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Laparoscopic versus Open Radical Colectomy for Right Colon Cancer Larger than Eight Centimeters: a Retrospective Cohort Study

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Research Article

Keywords: Right hemi-colon cancer, larger than 8 centimeters, laparoscopic surgery, short-term outcome, long-term outcome

Posted Date: November 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11285844/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Laparoscopic surgery has been widely performed in patients with colorectal cancer due to the advantages of minimal trauma, and several randomized controlled studies have revealed that short-term outcomes are improved and long-term survival is not affected. However, patients with right hemicolon tumors larger than 8 centimeters were excluded from these studies, and the feasibility of laparoscopic surgery for these patients is unclear. This study aimed to investigate the feasibility and safety of laparoscopic surgery for patients with right hemicolon tumors larger than 8 centimeters.

Methods

A retrospective study was performed and patients with right hemicolon tumor larger than 8 centimeters were enrolled in this study from January 2015 to January 2021. The clinical and pathological data of patients were collected and analyzed.

Results

A total of 274 cases were included in the analysis. Eighty-three patient received open surgery while 191 patients received laparoscopic surgery. Compared with the open group, the laparoscopic group showed less blood loss ($p < 0.001$), shorter incision length ($p < 0.001$), less pain ($p < 0.001$), earlier gastrointestinal function recovery ($p < 0.001$), fewer postoperative complications ($p = 0.015$), more lymph nodes harvested ($p = 0.013$) and shorter hospital stays ($p < 0.001$). The 5-year DFS was 80.7% (95% CI 75.1%–86.8%) in the laparoscopic surgery group and 75.7% (95% CI 67.0%–85.6%) in the open surgery group ($p = 0.309$).

Conclusions

Compared with open surgery, laparoscopic surgery is safe and feasible with short-term benefit and equivalent long-term survival for patients with right hemicolon cancer larger than 8 centimeters.

Introduction

Colorectal cancer is a common malignancy of the gastrointestinal tract and ranks third in morbidity and mortality worldwide.[1–3] Surgery is the main treatment and the only radical treatment. In recent decades, laparoscopic surgery has been widely performed as a standard treatment for colorectal cancer due to the advantages of minimal trauma. Several RCTs (randomized controlled trials) have demonstrated various advantages of laparoscopic surgery in enhanced recovery after surgery, including reducing pain, improving lung function, reducing postoperative intestinal obstruction and reducing

incision infection.[4–11] Furthermore, the long-term outcome for patients with colorectal cancer who received laparoscopic surgery is comparable to that of patients who received open surgery.[12–15] However, these studies did not include patients with large tumors. In most studies, the median diameter of tumors is approximately 4 centimeters, [12–14] and a recent RCT excluded patients with tumors larger than 8 centimeters.[10, 15] However, with the popularization of laparoscopy and the improvement of laparoscopy technology, it remains unclear whether laparoscopy is suitable for patients with tumors larger than 8 centimeters. Therefore, we performed this study to investigate whether laparoscopic surgery is feasible for right hemicolon tumors larger than 8 centimeters. According to intention to treat, we explored whether patients with right hemicolon tumors larger than 8 centimeters who underwent laparoscopic surgery obtained a better recovery after surgery and an equivalent long-term survival than those performed open surgery. To our knowledge, this is the first study to explore whether laparoscopic surgery is suitable for patients with right hemicolon tumors larger than 8 centimeters.

Materials and Methods

Patients

A total of 274 patients with tumors larger than 8 centimeters in the right hemicolon who underwent CME (complete mesocolic excision) with central vascular ligation were enrolled in this study at Nanfang Hospital from January 2015 to January 2021. The inclusion criteria of patients were as follows: (1) patients aged from 18–80 years old; (2) tumors located in the ileocecum, ascending colon or transverse colon near the hepatic flexure; (3) maximum diameter of the tumor larger than 8 centimeters and patients received right hemicolectomy. Patients who met the following criteria were excluded: (1) Patients suffering from other cancers at the same time or during follow-up. (2) Patients had previously undergone abdominal surgery. (3) The final pathological report showed that the tumor removed was not cancer. (4) The patient was admitted for emergency surgery due to obstruction, perforation, or massive bleeding. (5) Preoperative or intraoperative examination revealed distant metastasis in patients.

The detailed clinical data of patients were collected including sex, age, BMI (body mass index), ASA (American society of anesthesiologists), location of the tumor, and CEA (carcinoembryonic antigen). The perioperative and recovery data of patients were recorded including operation time, incision length, blood loss during surgery, pain score on the second day after surgery, time interval from surgery to first flatus, drinking water and liquid food, number of lymph nodes harvested, postoperative hospital stay, complications and hospital mortality within 30 days. The pathological data of patients were collected including tumor size, differentiation, histological type of the tumor, TNM (tumor-node-metastasis) stage according to the AJCC (American Joint Committee on Cancer) 7th edition and MSI (microsatellite instability). All laparoscopic procedures require laparoscopic completion of CME with central cardiovascular ligation regardless of incision length due to the large tumor. This study was approved by the Medical Ethics committee of NanFang Hospital of Southern Medical University. Ethics review approval number is NFEC-2023-553.

Procedure and Outcome

In this study, all senior attending colorectal surgeons have rich experience of more than 1000 laparoscopic and open surgery for colon cancer. CME with central vascular ligation was performed as a standardized procedure in all patients.[16] The brief process of the surgery is as follows: (1) Medial dissociation of the right hemicolon: dissociate the mesentery at the lower edge of the ileocecal vascular pedicle, dissect and ligate the ileocecal artery and vein, and clean the lymph nodes; expand the right posterior colon space (Toldt's space) toward the head side along the superior mesentery vein; dissect and ligate the right colon vein along the confluence of the right superior branch of the gastrocolic vein trunk, and clean the lymph nodes; dissect the middle colon artery toward the head side. Standard right hemicolectomy requires ligating the right branch of the middle colon artery, while expanded right hemicolectomy requires ligating the root of the middle colon artery. In addition, expanded right hemicolectomy for colon cancer near the hepatic flexure requires ligation of the right gastroepiploic artery and dissection of the subpyloric lymph nodes. (2) Surrounding dissociation of the right hemicolon: at the ileocecum, the mesocolon attached to the right iliac fossa is dissociated to interpenetrate the right posterior colon space and dissociate the adhesion between the mesocolon and peritoneum. (3) Dissociation of the hepatic flexure of colon: standard right hemicolectomy involves cutting the gastrocolic ligament from the nonvascular area outside the midpoint of the vascular arch of the greater curvature of the stomach, while expanded right hemicolectomy involves cutting the gastrocolic ligament close to the nonvascular area inside the gastric-omentum vascular arch of the greater curvature of the stomach. The adhesion between the transverse colon mesocolon and the posterior wall of the stomach was separated, and the posterior space of the transverse colon was dissociated so that it could be connected with the posterior space of the right colon. (4) Tumor removal and intestinal resection anastomosis: Remove the tumor through the midline incision of the upper abdomen, and then perform intestinal resection and anastomosis according to the surgeon's preference.

The primary observed outcomes of this study were short-term outcomes including intraoperative blood loss, time interval from surgery to first flatus, postoperative hospital stay and postoperative complications. The secondary observed outcome of this study was long-term survival. Analysis of long-term survival was assessed by DFS (disease-free survival) and OS (overall survival). DFS was defined as the time interval from surgery to recurrence and OS was defined as the time interval from surgery to death. Patients were followed up after surgery every three months.

Statistical analysis

All statistical analyses were completed using R software (version 3.6.3). For quantitative data, Levene's test was used for homogeneity of variance and the Shapiro-Wilk test was used to determine whether the normal distribution was met. The quantitative data that met the requirements of variance chi-square and normal distribution were statistically described by means and SD (standard deviations), while those that did not were statistically described by the median and IQR (interquartile range). The categorical data were depicted by rate or proportion. Student t test was used for comparisons between groups of

quantitative data conforming to a normal distribution. The Wilcoxon rank sum test was applied to compare between groups for quantitative data that did not conform to a normal distribution. The Kaplan–Meier method was used to estimate DFS and OS. The log rank test was performed to compare the DFS and OS between groups. All tests were two-sided, and $p < 0.05$ was considered to be significantly different.

Results

From January 2015 to January 2021, 1085 patients underwent right hemicolectomy in Nanfang Hospital. Among these patients, 317 patients with right hemicolon tumors larger than 8 centimeters were found according to pathological reports. According to the intention to treat, patients were then divided into a laparoscopic surgery group and an open surgery group. Due to unforeseen metastatic disease encountered or synchronous lesions, 43 patients were excluded from this study. Finally, 274 cases were included in the analysis and the inclusion of patients is shown in Fig. 1. Of the 274 patients finally enrolled, 191 patients received laparoscopic surgery while 83 patients received open surgery.

The baseline data of patients in the laparoscopic surgery group and open surgery groups were comparable and are presented in Table 1. There were 111 males (58.1%) of 191 in the laparoscopic surgery group and 45 males (54.2%) of 83 in the open surgery group. The median age of the laparoscopic surgery group was 60.0 (IQR, 50.0–69.0) years and the age of the open surgery group was 57.0 (IQR, 47.5–67.5) years. The mean BMI of the laparoscopic surgery group was 21.58 (SD, ± 2.72) kg/cm^2 and the mean BMI of the open surgery group was 20.98 (SD, ± 2.83) kg/cm^2. The proportions of tumors located in the hepatic flexure, ascending colon and ileocecum were 55.5%, 18.8% and 25.7% in the laparoscopic surgery group and 57.9%, 14.5% and 27.7% in the open surgery group, respectively. The ASA scores were no significant difference between laparoscopic group and open group ($p = 0.476$). We also collected data on tumor biomarkers CEA. There were no differences in CEA ($p = 0.879$) between the groups. There were no significant differences in baseline data between the groups.

The perioperative and recovery data of patients in the laparoscopic surgery group and open surgery group are summarized in Table 1. In the laparoscopic surgery group, ten patients in the laparoscopic surgery group were converted to open surgery due to large tumors invaded surrounding tissues. The intraoperative blood loss of patients in the laparoscopic surgery group (median 30 ml, IQR 20–50) was significantly less ($p < 0.001$), compared with the intraoperative blood loss of patients in the open surgery group (median 100 ml, IQR 50–150). Patients who underwent laparoscopic surgery had a longer surgery duration than those who underwent open surgery [median 180 minutes (IQR 148–210) vs median 145 minutes (IQR 116–172), $p < 0.001$]. As expected, the incision length of patients in laparoscopic surgery group was less than those in open surgery group [median 6.0 cm (IQR 6.0–8.0) vs median 15.0 cm (IQR 12.0–18.0), $p < 0.001$]. The median pain score indicated significant differences between the groups [median 2.0 scores (IQR 2.0–3.0) vs median 3.0 scores (IQR 3.0–4.0), $p < 0.001$]. Patients who received laparoscopic surgery had a shorter interval from surgery to the first flatus [median 3.0 days (IQR 2.0–3.0) vs 3.0 days (IQR 3.0–4.0), $p < 0.001$, Fig. 2a], to the first drinking water [median 1.0 days (IQR 1.0–

2.0) vs 2.0 days (IQR 2.0–3.0), $p < 0.001$, Fig. 2b], to the first liquid food [median 3.0 days (IQR 2.0–3.0) vs 3.0 days (IQR 2.0–4.0), $p < 0.001$, Fig. 2c] and a shorter postoperative hospital stay [median 7.0 days (IQR 6.0–8.0) vs median 8.0 days (IQR 7.0–11.0), $p < 0.001$, Fig. 2d]. Complications that occurred in the laparoscopic surgery group appeared to be lower than those in the open surgery group [5.8% (11/191) vs 15.7% (13/83), $p = 0.015$]. The comparison of complications between the laparoscopic group and the open group is shown in Table 2. There were no cases died within 30 days after surgery in this study.

The pathological data of patients in the laparoscopic surgery group and open surgery group are shown in Table 3. The pathological data of patients in the laparoscopic surgery group and open surgery group are shown in Table 4. There was no significant difference in T stage between the two groups (p = 0.331). Analogous results were found in the N stage (p = 0.427). The majority of patients had more than 12 lymph nodes harvested in their specimens, except for two patients who had 11 lymph nodes harvested. There was significant difference in the number of lymph nodes harvested between the two groups [median 40.0 (IQR 28.5–51.0) vs median 33.0 (IQR 22.0–49.0, p = 0.013)].

All patients were followed up. The median follow-up time was 63 months. Recurrence occurred in 55 (20.1%) of 274 patients; 35 (18.3%) of 191 patients in the laparoscopic group and 20 (24.1%) of 83 patients in the open group. Kaplan—Meier curves of DFS and OS are shown in Fig. 3. The 5-year DFS was 80.7% (95% CI 75.1%–86.8%) in the laparoscopic surgery group and 75.7% (67.0%–85.6%) in the open surgery group (Fig. 3a). The 5-year OS was 83.8% (95% CI 78.4%–89.6%) in the laparoscopic surgery group and 78.7% (70.2%–88.3%) in the open surgery group (Fig. 3b). There was no difference in DFS and OS between the groups according to the Kaplan—Meier curves and the log rank test. In this study, the HRs (hazard ratios) for DFS and OS for laparoscopic surgery versus open surgery were 0.75 (95% CI 0.43–1.30, $p = 0.309$; Fig. 3a) and 0.76 (95% CI 0.42–1.39, $p = 0.377$; Fig. 3b), respectively.

Discussion

Previous RCTs revealed the advantages of laparoscopic surgery in colorectal cancer, but did not involve large tumors larger than 8 centimeters.[4–11] Our study provides the experience of treating patients with right hemicolon cancer larger than 8 centimeters. We retrospectively collected the data of patients with right hemicolon cancer larger than 8 centimeters and found that laparoscopic surgery was safe and feasible with short-term benefit and equivalent long-term survival, compared with open surgery.

Our research indicates that patients with right hemicolon tumors larger than 8 centimeters can achieve better short-term outcomes from laparoscopic surgery, including less blood loss during operation, shorter incision length, less pain, earlier gastrointestinal function recovery, more lymph nodes harvested, fewer complications and shorter hospital stays. In addition, the long-term survival of patients with right hemicolon cancer larger than 8 centimeters between laparoscopic surgery and open surgery were equivalent. These results suggest that laparoscopic surgery is safe and feasible for the patients with tumors larger than 8 centimeters in right hemicolon.

Ten patients (5.2%, 10/191) in the laparoscopic group underwent conversion to open surgery. The rate of conversion to open surgery is lower than that in several RCTs conducted in Western countries. Similar result was observed in an RCT conducted in Japan, and Seiichiro et al considered that low BMI and the body shape of Japanese patients were more suitable for laparoscopic surgery than that of Western patients.[10] Some reports also suggested that a higher conversion rate was associated with obesity.[17–21] The mean BMI was 24 to 26 in previous RCTs reported in Western countries, while 22 in the RCT reported in Japan. In our study, the mean BMI was 21.39 (SD, ± 2.76) kg/m^2, which means these patients were more suitable for laparoscopic surgery.

The overall complication rate in our study was lower (8.8%, 24/274) than that in previous studies[22–24]. With the development of the laparoscopic technique of CME with central vascular ligation in the past decade, the complication rate of laparoscopic surgery has decreased. There was significant difference in postoperative complications between the open surgery group and the laparoscopic surgery group [5.8% (11/191) vs 15.7% (13/83), $p = 0.015$]. The result suggested that laparoscopic surgery in patients with tumors larger than 8 centimeters in the right hemicolon obtained a lower risk of complications. In the laparoscopic surgery group, complications are concentrated in lymphatic leak, incomplete intestinal obstruction and intra-abdominal infection, while incision infection, intra-abdominal infection and anastomotic leakage were more likely to occur in the open group. Laparoscopic surgery uses an ultrasonic knife to dissect tissues without ligation, while open surgery relies more on suturing and ligation. This is considered to be a possible reason for increased lymphatic leakage in laparoscopic surgery. However, in the open surgery group, the long incision of surgery increases the possibility of incision infection.

The results of this study indicated that the short-term results of patients who underwent laparoscopic surgery were superior to those of patients who underwent open surgery. The blood loss of patients in laparoscopic surgery group was significantly decrease, compared with that in the open surgery group. This result may be attributed to the better and clearer vision provided by laparoscope and more precise operation provided by the laparoscopic instruments.

Another finding of this study was that patients in the laparoscopic surgery group obtained a better recovery of gastrointestinal function than those in the open surgery group. This result was consistent with previous studies. In the laparoscopic surgery group, a shorter incision length helps reduce postoperative pain. Therefore, patients can get out of bed earlier, promoting the recovery of gastrointestinal function.

The status of lymph node metastasis is critical for patients with colorectal cancer. The prerequisite for determining the status of lymph nodes is to obtain enough lymph nodes harvested. There were more lymph nodes harvested in the laparoscopic surgery group [40.0 (IQR 28.5–51.0)] than in the open surgery group [33.0 (IQR 22.0–49.0)], which might result in potential benefits for patients due to a more accurate status of lymph node metastasis.

Concerning the postoperative hospital stay, several RCTs reported that the median postoperative hospital stay was 5 to 10 days.[4–6, 9] In our study, the median was 7.0 days (IQR 6.0–8.0) in the laparoscopic surgery group and 8.0 days (IQR 7.0–11.0) in the open surgery group (p = 0.013). There was significant difference between the groups and a shorter hospital stay was observed in the laparoscopic surgery group. The hospital stays of patients who underwent laparoscopic surgery were decreased.

More importantly, this study also provided long-term observations of patients with hemicolon tumors larger than 8 centimeters underwent right hemicolectomy. The 5-year DFS was 80.7% (95% CI 75.1%–86.8%) in the laparoscopic surgery group and 75.7% (95% CI 67.0%–85.6%) in the open surgery group (Fig. 3a). The 5-year OS was 83.8% (95% CI 78.4%–89.6%) in the laparoscopic surgery group and 78.7% (95% CI 70.2%–88.3%) in the open surgery group (Fig. 3b). There were no significant differences in DFS and OS between the laparoscopic group and the open group. In this study, the HRs for DFS and OS for laparoscopic surgery versus open surgery were 0.75 (95% CI 0.43–1.30, p = 0.309; Fig. 3a) and 0.76 (95% CI 0.42–1.39, p = 0.377; Fig. 3b), respectively. The long-term survival of patients who underwent laparoscopic surgery and open surgery were equivalent. A possible explanation for this is improvement of surgical techniques of CME with central vascular ligation.

In short, laparoscopic surgery for right hemicolon cancer larger than 8 centimeters is feasible and safe.

The limitation of this study is that it is a retrospective study and we cannot ignore the unavoidable selection bias. Currently, no other studies to have investigated the feasibility and safety of laparoscopic surgery for patients with right hemicolon tumors larger than 8 centimeters. This study lays the foundation for further RCT studies.

Laparoscopic surgery is safe and feasible with short-term benefit and equivalent long-term survival for patients with right hemicolon cancer larger than 8 centimeters, compared with open surgery.

Declarations

Disclosures

The authors, Jixiang Zheng, Mingyuan Feng, Xinyi Zhou, Ting Wang, Shijie Wang, Hongli Ji, Jie Tan, Baoxiong Zhuang and Jun Yan, have no conflict of interest or financial ties to disclose.

Funding/support:

This work was supported by grants 82273360, 82103041, and 62375104 from the National Natural Science Foundation of China; grant 2020B121201004 from the Guangdong Provincial Key Laboratory of Precision Medicine for Gastrointestinal Cancer; grant 2019JC05Y361 from the Guangdong Provincial Major Talents Project; grants 2020CR001 and 2020CR011 from the Clinical Research Project of Nanfang Hospital; grant 2022B021 from the President Foundation of Nanfang Hospital, Southern Medical University; and grants 202212121011, S202212121104, and S202212121092 from the National Training Program for Undergraduate Innovation and Entrepreneurship.

Author Contributions:

Jixiang Zheng, Mingyuan Feng, Ting Wang, Shijie Wang, Baoxiong Zhuang and Jun Yan conceived and design the study.

Jixiang Zheng, Mingyuan Feng, Xinyi Zhou, Hongli Ji and Jie Tan, collected and analyzed the data.

Jixiang Zheng, Mingyuan Feng, Xinyi Zhou, Baoxiong Zhuang and Jun Yan wrote the manuscript.

Baoxiong Zhuang and Jun Yan verified the data and review the manuscript.

All authors read and approved the final manuscript.

Data availability statement

The data that support the findings of this study are available from the corresponding author (yanjunfudan@163.com) upon reasonable request.

Ethical statement

Nanfang Hospital, Guangzhou, Guangdong, People's Republic of China approved this study. Patient informed consent was waived by the institutional review board because of the retrospective design of the study, and patient information was protected.

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Tables

Table 1

The baseline data of patients in the laparoscopic group and surgery group.

Sex, n (%)	**Laparoscopic group (n = 191)**	**Open group (n = 83)**	**p**
			0.641
Male	111 (58.1)	45 (54.2)	
Female	80 (41.9)	38 (45.8)	
Age, years			0.414
Median, IQR	60.0 (50.0–69.0)	57.0 (47.5–67.5)	
BMI, kg/m^2			0.100
Mean, SD	21.58 (± 2.72)	20.98 (± 2.83)	
ASA, n (%)			0.476
I	28 (14.7)	15 (18.1)	
II	99 (51.8)	48 (57.8)	
III	55 (18.8)	17 (20.5)	
IV	9 (4.7)	3 (3.6)	
Location, n (%)			0.414
Hepatic flexure	106 (55.5)	48 (57.9)	
Ascending colon	36 (18.8)	12 (14.5)	
Ileocecum	49 (25.7)	23 (27.7)	
CEA, n (%)			0.879
Elevated	61 (31.9)	28 (33.7)	
Normal	130 (68.1)	55 (66.3)	
Operation time, min			< 0.001
Median, (IQR)	180 (148–210)	145 (116–172)	
Incision length, cm			< 0.001
Median, (IQR)	6.0 (6.0–8.0)	15.0 (12.0–18.0)	
Blood loss, ml			< 0.001
Median, (IQR)	30 (20–50)	100 (50–150)	

Sex, n (%)	Laparoscopic group (n = 191)	Open group (n = 83)	p
			0.641
Pain score			< 0.001
Median, (IQR)	2.0 (2.0–3.0)	3.0 (3.0–4.0)	
Flatus, days			< 0.001
Median, (IQR)	3.0 (2.0–3.0)	3.0 (3.0–4.0)	
Drinking water, days			< 0.001
Median, (IQR)	1.0 (1.0–2.0)	2.0 (2.0–3.0)	
Liquid food, days			< 0.001
Median, (IQR)	3.00 (2.00–3.00)	3.00 (2.00–4.00)	
Hospital stays, days			< 0.001
Median, (IQR)	7.0 (6.0–8.0)	8.0 (7.0–11.0)	
Complications, n (%)			0.015
No	180 (94.2)	70 (84.3)	
Yes	11 (5.8)	13 (15.7)	

Table 2
Detail information of complication.

Complications	Laparoscopic group (n = 191)	Open group (n = 83)
Number of patients	11	13
Lymphatic leak	3	2
Incision infection	1	3
Intestinal obstruction	3	2
Gastroparesis syndromes	1	1
Pulmonary infection	1	1
Intra-abdominal infection	3	3
Anastomotic leakage	1	2
Postoperative bleeding	0	1

Table 3

The pathological data of patients in the laparoscopic group and open group.

Size, n (%)	**Laparoscopic group (n = 191)**	**Open group (n = 83)**	**p**
			0.153
> 10 cm	51 (26.7)	30 (36.1)	
≤ 10 cm	140 (73.3)	53 (63.9)	
T stage, n (%)			0.331
T3	99 (51.8)	37 (44.6)	
T4	92 (48.2)	46 (55.4)	
N stage, n (%)			0.427
N0	113 (59.2)	56 (67.5)	
N1	54 (28.3)	19 (22.9)	
N2	24 (12.6)	8 (9.6)	
LN harvested			0.013
Median, (IQR)	40.0 (28.5–51.0)	33.0 (22.0–49.0)	
Differentiation, n (%)			0.320
Poor	58 (30.4)	31 (37.3)	
Well	133 (69.6)	52 (62.7)	
Histology, n (%)			0.198
Adenocarcinoma	121 (63.4)	45 (54.2)	
Mucous	70 (36.6)	38 (45.8)	
MSI, n (%)			0.197
MSI-low	132 (69.1)	50 (60.2)	
MSI-high	59 (30.9)	33 (39.8)	

Table 4
The pathological data of patients in the laparoscopic group and open group.

Size, n (%)	**Laparoscopic group (n = 191)**	**Open group (n = 83)**	**p**
			0.153
> 10 cm	51 (26.7)	30 (36.1)	
≤ 10 cm	140 (73.3)	53 (63.9)	
T stage, n (%)			0.331
T3	99 (51.8)	37 (44.6)	
T4	92 (48.2)	46 (55.4)	
N stage, n (%)			0.427
N0	113 (59.2)	56 (67.5)	
N1	54 (28.3)	19 (22.9)	
N2	24 (12.6)	8 (9.6)	
LN harvested			0.013
Median, (IQR)	40.0 (28.5–51.0)	33.0 (22.0–49.0)	
Differentiation, n (%)			0.320
Poor	58 (30.4)	31 (37.3)	
Well	133 (69.6)	52 (62.7)	
Histology, n (%)			0.198
Adenocarcinoma	121 (63.4)	45 (54.2)	
Mucous	70 (36.6)	38 (45.8)	
MSI, n (%)			0.197
MSI-low	132 (69.1)	50 (60.2)	
MSI-high	59 (30.9)	33 (39.8)	

Figures

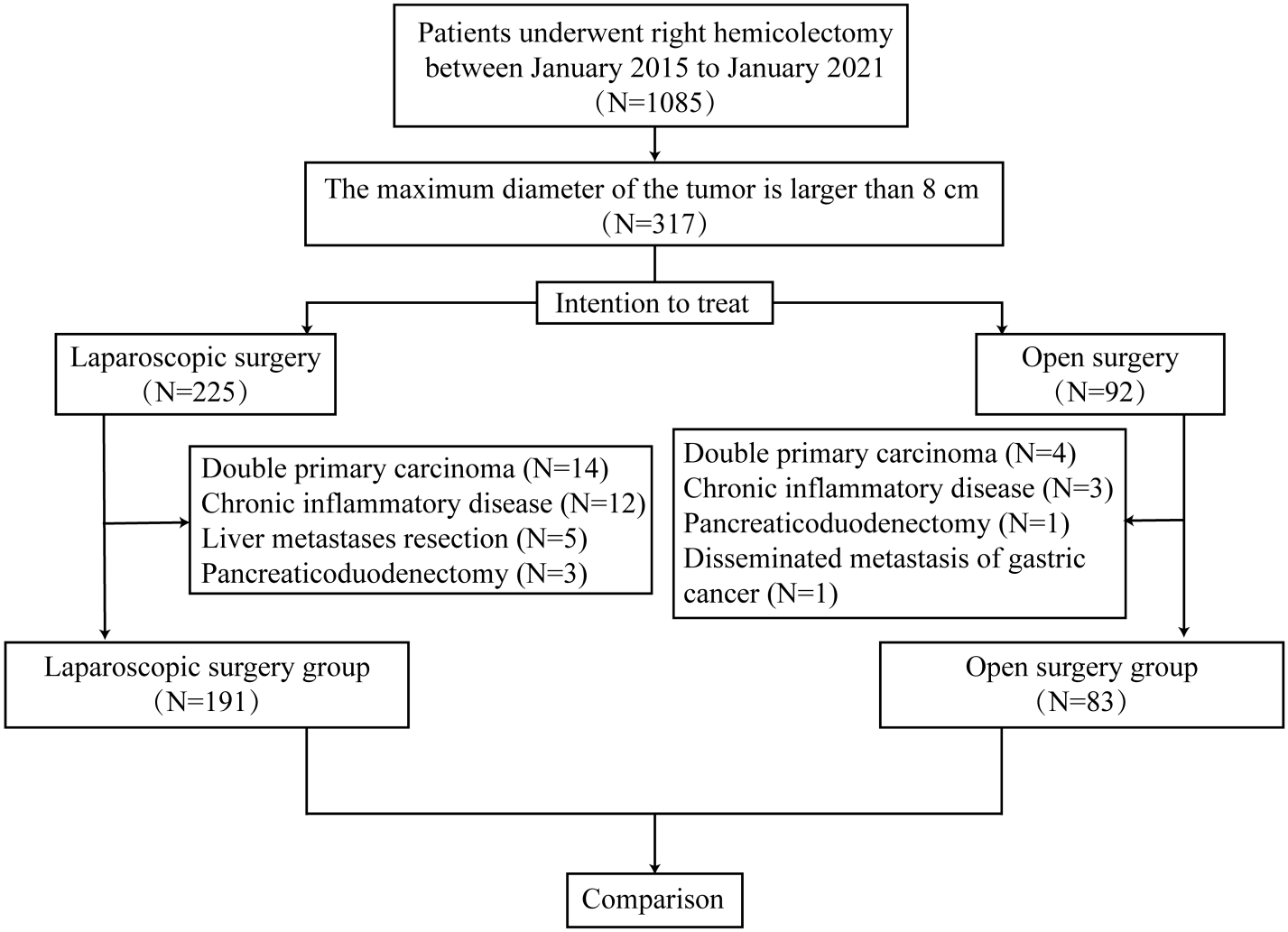


Figure 1

The flowchart of patients suitable for comparison between laparoscopic surgery and open surgery.

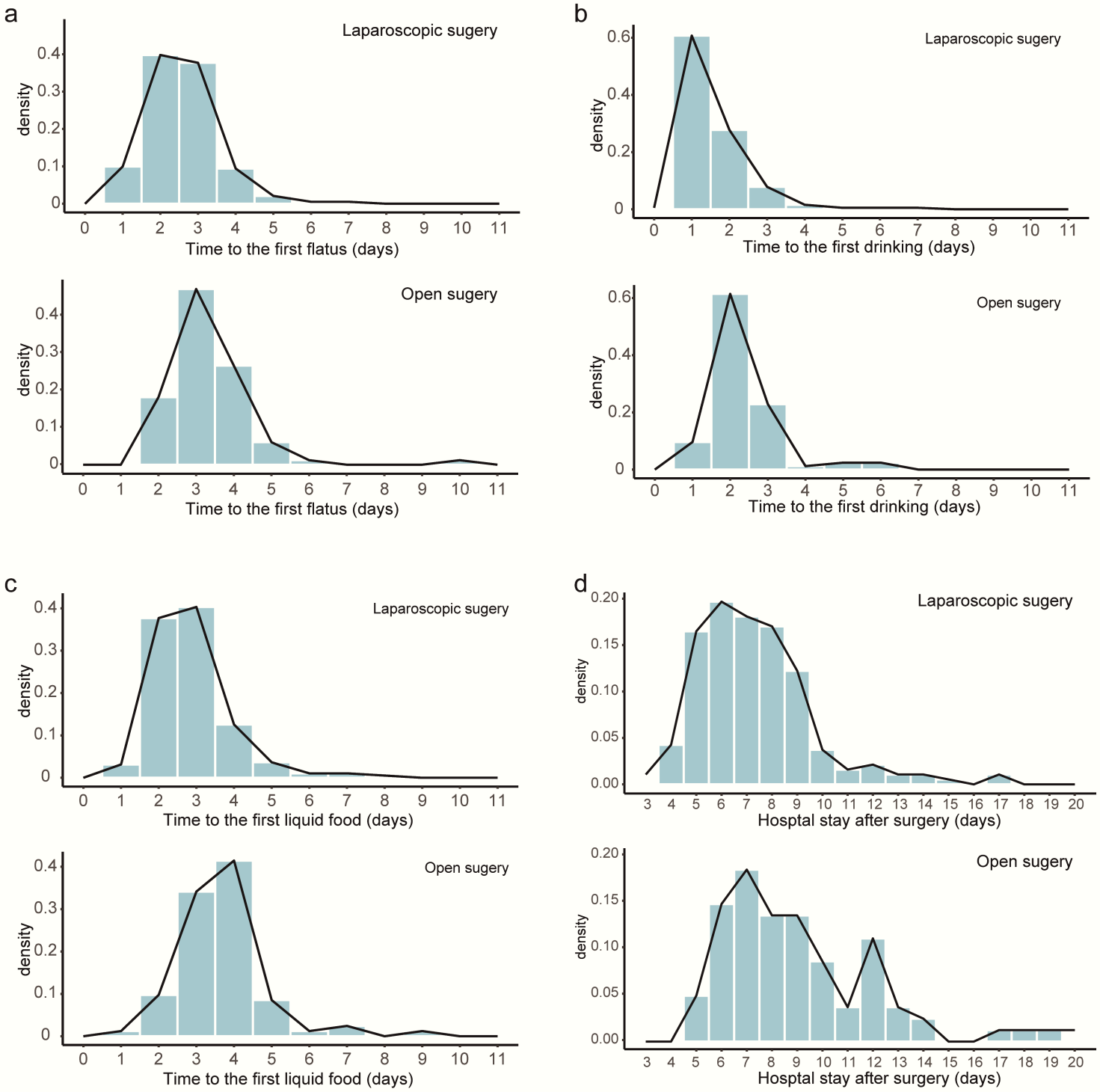


Figure 2

Histograms of postoperative recovery. (a) Patients' distribution in time to the first flatus; (b) Patients' distribution in time to the first (days); (c) Patients' distribution in time to the first liquid food; (d) Patients' distribution in hospital stay after surgery.

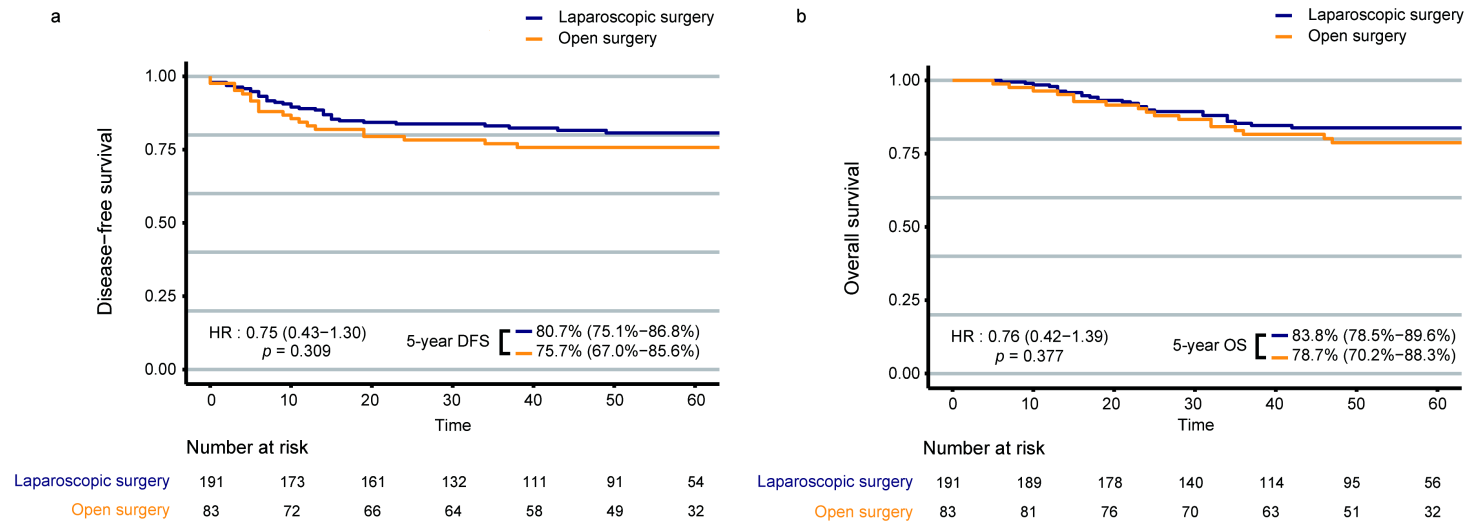


Figure 3

Comparison of disease-free survival (a) and overall survival (b) between the laparoscopic surgery group and open surgery group.