Long-term outcome of reduced-port laparoscopic surgery (single port surgery + 1 port) as a technical option in the patients with rectal cancer

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Research Article

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Abstract

Background

The purpose of this study was to clarify the oncological safety of reduced-port laparoscopic surgery (RPS) for the patients with rectal cancer, by assessing the long-term outcome.

Methods

A total of 63 selected patients with clinical Stage I-III (T1-3 and N0-2) rectal cancer located within 15 cm from the anal verge were enrolled in this study. They had undergone laparoscopic anterior resection of the rectum by RPS, i.e., a platform with three channels on a single port plus one port surgery.

Results

The median operation time and intraoperative blood loss were 272 minutes and 10 mL, respectively. The median number of harvested lymph nodes was 22. Additional ports were required in 8 patients (13%), and conversion to open surgery was needed in one patient (2%). Intra- and postoperative complications occurred in one (2%) and 12 patients (19%), respectively. The median postoperative hospital stay was 8 days. The median follow-up period was 58 months, and cancer recurrence occurred in 4 patients (6%). The five-year relapse-free and overall survival rates were 100% and 100% in the patients with pathological Stage I disease, and 84% and 91% in the patients with pathological Stage II/III disease, respectively.

Conclusions

In the selected patients with rectal cancer, anterior resection by RPS may be secure in technical and oncological aspect as well as multi-port laparoscopic surgery and a reliable surgical option.

Background

Multiple-port laparoscopic surgery (MPS) for colorectal diseases is as widely accepted as standard laparoscopic surgery because of its lower invasiveness, good short-term and long-term outcomes, good cosmesis, and lower expenditure [1–9]. Recently, in order to decrease the surgical invasiveness and improve the cosmesis even further, several novel approaches have been developed; one of these is reduced-port laparoscopic surgery (RPS), which is a minimally invasive laparoscopic surgical technique designed to decrease abdominal wall trauma and port-site hernia, and to obtain better cosmesis by the reduced number and/or size of the inserting ports [10–12]. Single-port laparoscopic surgery (SPS) through an umbilical incision or Pfannenstiel incision might be the ultimate RPS technique, and this technique has been widely attempted and is quickly being adopted for several procedures, including appendectomy, cholecystectomy, colorectal resections, and nephrectomy [13–18].
Although we have also introduced SPS techniques for the aforementioned procedures [19], the handling of instruments from a single port could be difficult, especially in the case of rectal resections. Furthermore, since the rate of anastomotic leakage in rectal resections is considered to be definitely not low, drainage tube is ordinarily placed in the pelvic space. The inserting portion of drainage tube can be utilized as another port from the beginning in addition to a single-port platform for enabling instrument handling by triangulation. Therefore, we have introduced RPS (single port plus one port) for rectal resection, and previously reported the feasibility and safety of RPS for rectal cancer surgery [20]. The purpose of this study was to further clarify the oncological safety of RPS as a technical option by evaluating the long-term outcomes of the surgery in patients with rectal cancer.

Methods

Patients:

A total of 63 selected patients with rectal cancer located within 15 cm from the anal verge underwent laparoscopic anterior resections; the procedures were performed by RPS between November 2011 and December 2017. The criteria for patient selection were clinical Stage I-III (T1-3 and N0-2) rectal cancer diagnosed by colonoscopy, contrast-enhanced chest-pelvic computed tomography, and pelvic magnetic resonance imaging, and don’t exist other active cancers or infections.

The patient characteristics are shown in Table 1. Information on the clinicopathological characteristics of the patients, including the age, gender, body mass index (BMI), ECOG performance status score (PS), histories of chemotherapy and radiation therapy, and pathological stages was collected from the medical records. The short-term outcomes were assessed by the operation time, amount of blood loss, the rate of additional port use, conversion rate to MPS or open surgery, rate/nature of intra- and postoperative complications, and postoperative length of hospital stay. The long-term oncological outcomes were evaluated by the rates of relapse free and overall survival.
Table 1
Clinicopathological features of 63 patients with rectal cancer.

<table>
<thead>
<tr>
<th>Clinicopathological features</th>
<th>n = 63</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y/o) *</td>
<td>64 (IQR 56–77)</td>
</tr>
<tr>
<td>Gender</td>
<td>male : female</td>
</tr>
<tr>
<td></td>
<td>39 : 24</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²) *</td>
<td>22.4 (IQR 20.1–24.2)</td>
</tr>
<tr>
<td>ECOG Performance Status Score</td>
<td>0 : 1</td>
</tr>
<tr>
<td></td>
<td>51 : 12</td>
</tr>
<tr>
<td>Neoadjuvant chemoradiotherapy</td>
<td>8 (13%)</td>
</tr>
<tr>
<td>pT stage</td>
<td>T0 : T1 : T2 : T3</td>
</tr>
<tr>
<td></td>
<td>2 : 18 : 13 : 30</td>
</tr>
<tr>
<td>pStage</td>
<td>pCR : I : II : III</td>
</tr>
<tr>
<td></td>
<td>2 : 25 : 16 : 20</td>
</tr>
</tbody>
</table>
* median (interquartile)

Among them, 18 patients received a preoperatively planned diverting ileostomy, since they had risk factors for anastomotic leakage, such as a procedure of super low anterior resection, history of neoadjuvant chemoradiotherapy, underlying liver cirrhosis and/or diabetes mellitus, and history of long-term steroid use for coexisting diseases. All the patients were informed of the details of RPS and the potential need for additional ports or an open surgery if the procedure proved difficult and provided informed consent to this procedure.

**Surgical techniques:**

All 63 patients underwent total mesorectal excision or tumor-specific mesorectal excision without lateral pelvic lymphadenectomy, performed by the same well-trained laparoscopic surgeon with a technical certificate from the Japanese Society for Endoscopic Surgery, with the assistance of residents.

The surgical procedures were performed as described in a previous report [20]. In brief, in the patients without a scheduled ostomy, a vertical 3-cm incision was made in the region of the umbilicus and a platform with 3 channels was placed. Another 5- or 12-mm port was placed in the right middle or low abdominal wall (Fig. 1A).

In the patients planning a diverting ileostomy, the platform was placed at the ostomy site using a 3-cm circular incision on the lower right side of the umbilicus, and another 5- or 12-mm port was placed in the
opposite abdominal wall (Fig. 1B).

The operator mainly used one channel of the platform and another port, which enable triangulation of the instruments, and a 5-mm flexible laparoscope was inserted through the other channel of the platform (Fig. 2). The lymphadenectomy was performed by the same techniques as those in MPS [21, 22]. Root lymphadenectomy along the inferior mesenteric artery (IMA) was performed to obtain en bloc resection by a medial approach from the right side. Mesorectal excision was performed by using an energy device such as laparoscopic coagulating shears or vessel sealing device to decrease heat damage for the pelvic nerve plexus.

Articulated laparoscopic linear staplers were used for vertical transection of the rectum to insert from a channel of the platform or another port. The specimen was extracted through the platform site, and anastomosis was created using a circular stapler. Finally, a drainage tube was placed in the pelvic space via another port site, and the umbilicus at the platform site was remodeled, or a diverting ileostomy was created.

The study was conducted with the approval (No.17007) of the Institutional Review Board of Kitasato University Kitasato Institute Hospital, after notifying the patients of the option available to them to drop out of the study.

Results

Patient background characteristics (Table 1):

The median age was 64 (IQR [Interquartile Range] 56–77) years, and 39 (62%) patients were male. The median BMI was 22.4 (IQR 20.1–24.2) kg/m², and the ECOG PS was 0 in 51 patients (81%). Neoadjuvant chemoradiotherapy had been administered in 8 (13%) patients. The pathological T-stage (T0:T1:T2:T3) and final Stage (pCR:I:II:III) were (2:18:13:30 patients) and (2:25:16:20 patients), respectively.

Operative data and short-term outcomes (Table 2):
Table 2
Operative data and short-term outcomes

<table>
<thead>
<tr>
<th>Operative data and outcomes</th>
<th>n = 63</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creation of diverting stoma</td>
<td>18 (29%)</td>
</tr>
<tr>
<td>Operative time (min) *</td>
<td>272 (IQR 214–315)</td>
</tr>
<tr>
<td>Intraoperative bleeding (mL) *</td>
<td>10 (IQR 10–50)</td>
</tr>
<tr>
<td>Number of harvested lymph nodes *</td>
<td>22 (IQR 15–28)</td>
</tr>
<tr>
<td>Preservation of left colic artery</td>
<td>45 (71%)</td>
</tr>
<tr>
<td>Additional port required</td>
<td>8 (13%)</td>
</tr>
<tr>
<td>Dense adhesion</td>
<td>4</td>
</tr>
<tr>
<td>Tight working space</td>
<td>3</td>
</tr>
<tr>
<td>Visceral obese</td>
<td>1</td>
</tr>
<tr>
<td>Conversion to open surgery</td>
<td>1 (2%; invasion to bladder)</td>
</tr>
<tr>
<td>Intra-operative complications</td>
<td>1 (2%; tumor perforation)</td>
</tr>
<tr>
<td>Post-operative complications</td>
<td>11 (17%)</td>
</tr>
<tr>
<td>Urinary dysfunction</td>
<td>4</td>
</tr>
<tr>
<td>Small bowel obstruction</td>
<td>3</td>
</tr>
<tr>
<td>Leakage</td>
<td>3</td>
</tr>
<tr>
<td>Wound infection</td>
<td>1</td>
</tr>
<tr>
<td>Post-operative hospital stay (day) *</td>
<td>8 (IQR 7–12)</td>
</tr>
</tbody>
</table>

*, median (interquartile)

Diverting ileostomy was created in 18 (29%) patients, including all the 8 patients who had received neoadjuvant chemoradiotherapy. The median operative time and median intraoperative blood loss were 272 (IQR 214–315) minutes and 10 (IQR 10–50) mL, respectively. The median number of harvested lymph nodes was 22 (IQR 15–28). The left colic artery was preserved in 45 (71%) patients, including the patients who had undergone and not undergone root lymphadenectomy along the IMA (18 and 27 patients, respectively). Additional ports (1 to 2 ports) or needle forceps were needed in 8 (13%) patients, because of the presence of dense adhesions because of previous gynecologic or gastrointestinal surgery (4 patients), a tight working space owing to a narrow pelvis (3 patients), or excessive visceral adipose tissue in the pelvis (1 patient). One (2%) patient required conversion to open surgery because of suspected urinary bladder invasion. There were no reoperation within 30 days after surgery. Although
tumor perforation was encountered during the operation in one patient because of tumor fragility, the patient showed no evidence of cancer recurrence during the follow-up period.

The major postoperative morbidity (≥ Grade III: Clavien-Dindo Classification) of anastomotic leakage occurred in 3 (5%) patients. Minor morbidities included urinary disorder, small bowel obstruction, and wound infection in 4 (6%), 3 (5%), and 1 (2%) patient, respectively. The median postoperative hospital stay was 8 (IQR 7–12) days.

**Long-term oncological outcomes (Table 3):**

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>n = 63</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up periods (month)*</td>
<td>79 (IQR 67–97)</td>
</tr>
<tr>
<td>Post-operative adjuvant chemotherapy</td>
<td>31 (49%)</td>
</tr>
<tr>
<td>Fluorinated pyrimidine type</td>
<td>20</td>
</tr>
<tr>
<td>CapeOX (capecitabine + oxaliplatin)</td>
<td>11</td>
</tr>
<tr>
<td>Recurrences</td>
<td>4 (6%)</td>
</tr>
<tr>
<td>Peritoneum</td>
<td>2</td>
</tr>
<tr>
<td>Lymph node</td>
<td>1 (inguinal)</td>
</tr>
<tr>
<td>Distant</td>
<td>1 (lung)</td>
</tr>
<tr>
<td>Local</td>
<td>1</td>
</tr>
</tbody>
</table>

The median follow-up period was 79 (IQR 67–97) months. Thirty-one (86%) of the 36 patients with pathological Stage II-III disease received adjuvant chemotherapy with oral agents (fluorinated pyrimidine-based therapy) in 20 (56%) patients or capecitabine plus oxaliplatin in 11 (31%) patients. During the follow-up period, cancer relapse was observed in 4 (6%) patients (peritoneal metastasis in 2 patients, distant lymph node metastasis in one patient, lung metastasis in one patient, and local relapse in one patient). The 5-year relapse-free and overall survival rates were 100% and 100% in the patients with pathological Stage I disease, including pCR by neoadjuvant chemoradiotherapy. Those in the patients with pathological Stage II/III disease were 88% and 94%, respectively (Fig. 3).

**Discussion**

Although MPS has been established as the standard technique for many abdominal surgical procedures, including colorectal surgery, further improvements over MPS towards achieving lesser invasiveness and better cosmesis, including SPS, RPS, and NOTES (natural orifice transluminal endoscopic surgery), have
been developed. Among the procedures, SPS has been adopted for a wide spectrum of abdominal surgeries, and comparable results to MPS have been reported [13–16, 19]. Regarding colon cancer, SPS has been reported to provide better cosmetic outcomes, less postoperative pain, faster postoperative recovery compared with MPS [23]. Furthermore, SPS can provide oncological outcomes with satisfactory in colon cancer patients [23]. On the other hand, there are some reports of the use of SPS for rectal surgery [24], and recent systemic review has reported that SPS can also be performed safely and provide short-term oncological outcomes with satisfactory [25]. However, the usefulness of SPS including long-term oncological outcomes is still unclear. The above reason considers to arise from technical and anatomical difficulties in SPS for rectal cancer. Since we also encountered difficulties in SPS for rectal cancer, we introduced RPS (SPS plus 1 port) for rectal surgery to allow triangular handling of laparoscopic instruments and placement of a drainage tube using another port, which may affect the outcomes [24].

In this study, the operative data and short-term outcomes of RPS showed no inferiority to MPS for rectal cancer. According to data from recent meta-analyses, systemic reviews [26, 27], as well as our previous retrospective study [20] of MPS for rectal cancer, the operation time, intraoperative blood loss, and number of harvested lymph nodes are 210 to 309 min, 25 to 150 mL, and 12 to 28, while the corresponding results in this study were 272 min, 10 mL, and 22, respectively. Furthermore, the rates of postoperative complications, rate of conversion to open surgery, and postoperative length of hospital stay according to previous data are 5–57%, 1–32%, and 7 to 15 days, while they were 19%, 2%, and 8 days, respectively, in this study. However, an additional port was required in 13% of the patients with technical/anatomical difficulties during rectal resection.

The long-term oncological outcomes in this study were also not inferior to those of MPS. The 5-year relapse-free and overall survival rates of patients with pathological Stage II/III disease in this study were 84% and 91%, respectively. These rates compare favorably with those reported from many other studies of MPS for rectal cancer [28, 29].

From the above findings, RPS performed by an expert laparoscopic surgeon may be superior to MPS in selected patients with rectal cancer, on account of its lower less invasiveness and better cosmesis [12], along with the favorable oncological outcomes.

Although this study of RPS for rectal cancer had several limitations, namely, the investigation involved only a single treatment arm, the sample size was small, the patients’ selection bias due to not consecutive patients, and the study was a retrospective study, we believe that it is a reliable surgical option of minimally invasive approaches for the patients with rectal cancer.

**Conclusions**

At present, this procedure performed by an expert laparoscopic surgeon may be a reliable surgical option for the selected patients, on account of its less invasiveness, the good cosmesis that it yields, and the
acceptable oncological outcomes. However, further evidence of the usefulness of this procedure as compared to that of SPS, MPS and robotic surgery is needed.

## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>RPS</td>
<td>reduced-port laparoscopic surgery</td>
</tr>
<tr>
<td>MPS</td>
<td>multiple-port laparoscopic surgery</td>
</tr>
<tr>
<td>SPS</td>
<td>Single-port laparoscopic surgery</td>
</tr>
<tr>
<td>BMI</td>
<td>body mass index</td>
</tr>
<tr>
<td>PS</td>
<td>performance status score</td>
</tr>
<tr>
<td>IMA</td>
<td>inferior mesenteric artery</td>
</tr>
<tr>
<td>NOTES</td>
<td>natural orifice translumenal endoscopic surgery</td>
</tr>
</tbody>
</table>

## Declarations

### Ethics approval and consent to participate

The protocol of this treatment has been approved by the Ethics Committee of Kitasato University Kitasato Institute Hospital (No. 17007) and conforms to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000).

### Consent for publication

We have notified the patients of the option available to the treatment to drop out of the study and got the consent to use images that preclude anonymity in the operation consent form in Japanese.

### Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that there is no competing interests that could be perceived as prejudicing the impartiality of the research reported.

### Funding
This work was partially funded by Chugai Pharmaceutical Co., Ltd. (Recipient: authors’ institute office). The funding played a role in the interpretation of data and the in writing the manuscript.

**Authors’ contributions**

Yoshiyuki Ishii: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Writing – original draft; Writing – review & editing. Hiroki Ochiai: Investigation; Resources. Hiroyuki Sako: Investigation; Resources. Masahiko Watanabe: Project administration; Supervision; Writing – review & editing.

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the World Journal of Surgical Oncology.

**Acknowledgements**

We gratefully acknowledge the work of past and present members of our department of surgery in Kitasato University Kitasato Institute Hospital.

**References**


**Figures**
Figure 1

Arrangement of port site. In a patient without scheduled ostomy, MIAP with 3 channels (SILS™ Port) and a 5-mm port were placed on the umbilicus and the right middle abdomen, respectively (A). In a patient with scheduled ostomy, MIAP with 3 channels (SILS™ Port) and a 5-mm port were placed in the ostomy site on right lower abdomen and the left middle abdomen, respectively (B).

MIAP, multiple-instrument access port
Figure 2

Manipulation of conventional laparoscopic instruments. The operator mainly handled the instruments by triangulation using 1 channel of MIAP and another 5-mm port. Left side of this figure is a cranial.

MIAP, multiple-instrument access port
Figure 3

Relapse free (A) and overall (B) survival curves in the patients with rectal cancer who underwent RPS (solid line, pathological Stage I including pCR; dotted line, pathological Stage II-III).