissections in the narrow pelvis, reducing the need to switch to laparotomy and thus reducing the incidence of postoperative complications[20-22].

In this study, more Clavien-Dindo grade 3 complications occurred in the L-TME group. It has been reported that grade 3 complications after radical resection of colorectal cancer have a negative impact on patient OS and DFS. The L-TME group had a relatively longer postoperative hospital stay due to the greater incidence of major postoperative complications, which could explain the poor survival rate caused by the delayed initiation of adjuvant chemotherapy[23]. The R-TME group had a lower rate of postoperative complications, which may be one reason for the improved survival rate. Previous studies have shown that R-TME and L-TME have similar long-term survival rates[24-26]. However, another study showed that L-TME and R-TME had 3-year OS rates of 70% and 93%, respectively, and 3-year DFS rates of 69% and 84%, respectively, indicating that R-TME had better long-term survival[27]. The results of this study showed that the 3-year OS and DFS rates for L-TME and R-TME patients who underwent robotic surgery were similar to those reported by the institute for patients with AJCC stage I to III rectal cancer. Local recurrence is the most common long-term complication in patients with rectal cancer[28]. The goal of the TME is to reduce local recurrence and improve OS while allowing patients to maintain an appropriate quality of life[29]. In this study, the local recurrence rate of R-TME was 2.7%, which is lower than that reported in previous studies[30-32].

Specimen quality is considered to be an important factor affecting the prognosis of rectal cancer patients, in which complete mesocrectomy and a negative circumferential margin (CRM) play important roles[33,34]. In this study, the R-TME group had a complete mesenteric resection rate similar to that of the L-TME group, which is consistent with previous findings. The results of this study showed that the rate of CRM positivity was greater in the L-TME group than in the R-TME group, and previous studies revealed that the rate of CRM positivity was greater in the L-TME group[35-37]. The unique advantages of robotic technology allow surgeons to maximize the replication of open TME principles, obtain better histopathological results, and improve the long-term survival rate of patients.

CONCLUSION

Compared with the L-TME group, the R-TME group achieved a lower conversion rate for laparotomies and a better tumor prognosis, especially for patients with AJCC stage III rectal cancer.

Table 2 Comparison of intraoperative and postoperative outcomes of rectal cancer patients

Clinical indicators	L-TME group (*n* = 112)	R-TME group (*n* = 128)	Statistical	*P* value
Conversion to laparotomy	6	1	$\chi^2 = 4.417$	0.036
Complications			$\chi^2 = 7.290$	0.007
Yes	36	22		
Not	76	106		
Complications Clavien-Dindo			$\chi^2 = 6.847$	0.144
Class I	95	118		
Class II	3	2		
Class III	14	6		
Class IV	0	1		
Level V	0	1		
Postoperative complications				
Anastomal fistula	13	5	$\chi^2 = 5.106$	0.024
Anastomotic bleeding	3	2	$\chi^2 = 0.365$	0.546
The anastomotic is narrow	4	2	$\chi^2 = 0.989$	0.32
Urinary tract infections	2	1	$\chi^2 = 0.488$	0.485
Urinary retention	3	2	$\chi^2 = 0.365$	0.546
Ileus	8	6	$\chi^2 = 0.656$	0.418
Infection of the incision in the abdominal wall	2	3	$\chi^2 = 0.091$	0.763
Pulmonary embolism	0	1	-	1
Sexual dysfunction	1	0	-	0.467
Length of postoperative hospital stay (d)	17 (3)	6 (2)	$Z = -2.541$	0.011

L-TME: Laparoscopic total mesorectal resection; R-TME: Robotic total mesorectal resection.

Table 3 Comparison of postoperative pathological examination results between the two groups of rectal cancer patients

Pathological indicators	L-TME group (*n* = 112)	R-TME group (*n* = 128)	Statistical	*P* value
Number of lymph nodes dissected	12 (7)	16 (8)	$Z = -3.295$	0.001
Tumor diameter (cm)	4.0 (1.5)	3.5 (2.4)	$Z = -0.006$	0.996
Pathological grading			$\chi^2 = 0.607$	0.738
High differentiation	5	8		
Medium differentiation	95	104		
Low differentiation	12	16		
Positive circumcision margin (case)	8	2	$\chi^2 = 4.658$	0.031
AJCC staging			$\chi^2 = 0.002$	0.999
Phase I	28	32		
Phase II	44	50		
Phase III	40	46		
Mesorectal resection (case)			$\chi^2 = 5.060$	0.08
completely	104	126		
Near-complete	6	2		

Imperfection	2	0		
Nerve invasion	23	18	$\chi^2 = 1.767$	0.184
Vascular invasion	25	20	$\chi^2 = 1.758$	0.185

L-TME: Laparoscopic total mesorectal resection; R-TME: Robotic total mesorectal resection; AJCC: American Joint Committee on Cancer.

Table 4 Comparison of the 3-year survival outcomes of rectal cancer patients

	TNM staging		Phase I		Phase II		Phase III	
	Number of cases	%	Number of cases	%	Number of cases	%	Number of cases	%
Disease-free survival	83	74.1	25	89.3	37	84.1	21	52.5
	109	85.2	30	93.8	44	88	35	76.1
	4.962		0.403		0.323		5.799	
	0.026		0.525		0.57		0.016	
Total survival	91	81.3	26	92.9	39	88.6	26	65
	117	91.4	31	96.9	47	94	39	84.8
	5.494		0.499		0.852		4.787	
	0.019		0.48		0.356		0.029	

TNM: Tumor-node-metastasis.

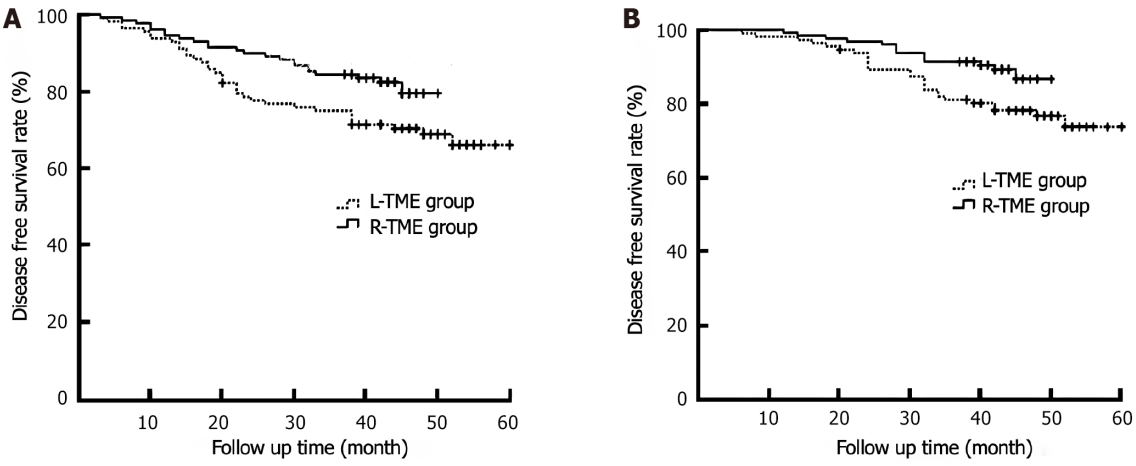

Figure 2 Comparison of the 3-year disease-free survival rate and overall survival rate between laparoscopic mesangectomy and robotic mesangectomy. A: 3-year disease-free survival rate; B: 3-year overall survival rate. L-TME: Laparoscopic total mesorectal resection; R-TME: Robotic total mesorectal resection.

FOOTNOTES

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