Safety and feasibility of single-port laparoscopic multivisceral resection for locally advanced left colon cancer

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Abstract. The aim of the present study was to evaluate the safety and feasibility of single-port laparoscopic multivisceral resection (S-MVR) for locally advanced left colon cancer. S-MVR is a challenging technique and to the best of our knowledge this is the first report of S-MVR for left colon cancer invading or adhering to neighboring organs. A retrospective review was conducted of patients who underwent laparoscopic multivisceral resection for locally advanced left colon cancer invading or adhering to neighboring organs from January 2008 to December 2014. Short-term and long-term outcomes were analyzed between groups of patients who underwent S-MVR and multi-port laparoscopic multivisceral resection (M-MVR) retrospectively. A total of 14 patients underwent S-MVR and 15 patients underwent M-MVR. There were no significant differences between groups in terms of operative factors and postoperative complications. The length of hospital stay was significantly shorter in the S-MVR group compared with the M-MVR group (P=0.048). Three-year overall survival was 61.9% in the S-MVR group (n=14). In patients with stage II (P=0.600) and III (P=0714) disease the three-year overall and disease-free survival was 81.8 and 58.3% in the S-MVR group and 80.0 and 70% in the M-MVR groups over a median follow-up of 34 months. In conclusion, S-MVR for locally advanced left colon cancer is safe and feasible in selected patients.

Introduction

The results of several prospective randomized trials have shown the benefits of laparoscopic surgery for localized colorectal cancer in terms of postoperative outcomes, including reduction of pain, earlier intestinal peristaltic recovery, shortening of postoperative stay, cosmetic advantages, and equivalent effectiveness on long-term cancer outcomes (1-4). However, locally advanced colon cancers sometimes invade or adhere to neighboring organs or structures, and en bloc multivisceral resection is necessary. According to the European Association of Endoscopic Surgery (EAES) consensus, potentially curative resection of colon cancer suspected of invading the abdominal wall or adjacent structures should be undertaken by open surgery (5). In the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guidelines, as open approach is suggested if a laparoscopic en bloc resection cannot be performed adequately for locally advanced adherent colon tumors (6). Because of increased the experience with laparoscopic approach for locally advanced colon cancer, the opportunities for adopting laparoscopic surgery for advanced colon cancer invading or adhering to neighboring organs or structures are considered to be increasing. Several studies have demonstrated that laparoscopic multivisceral resection for advanced colorectal cancer was safe and feasible in selected patients (7-9).

The first single-port surgery (SPS) procedure was described for right colectomy in 2008 (10). Compared with conventional multi-port surgery, the benefits of SPS include better cosmetic outcomes, less postoperative pain (11-13), faster postoperative recovery (14), and earlier discharge from the hospital (13,14). SPS for colorectal cancer was shown to be safe, feasible (11,12,15), and able to provide perioperative and short-term oncological outcomes equal to those of multi-port surgery (16,17). However, cases of locally advanced colon cancer invading or adhering to neighboring organs were excluded in these studies (11-17), and there is no study of SPS for locally advanced left colon cancer invading or adhering to neighboring organs. Therefore, in this study, we aimed to evaluate the safety and feasibility of single-port laparoscopic multivisceral resection (S-MVR) for locally advanced left colon cancer invading or adhering to neighboring organs, based on a retrospective comparison with multi-port laparoscopic multivisceral resection (M-MVR).

Patients and methods

Patient profiles. Multivisceral resection was defined as en bloc resection of any organ or structure to which the primary tumor was adherent. The preoperative diagnosis of cancer was established with a barium enema, a colonoscopy, and

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computed tomography for evaluation of local disease and distant metastases. Locally advanced colon cancer was diagnosed with preoperative computed tomography when the tumor and surrounding structures were unclear. In cases with unclear boundaries, we judged whether the tumor invaded adjacent organs or structures during the intraoperative period. Patients who had a diagnosis of Stage IV disease who underwent macroscopic complete resection of the primary tumor were included in this study, but those who underwent palliative resection of the primary tumor were excluded.

In our department, the first SPS for benign disease was carried out in May 2009. Before January 2010, SPS was performed only for benign disease and early colon cancer only, but the indication was expanded later to include advanced colorectal cancer. SPS for locally advanced colon cancer invading or adhering to neighboring organs has been performed since January 2011, and since then, it has been considered the primary treatment for colon cancer in those eligible for conventional multi-port surgery.

Between January 2008 and December 2014, a total of 38 patients underwent multivisceral resection for locally advanced left colon cancer invading or adhering to neighboring organs at our department. Among these patients, 9 patients underwent open surgery because of an emergency operation (n=3), a tumor associated abscess (n=2). In addition, we performed open surgery when urinary diversion and total cystectomy were needed (n=4). In total, 29 consecutive patients who underwent S-MVR or M-MVR for locally advanced left colon cancer with adjacent organs or structures in this study. Patients received written information describing the differences between S-MVR and M-MVR. All of the patients agreed to receive S-MVR and provided written informed consent. The study was approved by the Ethics Committee of Osaka Police Hospital.

Data collection. For each patient, the following variables were collected from our prospectively maintained database; age, sex, body mass index (BMI), American Society of Anesthesiology Score (ASA score), previous abdominal surgery, tumor location, tumor size, operative procedure, stoma construction, operative time, blood loss, conversion rate, morbidity, mortality, length of hospital stay, and pathological findings. Postoperative complications were classified according to the Dindo *et al* Classification (18). Operative mortality was defined as death on the same admission or within 30 days of surgery. All patients were followed for at least 30 days after surgery.

Surgical procedure. SPS was performed, as described previously (19). A flexible laparoscope 10 mm in diameter and only standard straight laparoscopic instruments were used. Every procedure was performed with an Ultracision harmonic scalpel regardless of whether it was single or multi-port surgery. High ligation of feeding vessels and en bloc resection of the primary tumor with a safe margin around the adjacent organs or structures were performed. For left colectomy, an extracorporeal functional end-to-end anastomosis was then created. For sigmoidectomy and high anterior resection, the sigmoid colon or upper rectum was divided laparoscopically with staplers. An end-to-end anastomosis was created with the trans-anal insertion of a circular stapler.

Statistical analysis. Continuous data are expressed as median (range), unless specifically noted. Preoperative factors, operative factors, and pathological outcomes were analyzed retrospectively. Statistical analyses were performed with the use of JMP 11.0 software (SAS Institute Inc., Cary, NC, USA). All group data are reported as median values. Differences in age, BMI, tumor size, operative time, blood loss, length of hospital stay, and number of harvested lymph nodes were analyzed with Mann-Whitney's U test. Other factors were analyzed with Fischer's exact probability test. Disease-free survival and overall survival rate were determined using Kaplan-Meier analysis with a log-rank test. All analyses were performed on an intention-to-treat basis: patients who had S-MVR converted to M-MVR were included in the S-MVR group. Patients who had M-MVR converted to open surgery were included in the M-MVR group. P<0.05 was considered to indicate a statistically significant difference.

Results

Table I lists the profiles of the patients analyzed by group. There were no significant differences between the S-MVR and M-MVR groups in terms of age, gender, BMI, ASA score, previous abdominal surgery, tumor location and tumor size. None of the patients received neoadjuvant chemotherapy or chemoradiotherapy in this study.

Table II summarizes the operative factors. The conversion rate in the S-MVR group was 14.3% (2/14 patients). None of the patients who underwent S-MVR was converted to open surgery. The reason for conversion to multi-port surgery was strong inflammatory adhesion to the small intestine in one patients and bladder invasion in one patient. In the M-MVR group, 5 patients were converted to open surgery because of tumor invasion of the small intestine in three, invasion of the right ureter and the abdominal wall in one, and invasion of the uterus in one. There were no significant differences between groups in terms of operative procedure, stoma construction rate (14.3% in the S-MVR group vs. 26.7% in the M-MVR group, P=0.651), operative time (222 min in the S-MVR group vs. 255 min in the M-MVR group, P=0.163), blood loss (60 ml in the S-MVR group vs. 220 ml in the M-MVR group, P=0.295), and the median number of harvested lymph nodes (30 in the S-MVR group vs. 25 in the M-MVR group, P=0.328).

Table III lists the adjacent organs or structures resected en bloc. The most commonly affected organs were the small intestine (28.6% in the S-MVR group and 46.7% in the M-MVR group). The number of resected organs or structures was similar between the two groups (P=1.000).

Table IV summarizes the postoperative complications in each group. The overall complication rate was 28.6% in the S-MVR group. There were no significant differences between groups in terms of postoperative complication. Length of hospital stay was significantly shorter with S-MVR than with M-MVR (11 vs. 18 days, P=0.048). Reoperation was performed in one patient in the M-MVR group because of anastomotic leakage. Perioperative death was not recorded in both groups.

Table V summarizes the pathological findings for each group. The R0 resection rate of the primary tumor was similar between groups (100% in the S-MVR group and 93.3% in the M-MVR group). The rate of pathological

Table I. Patient profiles.

Characteristic	S-MVR (n=14)	M-MVR (n=15)	P-value
Median age, years (range)	71 (36-89)	69 (53-91)	0.878
Sex, n			
Male/female	6/8	10/5	0.272
Median BMI, kg/m^2 (range)	21.5 (14.1-32.9)	19.4 (12.5-30.5)	0.176
ASA score, n			0.814
1 or 2/ ≥3	12/2	12/3	
Previous abdominal surgery, n	4	3	0.682
Tumor location, n			0.330
Descending/sigmoid	3/11	1/14	
Median tumor size, mm (range)	60 (25-110)	70 (40-110)	0.333

ASA score, American Society of Anesthesiology Score; BMI, body mass index; S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.

Table II. Comparison of operative factors.

Factors	S-MVR (n=14)	M-MVR (n=15)	P-value
Operative procedure, n			0.591
Left hemicolectomy	3	1	
Sigmoidectomy	8	9	
High anterior resection	3	5	
Stoma construction, n	2	4	0.651
Median operative time, min (range)	222 (129-323)	255 (174-395)	0.163
Median blood loss, ml (range)	60 (5-600)	220 (5-2670)	0.295
Median number of harvested lymph nodes, (range)	30 (17-58)	25 (10-72)	0.328
Conversion to MPS, n	2	-	-
Conversion to open surgery, n	0	5	-

S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.

T4b disease was 35.7% in the S-MVR group and 33.3% in the M-MVR group (P=1.000). There were no significant differences between groups in terms of the grade of differentiation, pathological lymph node metastasis, and TNM classification.

Table VI lists the detail of cancer recurrence in both groups. 4 patients in the S-MVR group and 3 patients in the M-MVR group had distant metastases. 4 patients had a diagnosis of pathological T4b. 5 of 7 patients had received postoperative adjuvant chemotherapy. None of 7 patients had received a secondary intervention. There was no significant difference between groups in the 3-year overall survival rate (61.9% in the S-MVR group vs. 58.7% in the M-MVR group, P=0.777) over a median follow-up period of 30.7 (2.0-63.9) months (Fig. 1). In pathologic Stage II or III patients, the 3-year overall survival rate was 81.8% in the S-MVR group and 80.0% in the M-MVR group (P=0.600) (Fig. 2). The 3 year disease-free survival rate was 58.3% and in the S-MVR group and 70.0% in

the M-MVR group (P=0.714) over a median follow-up period of 34.0 (2.0-63.9) months (Fig. 3).

Discussion

Previously, we reported that SPS was safe, feasible and could provide perioperative and short-term oncological outcomes equal to those of multi-port surgery (15,16). S-MVR is a somewhat challenging technique, and we consider that maintaining the regional oncologic outcome is the most important factor for surgical treatment. In our series, the R0 resection rate of the primary tumor was 100% in the S-MVR group, and similar with the M-MVR group. No gross or microscopic positive resection margins were observed in the S-MVR group. The median number of harvested lymph nodes was 30 in the S-MVR group, and did not differ compared with the M-MVR group, which exceeded that of other reports (7-9). To the best of our knowledge, this is the first study to report the

Table III. Organs or structures resected at multivisceral resection.

Organ or structure	S-MVR (n=14)	M-MVR (n=15)	P-value
Small intestine	4	7	0.450
Abdominal wall	3	2	0.651
Urinary bladder	3	2	0.651
Ovary	3	1	0.330
Appendix	1	1	0.776
Seminal vesicle	1	0	0.483
Uterus	1	2	0.527
Ureter	0	1	0.517
Total	17	18	
Number of resected organs or structure			
1/ 2/	11/3	12/3	0.709

S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.

Table IV. Postoperative complications.

Complication	S-MVR (n=14)	M-MVR (n=15)	P-value
Bleeding	1	0	0.483
Anastomotic leakage	0	1	0517
Wound infection	2	3	0.814
Abdominal abscess	2	1	0.598
Pneumonia	0	1	0.517
Urinary tract infection	1	2	0.527
Bowel obstruction	0	2	0.483
Colitis	1	0	0.483
Reoperation	0	1	0.517
Perioperative death	0	0	-
Overall complications	4	7	0.450
Length of hospital stay, days (range)	11 (7-97)	18 (8-90)	0.048

S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.

clinical outcomes of S-MVR for locally advanced left colon cancer.

In this study, we showed that S-MVR and M-MVR do not differ significantly in terms of blood loss, operative time and number of harvested lymph nodes. The operative time in the present study was comparable with that of other reports (7-9). S-MVR was performed successfully in 78.6% of patients. Some studies of SPS have reported that the conversion rate to MPS or open surgery ranged from 1.4 to 10.9% (11,12,14). Previous reports have demonstrated the safety and feasibility of SPS in colorectal cancer, but their inclusion criteria yielded highly selected patients (with early cancer or small tumors) (11,12). The EAES consensus and SAGES guidelines do not necessary recommend laparoscopic en bloc resection for locally advanced adherent colon cancers (5,6). However, our results with S-MVR for advanced primary colon cancer had high reliability in terms of oncological clearance, blood loss, operative time and a successful completion rate regarding the regional oncologic aspect.

In this study, the rate of pathological tumor invasion of adjacent organs or structures (pT4b) was 35.7% in the SPS group, and did not differ compared with the MPS group (P=1.000). A previous review reported that pathological true infiltration is present in 54.1% of patients who underwent multivisceral resection for colorectal cancer, whereas peritumoral adhesion can be caused by an inflammatory reaction in the remaining patients (20). Because it is very difficult to judge whether the adhesion is due to true tumor invasion or an inflammatory reaction intraoperatively, it is important to resect the primary colon cancer en bloc with adjacent organ, preventing exposure and dissemination of cancer cells.

We showed that the overall postoperative complication rate in the SPS group was 28.6%, and did not differ compared with the MPS group (P=0.450). None of the patients in the

Table V. Pathological outcomes.

Outcome	S-MVR (n=14)	M-MVR (n=15)	P-value
Residual tumor status of the primary tumor			0.517
R0/R1	14/0	13/1	
Grade of differentiation, n			0.814
Well or moderate/poor or mucinous	12/2	11/3	
Depth of tumor invasion, n			0.992
T3	2	1	
T4a	7	9	
T4b	5	5	
Lymph node metastasis, n			0.449
N0	5	9	
N1	4	3	
N2	5	3	
TNM classification, n			0.461
II	4	6	
III	7	4	
IV	3	5	

S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.

Table VI. Cancer recurrence.

Sex	Age	Operation type	Tumor depth	Stage	Timing of recurrence	Recurrence pattern	Prognosis
M	43	S-MVR	T4b	III	6 m	Liver, peritoneum	3 y 6 m deceased
M	51	S-MVR	T4b	III	6 m	Liver, lung, peritoneum, para-aortic lymph node	7 m deceased
F	85	S-MVR	T4a	III	6 m	Lung	2 y 10 m alive
F	76	S-MVR	T4a	III	1 y 4 m	Lung,	3 y 2 m alive
F	83	M-MVR	T4b	III	7 m	Peritoneum, para-aortic lymph node	3 y 6 m deceased
M	81	M-MVR	T4a	III	7 m	Virchow lymph node	2 y 10 m deceased
M	63	M-MVR	T4b	III	3 m	Liver, lung, peritoneum	6 m deceased

S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection; M, male; F, female; y, years; m, months.

SPS group experienced perioperative death. Previous studies of laparoscopic multivisceral resection have reported that the morbidity ranged from 21 to 33% (7-9), and our series was comparable with those of the previous studies. The incidence of complications in the MPS group in the present study was higher compared with that of other reports (7-9). Even minor complications that might have little or no influence on postoperative hospital stay or mortality were counted. Nevertheless, we understand that the rate of complications is within an acceptable range. Regarding the length of hospital stay, recent studies in Western countries indicate a median or mean postoperative hospital stay of 5 to 10 days, whereas the median hospital stay was 11 days in the SPS group and 18 days in the MPS group in this study. The reason of longer hospital stay is that the Japanese health insurance system, which maintains low medical costs, has influenced this result.

Our perioperative outcomes of single-port multivisceral resection might be explained by two factors. First, we selected the patients carefully according to whether S-MVR was possible. In this study, none of patients underwent total cystectomy and urinary diversion. Laparoscopic total cystectomy and intracorporeal urinary diversion are technically challenging under robotic assistance, and many surgeons are still adopting the hybrid approach when performing the cystectomy using robotic assistance and completing the urinary diversions extracorporeally (21). We consider that open surgery should be chosen if total cyctectomy and urinary diversion are needed. Second, we have experience in carrying out a large number of single-port laparoscopic colorectal surgeries. Therefore, the frequency of single-port multivisceral resections is increasing gradually at our department. It is very important
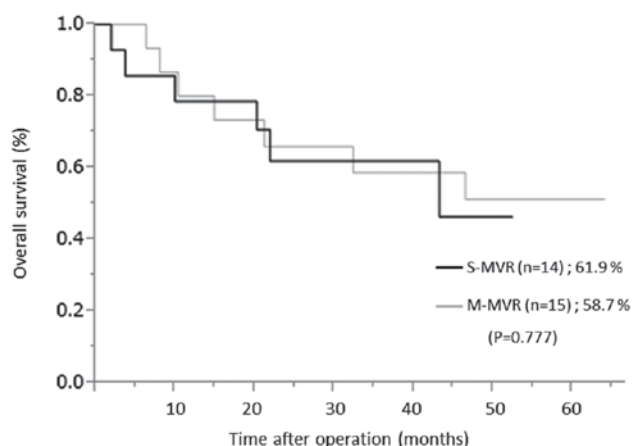
Figure 1. Kaplan-Meier analysis of overall survival at 3 years for all patients between the S-MVR and M-MVR group (P=0.777). S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.
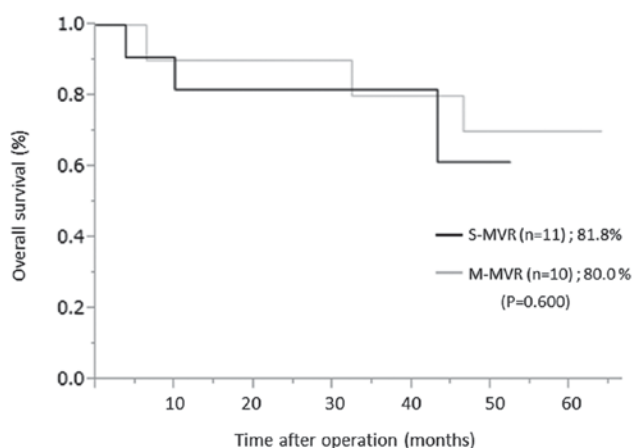

Figure 2. Kaplan-Meier analysis of overall survival at 3 years for pathological Stage II or III patients between the S-MVR and M-MVR group (P=0.600). S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.
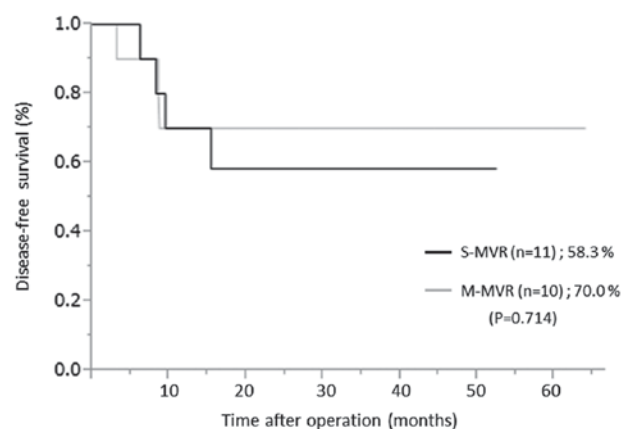

Figure 3. Kaplan-Meier analysis of disease-free survival at 3 years for pathological Stage II or III patients between the S-MVR and M-MVR group (P=0.714). S-MVR, single-port laparoscopic multivisceral resection; M-MVR, multi-port laparoscopic multivisceral resection.

to select optimal cases and perform single-port laparoscopic colorectal surgeries adequately for successful single-port multivisceral resection.

We showed that the pathological R0 resection rate was 100% in the SPS group. High vascular ligation and a non-touch technique were maintained in this series. None of patients in the SPS group had regional lymph nodes recurrence. However, 4 patients had distant metastases in the SPS group. Cukier *et al* reported that 3 year overall survival and disease-free survival rate was 85.9 and 73.7%, respectively (22). López-Cano *et al* reported that 5-year overall disease-free survival rate was 48% (23). Luna-Perez *et al* reported that 5-year overall survival rate was 45% over a median follow-up period of 36.8 months (24). Our oncological outcome was comparable with those of the previous studies regardless of operative approach.

The main limitations of this study are that it was carried out at a single institution and that it was very small and retrospective in nature. Therefore, it contains selection bias and an inability to match the backgrounds of patients between groups. In addition,

our total patient population may be typical for Japan and not be applicable to the average European or United States population. However, we believe that when patients are selected appropriately, the single-port multivisceral resection has no adverse effects on perioperative and short-term oncological outcomes. More studies are needed to validate our results and prove the true value of the single-port multivisceral resection.

To the best of our knowledge his is the first report of S-MVR for left colon cancer invading or adhering to neighboring organs. S-MVR in locally advanced left colon cancer is safe and feasible in appropriately selected patients.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Authors' contributions

MTe drafted the paper and analyzed and interpreted data. MO, YS, KK and MTa made substantial contributions to the acquisition of the data. HA made substantial contributions to the concept and design of the study.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Osaka Police Hospital.

Consent for publication

Not applicable.

Competing interests

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