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Original Article

Laparoscopy and laparotomy for patients with transverse colon cancer: comparative analysis of short-term surgical outcomes

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Abstract: Objective: To compare the efficacy of laparoscopy versus laparotomy in the treatment of transverse colon cancer. Methods: Data from 100 patients with transverse colon cancer treated in our hospital from January 2018 to December 2020 were retrospectively analyzed in this study. According to the treatment methods, these patients were assigned into two groups: a laparotomy group (n=50) and a laparoscopy group (n=50). The intraoperative parameters, postoperative recovery, incidences of complications, postoperative pain, quality of life (QoL) score, postoperative serum inflammatory cytokine (hs-CRP, TNF-α, and IL-6) levels, and prognostic nutritional index (PNI) were analyzed and compared between the two groups. Results: There was no significant difference in number of resected lymph nodes between the two groups. The operation time and intraoperative bleeding in the laparoscopy group were significantly less than those in the laparotomy group (P<0.05). The hospital stay, duration of gastrointestinal function recovery, and time of first postoperative flatus in the laparoscopy group were significantly shorter than those in the laparotomy group (all P<0.001). Moreover, the incidence of overall complications in the laparoscopy group was significantly lower than that in the laparotomy group (P<0.05). Compared with those in the laparotomy group, the VAS score was obviously lower and the QoL score was significantly higher in the laparoscopy group (all P<0.001). Patients in the laparoscopy group exhibited lower levels of postoperative hs-CRP, TNF-α and IL-6 in contrast to those in the laparotomy group (P<0.05). In additional, there was no significant difference in the PNI level before surgery between two groups. After surgery, the PNI level in the laparoscopy group was obviously higher than that in the laparotomy group (P<0.001). Conclusion: Laparoscopy is superior to laparotomy in treatment of transverse colon cancer through achieving better intraoperative outcomes, promoting postoperative recovery, reducing the incidence of complications and inflammatory reactions, alleviating postoperative pain, and improving therapeutic effects.

Keywords: Transverse colon cancer, laparotomy, laparoscopy, curative effect

Introduction

Colorectal carcinoma was one of the most common malignancies in the world, and the incidence of colorectal carcinoma is increasing year by year [1-3]. Open procedures were commonly used for patients with colorectal carcinoma in clinical practice. However, has been shown that laparoscopic procedures had obvious benefits such as a small estimated blood loss, short hospital stay, as well as good recovery and oncological outcomes [4, 5]. Carcinoma in the transverse colon, accounting for 10% all colonic cancers, is often excluded in previous randomized controlled research because of its special anatomical location and requirement of excellent surgical skills [6, 7]. The surgery for patients with transverse colon cancers is usually determined by the surgeon's surgical preference and the site of tumor.

In recent years, the increasing experience in laparoscopic colonic resections among surgeons has led to cumulative publication of studies [8, 9]. However, there are few studies on laparoscopic operation for patients with transverse colon cancer and limited data regarding the effect of surgical methods on quality of life (QoL) and potential short or long-term outcomes. Moreover, previous trials were limited in quality of methodology and sample size, and failed to draw a clear conclusion on which treatment method is optimal for transverse colon cancer in improving prognosis and reducing

complications. Thus, the selection of treatment methods for patients with transverse colon cancer has become an important challenge for doctors.

At present, the typical treatment method for colorectal cancer is surgical resection. With the continuous advancement of instruments and the development of laparoscopic technology, increasing surgeons choose to use laparoscopy for colorectal cancer. However, there is little data regarding the comparison between open surgery and laparoscopy for the treatment of transverse colon cancer. Many retrospective control studies also chose to avoid the subjects of transverse colon cancer, which may be associated with the following reasons. First, compared with colon cancer in other segments, transverse colon cancer has a relatively low incidence, accounting for about 10% among all colon cancer, which makes surgeons have less experience in laparoscopic surgery for transverse colon cancer than for other colon segments, so there is limited available data. Secondly, laparoscopic lymph node dissection around the middle colon artery is difficult. Third, the operation for transverse colon cancer involves or adjoins numerous important vessels and organs, such as the superior Mesentery vein, pancreas, spleen, and duodenum. The complex anatomical environment increases the difficulty and risk of laparoscopic surgery and lymph node dissection.

In order to further explore the clinical efficacy of laparoscopic surgery in the treatment of transverse colon cancer. This study selected 100 patients with transverse colon cancer admitted to Department of Oncological Surgery, Lanxi People's Hospital from January 2018 and December 2020 as the research subjects. The perioperative outcomes between patients who received laparoscopy and an open surgery were compared and analyzed. The results of this study will decipher the advantages of the laparoscopic approach over the conventional open surgery and provide some clinical reference for the treatment of transverse colon cancer.

Materials and methods

General information

This retrospective study enrolled 100 patients with confirmed transverse colon cancer who were admitted to our hospital between January 2018 and December 2020. According to the surgical methods, the eligible patients received either conventional segmental transverse colectomy by laparotomy (the laparotomy group, n=50) or segmental transverse colectomy by laparoscopy (the laparoscopy group, n=50). This study was approved of by the Ethics Committee of Lanxi People's Hospital (No. 2017-076).

Inclusion criteria: (1) Patients who met the diagnostic criteria of transverse colon cancer. Namely, the tumor was located in the mid part of the transverse colon excluding the 10 cm distal third in splenic flexure and the 10 cm proximal part in hepatic flexure. (2) Patients who underwent transverse colectomy, namely, the resection of a variable length of bowel with the lymph vascular supply along the middle colic pedicle between the splenic and hepatic flexure and ligation. (3) Patients who did not have perforation of bowel, invasion of adjacent organs, distant metastases, or obstruction of bowel. Patients were excluded if they had severe hepatic and renal dysfunction, gastrointestinal disease requiring surgical intervention, other previous or concurrent malignant tumors, severe cardiopulmonary dysfunction, severe abdominal infection, inflammatory bowel diseases, a history of abdominal surgery, or conversion to laparotomy.

Surgical methods

Laparoscopy and open resections were performed by the team members of the colorectal surgery group. Before surgery, a nasogastric tube and a Foley catheter were regularly applied. Laparoscopic approach: After successful tracheal intubation and general anesthesia, the patient was placed in the supine position with leg split, both upper extremities adducted, as well as head high and the feet low. After routine sterilization and draping, the establishment of pneumoperitoneum (pressure 12 mmHg) was conducted by puncture. The Trocar (Shanghai Johnson & Johnson Medical Equipment Co. LTD.) was inserted using traditional five-hole method. After laparoscopic exploration, the root of the mesentery was exposed through turning the omenti up and placing the small intestine in the left lower abdomen. After locating the superior mesenteric vein (SMV) projection, the retroperitoneum was opened in the direction of the SMV into the right Toldt's space. The range and plane of dissection was

towards the right to the front of the prerenal fascia, lateral to the peritoneal fold, and up to the hepatocolic ligament. The anterior pancreatic space was entered through sharply separating upward from the inside. Next, the dissection was performed from the right side to the lateral edge of the descending duodenum. The root of vascular sheath was found along the SMV. Then, the left and right branches of the middle colonic veins were exposed, ligated and disconnected at the root. The middle colic artery was found at the lower border of the pancreas and the root of the transverse mesentery, and it was ligated and disconnected at the root. At the same time, the lymph nodes at the root of the superior mesenteric artery were dissected. Toldt's space was extended from left to the tail of the pancreas. The transverse mesocolon was freed on the surface of the pancreas, and the spleen blood vessels were protected. At the incision of the gastrocolic ligament, the ligament was cut along the gastroepiploic vascular arch situated in the greater curvature of the stomach. The cut extended from the right side to the duodenal bulb and from the left side to the splenic flexure. The transverse mesocolon was dissected along the surface of the pancreas. The hepatic flexure, splenic flexure and part of the ascending and descending colons were fully dissociated. The incision protection ring was placed in a midline incision of the upper abdomen. The transverse colon tumor, transverse mesocolon and all omenti were removed in vitro, and the anastomosis was completed. Finally, closure of abdomen was performed following irrigation of abdominal cavity and placement of drainage.

The open surgery approach group underwent typical transverse colectomy with midline incision. The anastomosis was same as that in the laparoscopy group. The midline incision was closed in layers using a separate propylene suture for each layer.

Observed indicators

The primary indicators included perioperative outcomes and incidence of complications, while the secondary indicators included visual analog scale (VAS) score, QoL score, and inflammatory cytokines levels.

Perioperative indexes such as operative time, intraoperative bleeding, and number of resected lymph nodes, as well as postoperative parameters including length of hospital stay, duration of gastrointestinal function recovery, time of first postoperative flatus, and the incidence of postoperative complications were compared between the two groups. VAS was employed for evaluating postoperative pain, with a scale range of 0-10, namely, from painless (0 point) to severe pain (10 points). The QoL questionnaire was used to assess the postoperative QoL in the patients. The QoL questionnaires included energy, fatigue, appetite, pain, sleep, attitude towards treatment, side effects of treatment and daily life, with higher scores indicating better QoL. Prognostic nutritional index (PNI) was used to evaluate the condition of nutrition in patients. PNI was calculated according to the following formula: PNI = serum albumin levels (g/L) + 5 × total number of peripheral blood lymphocyte (× 10^9/L). The serum inflammatory cytokines including high-sensitivity C-reactive protein (hs-CRP, Lot Number: PC190), interleukin-6 (IL-6, Lot Number: PI330), and tumor necrosis factor-α (TNF-α, Lot Number: PT518) were examined using enzyme-linked immunosorbent assay (ELISA) according to the instructions in kits. The ELISA kits were purchased from Shanghai Beyotime Biotech. Inc.

Statistical analysis

All data in the study were analyzed using Statistic Package for Social Science (SPSS) software, version 23.0. Categorical data were expressed as percentages, and the comparison between groups was conducted through chi-square test. Measurement data were presented as mean ± standard deviation (SD). Independent-sample t test was used for comparing data between two groups and paired t test was employed for comparing data between before and after operation. $P<0.05$ was considered statistically significant.

Results

Comparison of general information

There was no obvious statistical difference between the laparotomy group and laparoscopy group regarding general information such as age, gender, body mass index, underlying disease, American Society of Anesthesiologists score, and tumor node metastasis stage. Therefore, the two groups were comparable ($P>0.05$, **Table 1**).

Table 1. Comparison of general information between the two groups

Parameters	Laparotomy group (N=50)	Laparoscopy group (N=50)	t/χ^2 value	*P* value
Age (years)	61.4±7.6	62.8±8.1	0.891	0.375
Male/Female	28/22	31/19	0.372	0.542
BMI (kg/m^2)	22.90±1.54	23.31±1.82	1.216	0.227
Hypertension (n)	6	8	0.332	0.564
Hyperlipidemia (n)	9	7	0.298	0.585
Diabetes (n)	10	11	0.060	0.806
ASA score			0.593	0.898
I	10	13		
II	23	21		
III	12	12		
IV	5	4		
TNM stage			0.544	0.762
I	9	12		
II	25	23		
III	16	15		

Note: BMI: Body Mass Index; ASA: American Society of Anesthesiologists; TNM: tumor node metastasis.

Table 2. Comparison of perioperative outcomes between the two groups

Parameters	Laparoscopy group (N=50)	Laparotomy group (N=50)	t/χ^2 value	*P* value
Operative time (min)	110.53±12.64	148.72±13.93	14.360	<0.001
Number of resected lymph nodes	13.70±2.12	13.32±1.94	0.935	0.352
Intraoperative bleeding (mL)	79.62±8.53	102.91±10.13	12.440	<0.001
Hospital stays (days)	7.42±1.21	10.62±1.83	10.310	<0.001
Duration of gastrointestinal function recovery (days)	3.72±0.63	4.82±0.83	7.465	<0.001
Time of first postoperative flatus (days)	2.12±0.43	3.94±0.73	15.190	<0.001

Comparison of perioperative outcomes

The operative time and intraoperative bleeding in the laparoscopy group were significantly less than those in the laparotomy group (P<0.05). There was no significant difference in the number of resected lymph nodes between the two groups. Postoperative parameters including hospital stay, duration of gastrointestinal function recovery, and time of first flatus in the laparoscopy group were remarkably shorter than those than in the laparotomy group, with statistical differences. See **Table 2**.

Comparison of the incidence of complications

In the laparoscopy group, there was 0 cases of intraoperative bleeding, 1 case of anastomotic leakage, 1 case of infection, and 1 case of intestinal adhesion, with an overall incidence 6%. The overall incidence of complications was 20% in the laparotomy group, including 2 cases of intraoperative bleeding, 2 cases of anastomotic leakage, 3 cases of infection, and 3 cases of intestinal adhesion. The incidence of complications in the laparoscopy group was significant lower than that in the laparotomy group (P<0.05, **Table 3**).

Comparison of VAS and QoL scores between the two groups

As shown in **Table 4**, the postoperative VAS score in the laparoscopy group was significantly lower than that in the laparotomy group, while the postoperative QoL score in the laparoscopy group was obviously higher than that in the laparotomy group (P<0.05).

Comparison of postoperative inflammatory cytokines

The postoperative serum levels of hs-CRP, TNF-α and IL-6 in the laparoscopy group were

Table 3. Comparison of the incidence of complications between the two groups

Postoperative outcomes	Laparoscopy group (N=50)	Laparotomy group (N=50)	t/χ^2 value	*P* value
Intraoperative bleeding	0 (0%)	2 (4%)	-	-
Anastomotic leakage	1 (2%)	2 (4%)	-	-
Infection	1 (2%)	3 (6%)	-	-
Intestinal adhesion	1 (2%)	3 (6%)	-	-
Overall complications	3 (6%)	10 (20%)	4.332	0.037

Table 4. Comparison of VAS scores and QoL scores between the two groups

Parameters		Laparoscopy group (N=50)	Laparotomy group (N=50)	t value	*P* value
VAS scores	Before surgery	1.28±0.31	1.30±0.27	0.344	0.732
	After surgery	2.32±0.54*	4.12±0.73*	14.020	<0.001
QoL scores	Before surgery	20.74±2.11	21.06±2.40	0.708	0.481
	After surgery	33.51±4.32*	28.94±3.22*	5.998	<0.001

Note: VAS: Visual analog scale; QoL: Quality of life. *P<0.05, compared with before surgery in the same group.

Table 5. Comparison of postoperative inflammatory cytokines between the two groups

Inflammatory cytokines		Laparoscopy group (N=50)	Laparotomy group (N=50)	t value	*P* value
hs-CRP (mg/L)	Before surgery	8.57±1.29	8.65±1.47	0.289	0.773
	After surgery	18.72±3.53*	25.24±4.12*	8.498	<0.001
TNF-α (ng/L)	Before surgery	7.49±1.64	7.54±1.71	0.149	0.882
	After surgery	21.41±2.62*	29.14±3.81*	11.820	<0.001
IL-6 (pg/L)	Before surgery	14.87±3.29	15.22±3.65	0.504	0.616
	After surgery	64.32±7.43*	75.82±8.24*	7.329	<0.001

Note: hs-CRP: High-sensitivity C-reactive protein; IL-6: Interleukin-6; TNF-α: Tumor necrosis factor-α. *P<0.05, compared with before surgery in the same group.

Table 6. Comparison of the PNI level between the two groups

Groups	Before surgery	After surgery	t value	*P* value
Laparoscopy group	43.61±6.54	42.49±5.23	0.946	0.347
Laparotomy group	43.56±6.37	37.84±4.65	5.128	<0.001
t value	0.039	4.698		
P value	0.969	<0.001		

Note: PNI: Prognostic nutritional index.

obviously lower than those in the laparotomy group, and statistical differences were found between the two groups, as shown in **Table 5**.

Comparison of the PNI level between the two groups

There was no significant difference in the PNI level before surgery between the laparoscopy group and the laparotomy group. After surgery, the PNI level in the laparoscopy group was obviously higher than that in the laparotomy group, and the difference was statistically significant, as described in **Table 6**.

Discussion

Laparoscopic operations have been increasingly conducted for colon cancer in the world. Studies have shown that laparoscopic surgery can be considered the gold-standard approach for colon tumors due to favorable short-term oncologic outcomes [10-12]. For transverse colon cancer, the knowledge regarding gold-standard operation is lacking, and little is known about laparoscopic operation for transverse colon cancer. The main limitation is the absence of research on analyzing and comparing laparoscopy with open approach for trans-

verse colon cancer. In this study, the obtained data were compared between laparoscopy group and laparotomy group. Our results showed that statistical differences were observed in operation time, intraoperative bleeding, hospital stay, duration of gastrointestinal function recovery, time of first postoperative flatus, VAS score, and QoL score between the two groups, and these results are consistent with those in previous studies [13, 14]. The results of this study also revealed that the overall incidence of postoperative complications was obvious lower in the laparoscopy group than in the laparotomy group. Previous studies also reported lower postoperative morbidity in the laparoscopy group than that in the laparotomy group [15, 16]. Moreover, the number of obtained lymph nodes was associated with survival, so it is recommended that clinical surgeons should obtain at least 12 lymph nodes for adequate sampling [7, 17, 18]. In this study, the number of lymph nodes harvested was almost equal and more than 13 in both groups, which could illustrate the comparable oncological clearance effects of the laparoscopy and laparotomy.

The adverse outcome of surgical treatment is the potential harm to the patients' body, resulting in a stress response characterized by an increase of inflammatory mediators and immunosuppression [19, 20]. The inflammatory response has a significant influence on the application of radiotherapy and chemotherapy in patients with colon cancer after surgery. TNF-α is a cytokine mainly produced by monocytes and macrophages. It serves as a sensitive indicator for an early stress response. After trauma and infection, TNF-α rapidly increases and then gradually decreases. IL-6 is a lymphokine induced by activated T cells and fibroblasts. It participates in stress, defense and immune responses. CRP is an acute inflammatory mediator and an infective marker. When the body is injured, hepatocytes synthesize a large amount of CRP to enhance the repair ability of tissues. It has been reported that serum CRP can reflect the degree of inflammation response in the body [21, 22]. Previous findings have shown that IL-6, CRP, and TNF-α are closely associated with inflammation, and cancer treatment can aggravate the production of proinflammatory cytokines [23, 24]. The results of this study showed that patients who underwent laparoscopy exhibited lower levels of IL-6, IL-8 and TNF-α in contrast with those received laparotomy, indicating that there was less stress response in patients receiving laparoscopy. This is because that under the laparoscope the operator had a clearer field of vision, which reduced the damage to the organs, peripheral nerves, and blood vessels during the operation, and helped to maintain the steady state of the intra-abdominal environment and reduce the stress response induced by surgery.

It was found that patients with transverse colon cancer had a poor nutritional status, and patients were prone to various complications after surgery [25]. PNI, as a common indicator evaluating the nutritional status and surgical complications in patients, could assess the nutritional and immune status of patients. A study employed PNI to assess the nutritional status of colon cancer patients and reported that patients with lower PNI scores had a higher incidence of complications [26]. The PNI level has been used as an early prognostic indicator. In this study, the postoperative PNI of the laparoscopy group was higher than that of the laparotomy group, and the incidence of complications in the laparoscopy group was lower than that of the laparotomy group, suggesting that laparoscopic colorectal cancer resection of transverse colon cancer had less impact on the nutritional status of patients, and potentially reduced the related complications. PNI, as a convenient and practical indicator, does not require a large amount of financial and human resources [27]. It can be calculated only based on the number of lymphocytes in the blood and the level of serum albumin. It is easy to obtain and can be used as an indicator supplement to evaluate the prognosis of patients. At the same time, for patients with lower PNI scores, necessary nutritional supplementation could be implemented before surgery to reduce postoperative complications and improve prognosis.

There were some limitations in the current study. This research focused on the change of inflammatory factor levels to reveal the potential mechanisms of laparoscopic colorectal cancer resection, but different mechanisms might be involved. In addition, this study was performed in a single center, with small sample size included, and without subgroups comparisons and long-term follow-up results. Therefore,

a multicenter controlled long-term follow-up study with larger sample size is needed in the future for further confirmation.

To sum up, compared with previous studies, laparoscopic colorectal cancer resection in this study demonstrated clear clinical short-term efficacy, less trauma, high safety, little impact on patients' inflammatory response, and rapid postoperative recovery. However, further exploration and research are required to confirm these conclusions. It is anticipated that with the continuous improvement of technology, laparoscopic colectomy will have a broader application prospect in the future.

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Disclosure of conflict of interest

None.

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