Comparison of the Short-Term Outcomes of Laparoscopic and Open Resections for Colorectal Cancer in Patients with a History of Prior Median Laparotomy

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Received: 29 March 2016 / Accepted: 28 June 2016 / Published online: 4 July 2016
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Abstract This study aimed to investigate the short-term outcomes of laparoscopic resection in comparison with those of open resection for colorectal cancer in patients with a history of prior median laparotomy (PML). Eighty-seven consecutive patients (87/1121, 7.8 %) with a history of PML who underwent major colorectal cancer resection were enrolled (laparoscopy, $n = 40$; open, $n = 47$). The conversion rate to open surgery was 25 % ($n = 10$). The laparoscopy group had a higher proportion of female patients (57.5 vs. 36.2 %), a lower rate of American Society of Anesthesiologists (ASA) score for physical status of ≥ 3 (7.5 vs. 25.5 %), and a lower pT4 tumor rate (15 vs. 38.3 %) than the open resection group. Regarding the reasons for PML, radical hysterectomy with extended lymphadenectomy for gynecologic cancer was more common (32.5 vs. 4.3 %), but gastrointestinal surgeries, such as gastrectomy and colectomy, were less frequent in the laparoscopy group. Regarding intraoperative outcomes, the laparoscopy group showed a similar operative time (197 vs. 204 min), intraoperative enterotomy rate (2.5 vs. 2.1 %), and bowel resection rate (2.5 vs. 2.1 %) with the open resection group. Regarding postoperative outcomes, the laparoscopy group showed a lower complication rate (20 vs. 40.4 %), significantly reduced time to soft diet (5 vs. 7 days), and shorter hospital stay (12 vs. 18 days). Despite the high rate of open conversion, favorable short-term outcomes were observed in the laparoscopic group. Laparoscopy may be chosen as the primary approach in selected patients with a

history of non-gastrointestinal PML (prior abdominal surgery for gynecological cancer).

Keywords Colorectal neoplasms · Laparoscopy · Laparotomy · Tissue adhesions · Postoperative complications · Conversion to open surgery

Introduction

At the beginning of the laparoscopic era, previous abdominal surgery was considered a relative contraindication for laparoscopy [1]. Previous studies have investigated the effects of a previous abdominal surgery on laparoscopy outcomes for benign and malignant colorectal diseases [1–9]. A history of prior abdominal surgery was found to increase the operative time [1], rate of conversion to open surgery [4, 5], intraoperative enterotomy rate [5, 8], postoperative complication rate [5, 10], and time to resumption of normal diet [8]. However, no study to date has yet compared the outcomes of laparoscopic resection surgery with those of open resection surgery for colorectal cancer in patients who had undergone previous abdominal surgery.

We believe that a comparison between laparoscopic and open surgeries in patients who had undergone prior median laparotomy (PML) can provide valuable insight for wider application of laparoscopy. We hypothesized that laparoscopy confers short-term benefits even in patients with a history of PML and that reasons for PML differ when selecting subsequent surgical approaches for colorectal cancer. Most previous studies that investigated outcomes in patients who had undergone previous abdominal surgery included all types of minor and major abdominal surgeries [1–3, 5, 6, 8]. To date, only one case-matched study has been conducted that focused on patients with a history of PML [9].

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We included only patients with a history of PML in the present study because gastrointestinal and gynecologic surgeries that involve only one abdominal quadrant are unlikely to lead to widespread adhesion and thus are less likely to influence future surgical procedures and their outcomes. This study aimed to investigate short-term outcomes of laparoscopic or open resection for colorectal cancer in patients with a history of PML. Reasons for PML were also compared between laparoscopic and open resection for patients with colorectal cancer.

Methods

Patients

This was a retrospective cohort study conducted at a tertiary referral center. Informed consent was obtained from all the patients before surgery. This study was approved by our institutional review board (YWMR-15-5-042). The Strengthening the Reporting of Observational Studies in Epidemiology guidelines were used to ensure the accurate reporting of the results of this observational study [11]. The eligibility criteria included having a histologically confirmed colorectal cancer and undergoing a major colorectal resection between January 1, 2008, and October 31, 2013. Patients who underwent non-resectional or bypass surgery, transanal local excision, emergency surgery, and multivisceral resection were excluded from the study population. Among 1121 patients, 179 (20.0 %) had a history of abdominal surgery but only 87 (7.8 %) had a history of PML. We compared the outcomes of laparoscopic resection surgery ($n = 40$) with those of open resection surgery ($n = 47$) in patients with a history of PML.

Definition of Midline Laparotomy

Prior median laparotomy (PML) was defined as that when patients had undergone an abdominal surgery through a median incision. Subcostal, paramedian, and McBurney's incisions were excluded. Patients who had undergone low midline incisions for minor gynecological surgeries such as cesarean section, salpingo-oophorectomy, and simple hysterectomy were also excluded, as were laparoscopic surgeries such as cholecystectomy and appendectomy.

Study End Points

The primary end point was the evaluation of short-term outcomes (intraoperative, postoperative, and pathological) of laparoscopic or open resection for colorectal cancer in patients with a history of PML. The secondary end point was the comparison of the reasons for having undergone PML between the patients who underwent laparoscopic

resection and those who underwent open resection for colorectal cancer.

Surgery, Adjuvant Therapy, and Follow-up

All surgeries were performed by two experienced colorectal surgeons [12–14]. Before surgery, the type of surgical approach (laparoscopy or open procedure) was discussed with the patients and their families. The final decision with regard to the type of surgical approach was made by the operating surgeon. After standardized preoperative preparation [15], tumor-specific complete mesocolic excision with central vascular ligation was performed for patients with colon cancer. Tumor-specific mesorectal excision, including high ligation of the inferior mesenteric artery, was performed for patients with rectal cancer. The operative principles underlying the laparoscopic approach were fundamentally the same as those underlying tumor-specific complete mesocolic excision or tumor-specific mesorectal excision through laparotomy. After recovery from surgery, patients with stage II, III, and IV disease were recommended to receive chemotherapy according to the National Comprehensive Cancer Network guidelines [16–18]. All the patients were registered in a computerized colorectal database. Patient follow-up was continued until death or December 31, 2014. The median follow-up period was 47.2 months (interquartile range, 22–67.1 months).

Outcome Measures

All laparoscopic data were analyzed according to the intention-to-treat principle. Postoperative complications were defined as events that required additional treatment within 30 days of surgery. All events were documented prospectively and graded based on the Clavien-Dindo classification system [19]. Conversion to open surgery was defined as discontinuation of the laparoscopic approach and using a conventional laparotomy incision to complete the planned surgical procedure.

Statistical Analyses

All statistical analyses were performed by using the MedCalc Statistical Software version 15.2.2 (MedCalc Software bvba, Ostend, Belgium) and IBM SPSS Statistics version 22.0 for Windows (IBM, Armonk, NY, USA). Student's t test was used to compare continuous variables, and either the chi-square test or Fisher's exact test was used to compare categorical variables. A p value of $<.05$ was considered statistically significant.

Results

Patients' Characteristics

The rate of conversion to open surgery was 25 % ($n = 10$). The patients' baseline characteristics are presented in Table 1. The laparoscopy group had a higher proportion of female patients (57.5 vs. 36.2 %), a lower rate of American Society of Anesthesiologists (ASA) score for physical status of ≥ 3 (7.5 vs. 25.5 %), and a lower pT4 tumor rate (15 vs. 38.3 %) than the open resection group.

Reasons for Prior Median Laparotomy

The details of the reasons for PML are listed in Table 2. Radical hysterectomy with extended lymphadenectomy for gynecological cancer was more frequent (32.5 vs. 4.3 %), but gastrointestinal surgeries such as gastrectomy, colectomy, proctectomy, small-bowel resection, bile duct surgery, and pancreatic surgery were less frequent in the laparoscopy group than in the open resection group ($p = .046$).

Intraoperative and postoperative outcomes

Regarding intraoperative outcomes, the laparoscopy group showed a similar operative time (197 vs. 204 min), intraoperative enterotomy rate (2.5 vs. 2.1 %), and bowel resection rate (2.5 vs. 2.1 %) with the open resection group.

Regarding postoperative outcomes, the laparoscopy group showed a lower complication rate (20 vs. 40.4 %, $p = .040$), significantly reduced time to soft diet (5 vs. 7 days, $p = .033$),

and shorter hospital stay when compared with the open resection group (12 vs. 18 days, $p = .011$). Although not statistically significant, the rate of Clavien-Dindo grade of ≥ 3 was lower in the laparoscopy group (19.1 vs. 7.5 %; Table 3).

Pathologic Outcomes

TNM stage 0, I, and II tumors were more common but TNM stage III and IV tumors were uncommon in the laparoscopy group ($p = .012$). The laparoscopy group had fewer harvested lymph nodes (20 vs. 26, $p = .033$) and smaller tumor size (3.7 vs. 5.1 cm, $p = .002$) than the open resection group (Table 4).

Discussion

The major findings of this study are as follows: (1) Although a high conversion rate (25 %) was observed, the postoperative complication rate was lower in the laparoscopy group. In addition, a number of short-term advantages such as reduced time to soft diet and shorter hospital stay were observed in the laparoscopic group. (2) The reasons for having undergone PML differed between the laparoscopy and open surgery groups. Patients who had undergone prior non-gastrointestinal surgery (gynecological surgery) were more frequently managed with a laparoscopic approach, whereas patients who had undergone prior gastrointestinal surgery were more frequently managed with an open surgical approach.

This study is unique in that it included only malignant conditions and compared the outcomes of laparoscopic

Table 1 Patient characteristics

	Laparoscopy ($n = 40$) n (%) or mean (SD)	Open ($n = 47$) n (%) or mean (SD)	p
Age (years)	67 (11.2)	68 (13.1)	.686
Sex (female)	23 (57.5)	17 (36.2)	.047
Body mass index (kg/m^2)	23 (4.0)	23 (3.4)	.482
ASA score (≥ 3)	3 (7.5)	12 (25.5)	.026
pT4 (+)	6 (15.0)	18 (38.3)	.015
Preoperative CRT (+)	3 (7.5)	5 (10.6)	.614
Name of operation			
APR, Hartmann	1 (2.5)	5 (10.6)	.476
Low anterior resection	14 (35.0)	11 (23.4)	
Proctocolectomy	1 (2.5)	1 (2.1)	
Sigmoid, left colectomy	12 (30.0)	12 (25.5)	
Total, subtotal colectomy	1 (2.5)	5 (10.6)	
Right colectomy	10 (25.0)	11 (23.4)	
Other	1 (2.5)	2 (4.3)	

SD standard deviation, ASA American Society of Anesthesiologists, CRT chemoradiation, APR abdominoperineal resection

Table 2 Reasons for prior median laparotomy

	Laparoscopy (<i>n</i> = 40) <i>n</i> (%)	Open (<i>n</i> = 47) <i>n</i> (%)	<i>p</i>
Gastrectomy	9 (22.5)	16 (34.0)	.046
Left colectomy, proctectomy	5 (12.5)	9 (19.1)	
Right colectomy	5 (12.5)	7 (14.9)	
Small-bowel resection	4 (10.0)	5 (10.6)	
Radical hysterectomy with extended lymphadenectomy for gynecologic cancer ^a	13 (32.5)	2 (4.3)	
Bladder resection, nephrectomy	2 (5.0)	1 (2.1)	
Bile duct, pancreas surgery	1 (2.5)	4 (8.5)	
Other	1 (2.5)	3 (6.4)	

^a Simple hysterectomy, cesarean section, and salpingo-oophorectomy are excluded (*n* = 17)

resection with those of open resection in patients with a history of PML (Table 5). In the present study, 15.8 % of all the patients had undergone a previous abdominal surgery and 7.7 % had undergone PML. We included only patients with a history of PML because abdominal surgeries that involve only one quadrant are unlikely to result in multiple adhesions and, thus, are less likely to influence future surgical procedures.

Short-Term Outcomes

In this study, short-term outcomes were evaluated in terms of intraoperative, postoperative, and pathological outcomes. Coleman et al. [20] demonstrated that adhesions from prior abdominal surgery increased the median operative time by 18 min in subsequent laparotomy. We did not observe any significant difference in operative time between the laparoscopic and open

Table 3 Intraoperative and postoperative outcomes

	Laparoscopy (<i>n</i> = 40) <i>n</i> (%) or mean (SD)	Open (<i>n</i> = 47) <i>n</i> (%) or mean (SD)	<i>p</i>
Intraoperative outcome			
Operative time (min)	197 (63.9)	204 (73.1)	.681
Blood loss (≥100 mL)	7 (17.9)	7 (22.6)	.630
Conversion to open surgery	10 (25.0)	—	—
Adhesion-related conversion	5 (12.5 %)	—	—
Enterotomy	1 (2.5)	1 (2.1)	.908
Bowel resection	1 (2.5)	1 (2.1)	.908
Postoperative outcome			
30-day complication (+)	8 (20.0)	19 (40.4)	.040
30-day mortality (+)	0 (.0)	0 (.0)	—
Clavien-Dindo score ≥3	3 (7.5)	9 (19.1)	.116
Type of complication(s) ^a			
Pulmonary	1	1	
Wound	5	7	
Leakage	1	3	
Hemorrhage	0	0	
Abscess	1	2	
Obstruction	1	2	
Urinary	0	1	
Other	1	4	
Mean time to soft diet (days)	5 (3.4)	7 (3.4)	.033
Mean hospital stay (days)	12 (9.7)	18 (11.6)	.011

SD standard deviation

^a Three patients had more than one type of complication

Table 4 Pathological outcomes

	Laparoscopy (<i>n</i> = 40) <i>n</i> (%) or mean (SD)	Open (<i>n</i> = 47) <i>n</i> (%) or mean (SD)	<i>p</i>
TNM classification			
0, I	15 (37.5)	7 (14.9)	.012
II	14 (35.0)	12 (25.5)	
III	9 (22.5)	18 (38.3)	
IV	2 (5.0)	10 (21.3)	
pT category			
0	4 (10.0)	1 (2.1)	.065
1	7 (17.5)	4 (8.5)	
2	5 (12.5)	3 (6.4)	
3	18 (45.0)	21 (44.7)	
4	6 (15.0)	18 (38.3)	
Circumferential margin (+)	2 (12.5)	2 (11.1)	.900
Histological grade (G3, other)	8 (20.0)	8 (17.0)	.721
Lymph node harvest (number)	20 (10.7)	26 (14.4)	.033
Distal margin (cm)	8.6 (8.3)	12.6 (16.1)	.168
Tumor size (cm)	3.7 (1.7)	5.1 (2.2)	.002

resection groups. The reason can be explained partly by the fact that all surgeries were performed by two experienced laparoscopic surgeons and well-trained operating room staff.

Similarly, the intraoperative enterotomy and bowel resection rates were not significantly different between the two surgical approaches. The rate of enterotomy in abdominal surgery has

Table 5 Review of literature

Author	Design	Number of subjects		OP time (min)	CONV (%)	INTRA Cx (%)	Enterotomy (%)	POST Cx (%)	Time to diet (days)	Hospital stay (days)
		PAS (+)	PAS (−)							
Vignali et al. [1]	Laparoscopy	91	91	218 vs. 192 ^a	17 vs. 9	NR	NR	25 vs. 23	5 vs. 4 ^b	10 vs. 9
Hamel et al. [2]	Laparoscopy	36	49	151 vs. 148	14 vs. 17	8 vs. 8	NR	47 vs. 37	4 vs. 4 ^b	7 vs. 8
Law et al. [3]	Laparoscopy	84	211	180 vs. 170	18 vs. 11	NR	NR	17 vs. 21	3 vs. 3	7 vs. 7
Arteaga Gonzalez et al. [4]	Laparoscopy	27	59	223 vs. 199	26 vs. 5 ^a	11 vs. 7	NR	39 vs. 39	2 vs. 2 ^c	6 vs. 8
Franko et al. [5]	Laparoscopy	347	473	NR	20 vs. 11 ^a	4 vs. 2	1.4 vs. 0.2 ^a	Ileus (7 vs. 3 ^a) Reop (2 vs. 0.2 ^a)	NR	NR
Offodile et al. [6]	Laparoscopy	191	223	185 vs. 177	17 vs. 15	NR	NR	Wound infection (22 vs. 12 ^a)	NR	7 vs. 6
Barleben et al. [7]	Laparoscopy	55	—	207	15	NR	NR	NR	NR	NR
Yamamoto et al. [8]	Laparoscopy	580	1121	243 vs. 244	12 vs. 10	NR	0.9 vs. 0.1 ^a	25 vs. 23	7 vs. 6 ^a	19 vs. 19
Aytac et al. [9]	Laparoscopy	50	50	211 vs. 192	16 vs. 8	4 vs. 6	2 vs. 0	54 vs. 20 ^a	4 vs. 3 ^b	9 vs. 6
Present study ^c	Laparoscopy vs. open	87	—	197 vs. 204	25	5 vs. 4	3 vs. 2	28 vs. 32	6 vs. 7	12 vs. 18 ^a

PAS prior abdominal surgery, OP time operative time, CONV conversion to open surgery, INTRA Cx intraoperative complication, POST Cx postoperative complication, NR not reported, Reop reoperation

^a Statistically significant

^b First bowel movement

^c Outcomes of laparoscopy (*n* = 40) in comparison with those of open surgery (*n* = 47)

been reported to range from 0.9 to 1.4 % [5, 8]. The higher rates of enterotomy (2.5 %) and bowel resection (2.1 %) observed in both the laparoscopy and open surgery groups in the present study could be attributed to the fact that we included only patients who had undergone PML and excluded patients who had undergone other minor abdominal surgeries.

As expected, we observed a number of short-term advantages of laparoscopy in the present study. With respect to postoperative outcomes, the 30-day morbidity rate was lower in the laparoscopic group than in the open resection group. In addition, the time to soft diet and mean hospital stay length were significantly reduced in the laparoscopic group. Conversion to open surgery has been reported in 16.5 to 26.1 % of all patients who had undergone laparoscopy and had a history of undergoing surgery [1–5]. In the present study, 25 % ($n = 10$) of all the patients in the laparoscopy group shifted to open surgery. Adhesion-related factors were the main cause for the conversion ($n = 5$), followed by locally advanced tumor ($n = 3$), uncontrolled bleeding ($n = 1$), and unclear vascular anatomy ($n = 1$). Thus, the history of PML likely contributed to the increased conversion rate.

We included only patients with colorectal cancer and analyzed their pathological outcomes. Regarding TNM classification, early-stage disease (TNM stages 0, I, and II) was more commonly managed with laparoscopy. Pathological outcomes such as margin length of laparoscopy were comparable with those of open resection.

Reasons for Prior Median Laparotomy

In colorectal cancer resection, the surgical field usually involves multiple quadrants of the abdomen. Thus, it is difficult to predict preoperatively whether the laparoscopic approach is suitable for patients with a history of PML. Examination of the details of prior surgeries revealed that patients who had previously undergone gynecological surgery were more frequently managed with a laparoscopic approach, whereas patients who had previously undergone gastrointestinal surgery were more frequently managed with an open surgical approach. Accordingly, female patients were more prevalent in the laparoscopy group because of the higher incidence of gynecological surgery. The conversion rate was lower in the patients with a history of non-gastrointestinal PML ($n = 3$, 30 %) than in the patients with a history of gastrointestinal PML ($n = 7$, 70 %), although the difference was not statistically significant ($p = .456$). The relevance of the surgical field according to types of previous surgeries is worth mentioning. Surgical manipulation induces postoperative adhesions. We postulated that bowel manipulation was more frequent in gastrointestinal surgeries than in non-gastrointestinal surgeries. Thus, gastrointestinal surgeries can cause more adhesions between bowels, which are difficult to dissect safely. By contrast, non-gastrointestinal surgeries unlikely result in extensive adhesions between bowels. Thus, dissection of the

adhesion may be rather easy in patients with a history of non-gastrointestinal surgery. Based on our findings, laparoscopy may be used as the primary approach in selected patients with a history of non-gastrointestinal PML (prior abdominal surgery for gynecological cancer).

In addition, high-risk medical conditions such as those with high ASA scores and difficult surgical situations such as pT4 tumors were found more frequently in the open resection group. If technical difficulties are anticipated, surgeons have been discouraged from choosing a laparoscopic approach [21]. Previous studies that investigated laparoscopic colorectal surgery in patients who had undergone prior abdominal surgery showed mean ASA scores ranging from 2 to 2.2 [1, 4, 9]. The proportion of patients with a high ASA score (≥ 3) has ranged from 7 to 28 % of study populations [3, 5, 8] and was 7.5 % in this study. With regard to tumor characteristics, the T4 tumor rate was 11 % in a previous study [8] and 15 % in our study. Although high ASA scores and pT4 tumor rates were less frequent in the laparoscopy group, we believe that a laparoscopic approach should not be regarded a contraindication in these populations.

The limitations of this study were its retrospective design and relatively small number of patients from a single center. The small study sample might have reduced the statistical power of the study. Unfortunately, we could not sufficiently evaluate the outcomes of the surgical approaches according to T stages because of the small sample size. However, to our knowledge, this is the first study to investigate the indications for laparoscopy in patients with a history of PML by comparing the outcomes of laparoscopy and those of open resection for colorectal cancer.

In summary, laparoscopic resection in patients with PML resulted in a high rate of conversion to open surgery (25 %). However, a lower rate of postoperative complication, shorter time to soft diet, and shorter hospital stay were observed in the laparoscopic group. As postulated, the reasons for PML differed between the laparoscopy and open surgery groups. Patients who had undergone non-gastrointestinal PML (gynecological surgery) were more frequently managed with a laparoscopic approach, whereas patients who had undergone gastrointestinal PML were more frequently managed with an open surgical approach. Identification of predictive factors related to the degree and range of adhesion would be informative for future studies.

Authors' Contributions YWK conceived and designed the study. YWK and IYK acquired the data. YWK performed the statistical analyses and interpreted the data. YWK wrote the manuscript. All the authors read and approved the final manuscript.

Compliance with Ethical Standards Informed consent was obtained from all the patients before surgery. This study was approved by our institutional review board (YWMR-15-5-042).

Conflict of Interest The authors declare that they have no competing interests.

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