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Comparison of single-incision plus one additional port laparoscopy-assisted anterior resection with conventional laparoscopy-assisted anterior resection for rectal cancer

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Abstract

Background: Reduced port laparoscopic surgery is the latest innovation in minimally invasive surgery. We performed single-incision plus one additional port laparoscopy-assisted anterior resection (SILS+1-AR) starting in August 2010. This study aimed at evaluating the feasibility of SILS+1-AR and comparing it with that of conventional laparoscopy-assisted anterior resection (C-AR).

Methods: Patients with preoperative clinical stage 0 to stage III rectal cancer were included. Demographic, intraoperative, and pathological examination data, as well as short-term outcome data, of 20 patients who underwent SILS+1-AR were retrospectively compared with that of 20 patients who underwent C-AR. Invasiveness of the 2 procedures was also evaluated through a vital signs diary and hematological examination on the postoperative days (POD) 1, 3, and 7.

Results: Operating time, mean estimated blood loss, the number of lymph nodes dissected, the number of lymph node metastases, or the mean distal resection margin length were not significantly different. However, postoperative neutrophil counts in the SILS+1-AR group were lower than those in the C-AR group ($P = 0.085$). A significant difference in body temperature was observed in the SILS+1-AR group on POD 1 ($P = 0.028$). No significant differences were observed in perioperative and overall morbidity between the 2 groups. Conversion to open surgery was required in 2 (10%) of the 20 patients in the SILS+1-AR group. The mean postoperative length of stay and recurrence rates were similar in the 2 groups.

Conclusion: SILS+1-AR for rectal cancer is similar to C-AR in safety, feasibility, and provision of oncological radicality.

Introduction

Laparoscopic colorectal surgery (LCS) is a safe and efficacious alternative to open colorectal surgery in the management of colorectal carcinoma [1, 2]. The short-term outcomes of the COLOR II trial showed that the radicality of laparoscopic resection (as assessed by a pathology report) in patients with rectal cancer is no different from that of open surgery, and that laparoscopic surgery was associated with similar rates of intraoperative complications, morbidity, and mortality [3]. In recent years, single-incision laparoscopic surgery (SILS) has further reduced the invasive nature of surgical procedures and provides even greater cosmetic benefits than conventional multiport laparoscopic surgery (CLS) [4]. However, the disadvantages of SILS are a loss of triangulation, interference between the instruments and the scope and the surgeon's arm and the scope, and obstruction of the operative fields due to parallel placement of the instruments [5]. These challenges are more evident in SILS for rectal procedures owing to the need for adequate oncological margins and creation of a tension-free anastomosis. Current evidence for SILS provides information regarding the outcomes of right-sided colectomy for select patients by experienced surgeons [6-8]; however, the evidence for rectal cancer is limited. Adding an additional port to SILS may bridge the gap between CLS and SILS with a relatively shorter learning curve while maintaining oncologic principles [9-11].

We began performing single-incision plus one additional port laparoscopy-assisted anterior resection (SILS+1-AR) in August 2010. This study aimed at evaluating the feasibility of SILS+1-AR and comparing it with that of conventional laparoscopy-assisted anterior resection (C-AR) for rectal cancer requiring extended lymph node dissection.

Material and Methods

Patients and Methods

We conducted a case-matched, controlled study comparing SILS+1-AR to C-AR for rectal cancer. We included patients who had preoperative clinical stage 0 to stage III rectal cancer that required anterior resection with extended lymph node dissection. The SILS+1-AR group included select patients who completed their treatment between August 2010 and May 2012 (n = 20). Patients who underwent C-AR for stage 0 to stage III rectal cancer between June 2008 and March 2012 were selected as the controls for this study (n = 20) and were matched to the SILS+1-AR patients for age, sex, body mass index (BMI), history of abdominal surgery, disease type, and tumor location. We excluded T3 rectal cancers located within 2 mm of the endopelvic fascia (circumferential margin positive), determined by computed tomography (CT) or magnetic resonance imaging (MRI). Staging and tumor location were determined according to the Japanese Society for Cancer of the Colon and Rectum (JSCCR) 2010 guidelines [12]. Demographic data, intraoperative parameters, and the postoperative outcomes for the 20 patients in the SILS+1-AR group were retrospectively compared with those of the 20 patients in the C-AR group.

Operative procedures

Three colorectal surgeons participated in this study; 1 surgeon performed the SILS+1-ARs, while the other 2 surgeons performed the C-ARs. All patients were placed in the modified lithotomy position in Trendelenburg. In the SILS+1-AR group, a 3-cm transumbilical incision was made, and the SILS Port (Covidien Ltd., Hamilton, Bermuda) with 3 built-in trocars was inserted into a single umbilical incision. An additional 12-mm trocar was placed in the right lower quadrant (Fig. 1a, 1b). A 5-mm standard definition flexible scope was inserted in the 5-mm trocar at the extreme caudal end of the SILS port for the duration of the

procedure. Activating laparoscopic coagulating shears were used for dissection. Straight and curved graspers (Roticulator Endo Grasp; Covidien Ltd.) were used to grasp the tissue. Dissection was performed using a medial-to-lateral approach with the left ureter and gonadal vessels preserved. The dissection was continued superior to the level of the root of the inferior mesenteric artery, and high ligation of the inferior mesenteric artery was achieved (Fig. 1c). Then, the root of the superior rectal artery and inferior mesenteric vein was divided. All procedures complied with the principles of total mesorectal excision (TME) [13], which requires removal of the entire mesorectum down to the pelvic floor (Figure 1d). After sufficient intestinal irrigation with a saline solution, transaction of the rectum was performed using an Echelon^{TM} 60 Endopath stapling device (Ethicon Endo Surgery, Cincinnati, OH, USA) through the additional port, and the specimen was retrieved through the umbilical port. Anastomosis was performed intracorporeally with an EEA circular stapler (Ethicon Endo Surgery) after the anvil was inserted extracorporeally (Fig. 1d). After lavage of the abdominal cavity, a close drain was inserted through the right flank port incision.

C-AR was performed with 4–5 access ports. Left colonic mobilization, lymph node dissection, high ligation of the inferior mesenteric artery, and anastomosis were performed using techniques similar to those used in the SILS+1-AR group. In the C-AR group, the umbilical incision was extended for specimen delivery.

Statistical analysis

The Student's *t*-test and Pearson χ^2 test were used for statistical analysis. All differences were considered significant at $P < 0.05$. All statistical analyses were performed using the Ekuseru-Toukei 2010 software for Windows (Social Survey Research Information Co., Ltd., Tokyo, Japan).

Results

Comparisons between SILS+1-AR and C-AR

Patient characteristics

The demographic characteristics of the patients in the 2 groups are presented in Table 1. There were no differences in age, sex, BMI, history of previous operation, tumor size, stage, or tumor location between the 2 groups. No patients received preoperative chemoradiotherapy.

Surgical findings

Perioperative results are provided in Table 2. The operating time for SILS+1-AR was shorter, although not significantly, than that for C-AR (187 [126–308] vs. 222 [139–385] min, P = 0.062). There were no significant differences in the mean estimated blood loss (SILS+1-AR: 22.5 [0–190], C-AR: 34.8 [0–355] mL), number of lymph nodes dissected (SILS+1-AR: 13.3 ± 7.3, C-AR: 14.5 ± 7.5), number of subserosal invasions (SILS+1-AR: 12 [60.0%], C-AR: 9 [45.0%]), number of lymph node metastases (SILS+1-AR: 5 [25.0%], C-AR: 6 [30.0%]), and the mean length of the distal resection margin (SILS+1-AR: 32.0 ± 14.4, C-AR: 28.6 ± 14.8 mm). A diverting stoma was utilized in 2 patients in the SILS+1-AR group (10.0%) and 2 patients in the C-AR group (10.0%). In the SILS+1-AR group, no additional ports were placed; however, conversion to open surgery was required in 2 (10%) of the 20 patients. The reasons for conversion included rectal cancer invasion of the urinary bladder (n = 1) and a bulky mass (92 mm) of rectal cancer (n = 1). Conversion to open surgery was not required in any of the C-AR patients. All procedures complied with

the principles of TME, which requires removal of the entire mesorectum down to the pelvic floor. All cases were circumferential resection margin negative, and the TME was complete with preservation of the bilateral pelvic autonomic nerve. There were no intraoperative complications in either group.

Evaluation of invasiveness

Changes in vital signs

Although the differences were not significant, the SILS+1-AR group had lower heart rate and systolic blood pressure values after surgery than the C-AR group. A significant difference was observed in the body temperature in the SILS+1-AR group on POD 1 ($P = 0.028$, Fig. 2).

Changes in hematological parameters

Changes in the hematological parameters are shown in Fig. 3. There were no significant differences in white blood cell count (WBC) or C-reactive protein (CRP) between the SILS+1-AR and C-AR groups after surgery. The postoperative neutrophil counts in the SILS+1-AR patients were lower on POD 7 than in the C-AR patients, although not significantly ($P = 0.085$, Fig. 3c). Generally, nutritional parameters, such as the percentage of lymphocyte counts and total protein levels, decreased transiently after surgery. The postoperative lymphocyte count was not significantly different between the SILS+1-AR and C-AR groups.

Safety assessment

No significant differences were observed in overall morbidity between the 2 groups, and the mean length of stay was similar in the 2 groups (SILS+1-AR: 11.3 [7–18], C-AR: 11.2

[7–23] days).

Recurrence

No patients received preoperative chemotherapy. Adjuvant chemotherapy was administered to 5 (25%) patients in the SILS+1-AR group and 6 (30%) patients in the C-AR group. The median duration of the follow-up was 40 (12–63) months. Recurrence was noted in 2 patients (10%) in the SILS+1-AR group and in 1 patient (5%) in the C-AR group. Table 3 provides the detailed data of these 3 patients for lymph node metastasis levels, clinical stage, lymphatic permeation, blood vessel invasion, adjuvant chemotherapy, and the site of recurrence.

Discussion

To our knowledge, this is the first report to evaluate the feasibility of SILS+1-AR compared with C-AR. We demonstrated that, compared with C-AR, SILS+1-AR is safe and feasible without an associated increase in operation time, postoperative complications, morbidity, or length of stay. Furthermore, there were no adverse effects on cancer-specific outcomes, including blood loss, lymph node dissections, subserosal invasions, lymph node metastases, and the length of the resection margin. Through the use of an additional port, parallel placement of the instruments is possible without interference between the scope and the surgeon's dominant hand, thus providing all of the benefits of conventional laparoscopic surgery.

SILS is the latest innovation in minimally invasive surgeries and has become widely used worldwide owing to technical advancements. Potential advantages, compared to standard laparoscopic surgery, include decreased perioperative pain, faster patient recovery, and superior cosmesis [14]. Although we were unable to compare the patients' satisfaction with

cosmesis between the SILS+1-AR and C-AR groups, all patients who underwent SILS+1-AR were satisfied with their small skin incision. Furthermore, the degree of satisfaction was very high during the post-discharge outpatient visits (data not shown). In addition, SILS reduces the potential risks of trocar-related complications such as small bowel injury, vascular injury during trocar insertion, port site herniation, and recurrences. However, the use of SILS in anterior resection for rectal cancer is extremely rare [15] because of the high level of technical expertise required. The tip of the laparoscopic stapler can be bent to a maximum of only 45°, which makes it difficult to transect the lower rectum with sufficient distal margins from the umbilicus port [11]. Therefore, it is important to consider whether the procedure is possible through an umbilical port alone; if not, there should be no hesitation in adding further port(s).

In the SILS+1-AR group, no additional ports were placed; however, conversion to open surgery was required in 2 of the 20 patients because of rectal cancer invasion of the urinary bladder and a bulky mass of rectal cancer. Although we excluded T3 rectal cancers that were circumferential margin positive based on CT or MRI findings, the tumor in 2 of the conversion cases was larger than that diagnosed on preoperative imaging. In such circumstances, it is difficult to achieve an oncological *en bloc* resection with negative resection margins by a laparoscopic approach; therefore, we converted the SILS+1-AR directly to open surgery.

A recent paper by Hirano et al [11] reported that SILS+1-AR is a promising alternative method for scarless abdominal surgery for the treatment of some patients with rectal disease. Moreover, Lim et al [16] demonstrated that adding another port to SILS may bridge the gap between conventional multiport laparoscopic surgery and SILS. In addition, Adair et al [17] reported that adding another port to SILS is a more realistic reflection of the technique used in

a clinical setting. Based on our results, we agree with their viewpoint. We also evaluated the less invasive nature of SILS+1-AR by comparing changes in parameters over time with those obtained by C-AR. The changes in the parameters related to inflammation, such as body temperature, WBC, and CRP, were similar between the 2 groups. We hypothesized that the postoperative neutrophil counts might reflect the dynamic changes in the host inflammatory response. However, the fact that the postoperative neutrophil counts in the SILS+1-AR group were substantially lower than those in the C-AR group in the current study (Figure 3) may mean that less inflammation occurred in the SILS+1-AR group. Moreover, the significant differences in body temperature that were observed in the SILS+1-AR group on the first postoperative day may indicate earlier normalization. Despite the fact that SILS+1-AR is less invasive than C-AR, the length of stay was similar between the groups and relatively long overall. Most patients were well enough to leave the hospital at POD 7; however, the hospital stay was determined not only by the patient's situation but also based on the characteristics of many Japanese patients who want a long hospital stay [18].

We also examined the postoperative recurrence in the 2 groups. In Japan, consensus exists regarding a lack of benefit relating to survival in irradiated patients with resectable rectal cancer [19-20]; therefore, none of the patients received preoperative chemoradiotherapy. In addition, in Japan, the indication for systemic chemotherapy is stage III rectal cancer or stage II rectal cancer with a high risk of recurrence [12]. Adjuvant chemotherapy was administered to 5 (25%) patients in the SILS+1-AR group and 6 (30%) patients in the C-AR group. The median duration of the follow-up was 40 (12–63) months. The cancer recurred in 2 patients (10%) in the SILS+1-AR group and 1 patient (5%) in the C-AR group. Table 3 provides the detailed data of these 3 patients for lymph node metastasis levels, clinical stage, lymphatic permeation, blood vessel invasion, adjuvant chemotherapy, and the site of recurrence. Further follow-up will be necessary to describe long-term outcomes in the 2

groups.

This study has certain limitations. Three colorectal surgeons participated in this study; the surgeon that performed the SILS+1-AR had experience with more than 500 laparoscopic colorectal resection procedures for colorectal cancer, while the others, who performed the C-AR, had experience with approximately 200 laparoscopic colorectal resection procedures. These differences in experience and the fact that the use of SILS+1-AR began 2 years later than that of C-AR may have introduced bias in the operative results, including a shorter operative duration for SILS+1-AR than for C-AR, although the difference was not significant.

In conclusion, in select patients treated by skilled surgeons, SILS+1-AR for rectal cancer is similar to C-AR with respect to safety, feasibility, and the provision of oncological radicality. Long-term follow up to assess local recurrence and survival is necessary to ascertain the oncological safety of SILS+1-AR in patients with rectal cancer.

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Figure Captions

Fig. 1 a: Port setting. In the SILS+1-AR group, 3-cm transumbilical incision was made, and the SILS Port (Covidien Ltd, Hamilton, Bermuda) with 3 built-in trocars was inserted into a single umbilical incision. 12-mm port is inserted in right lower quadrant of the abdomen. b: Intra-operatively, the system allows greater freedom of movement of the instruments. c: SILS+1-AR with lymph node dissection around the inferior mesenteric artery. d: All procedures had to comply with the principles of TME

Fig. 2 a , b and c: Changes in vital signs after operation. a: There was a significant difference in the body temperature in the SILS+1-AR group on the first day postoperatively ($P = 0.028$)

Fig. 3 a and b: Changes in white blood cell counts (WBC) and C-reactive protein (CRP) after operation. c, d and e: Changes in neutrophil counts (c), lymphocyte counts (d) and serum total protein levels (e). In the present study, the postoperative neutrophil counts in the SILS+1-AR patients were lower on POD 7, although not significantly, than in the C-AR patients ($P = 0.085$)

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Figure 1

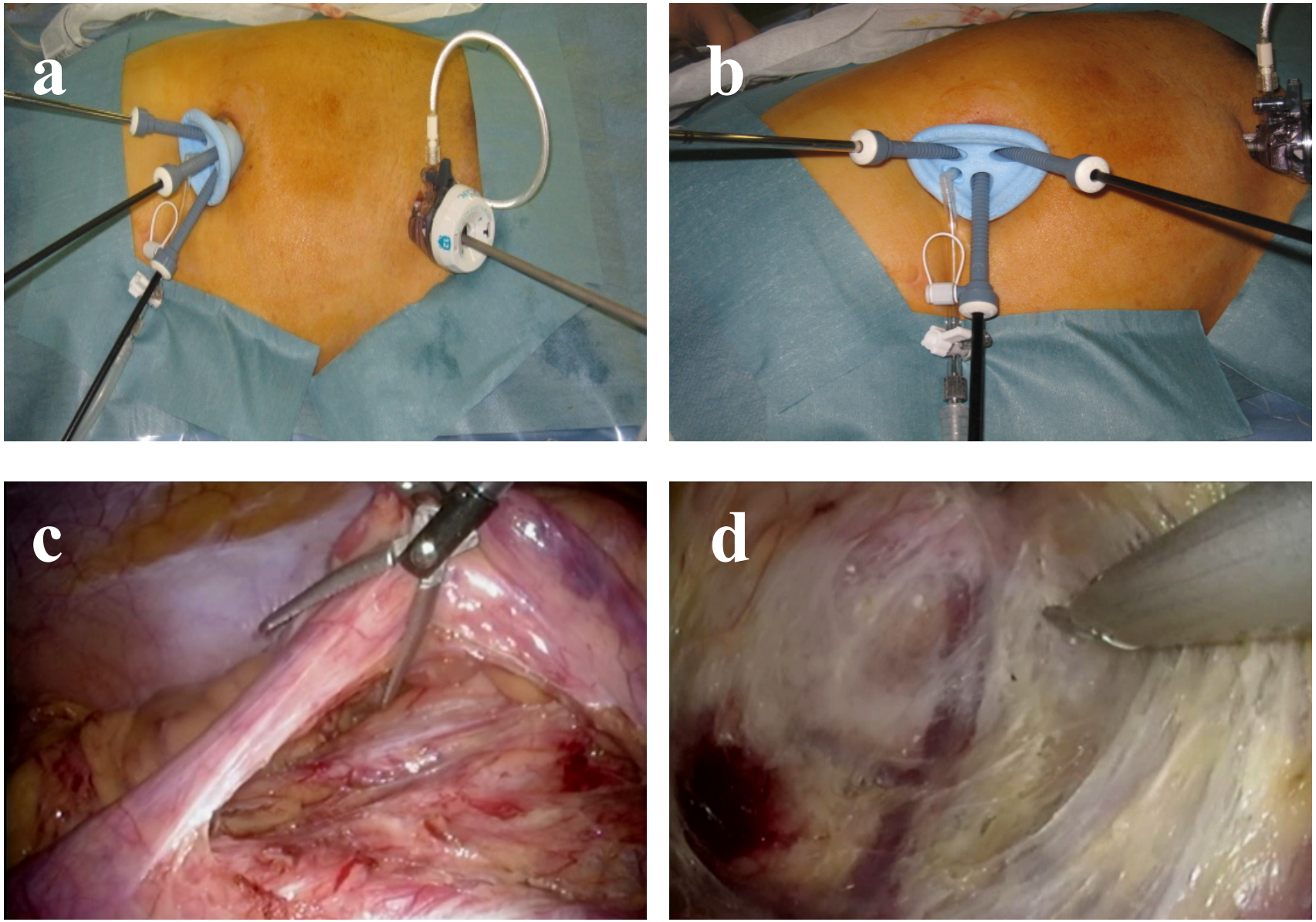
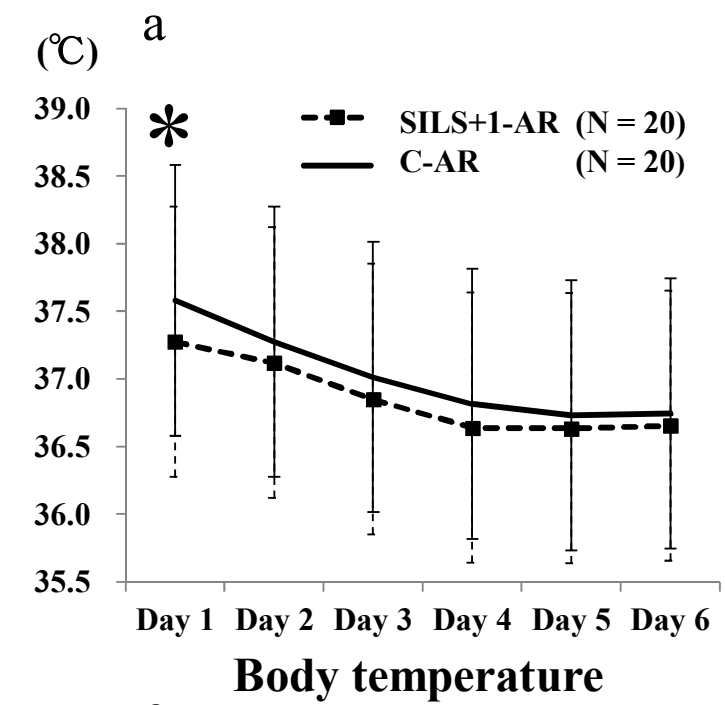


Figure 2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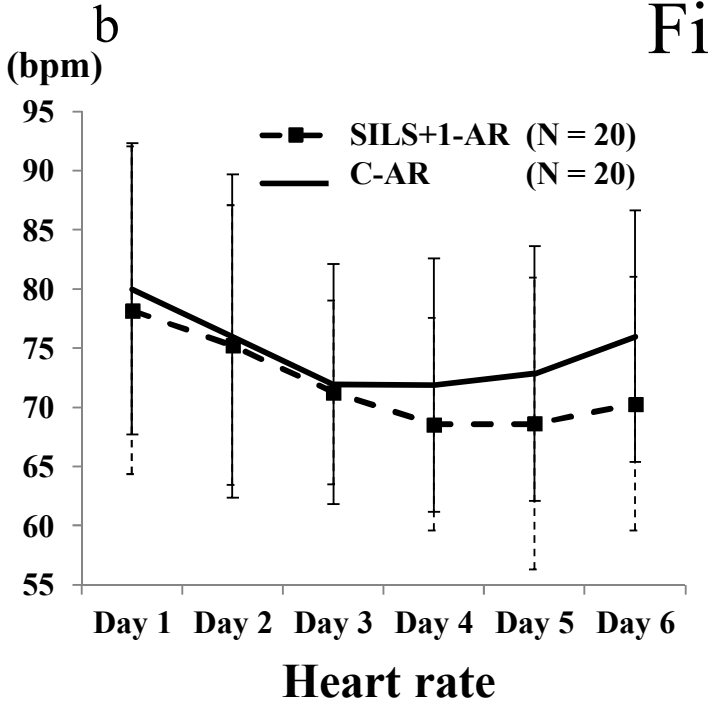
SILS+1-AR (N = 20)
C-AR (N = 20)
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6
Body temperature


b
(bpm)
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90
85
80
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70
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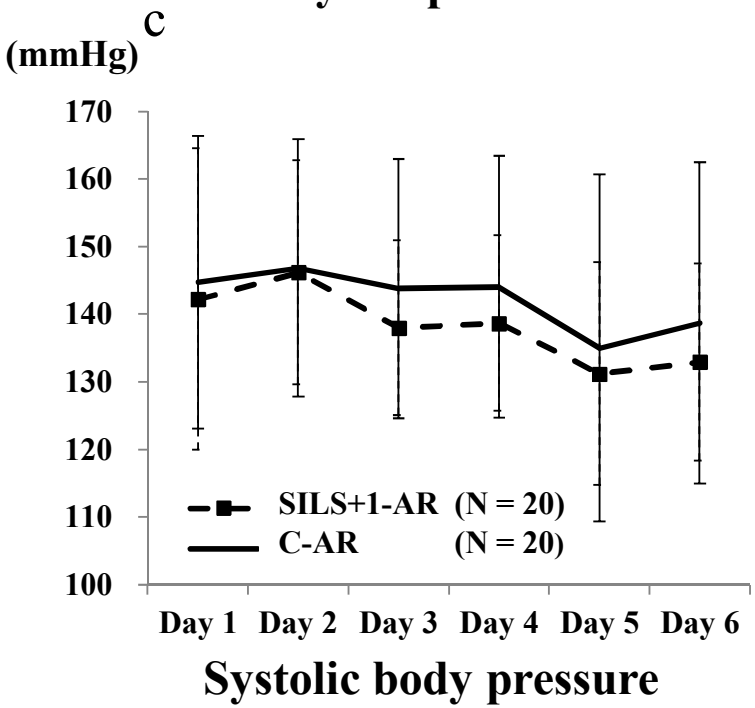
SILS+1-AR (N = 20)
C-AR (N = 20)
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6
Heart rate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150
140
130
120
110
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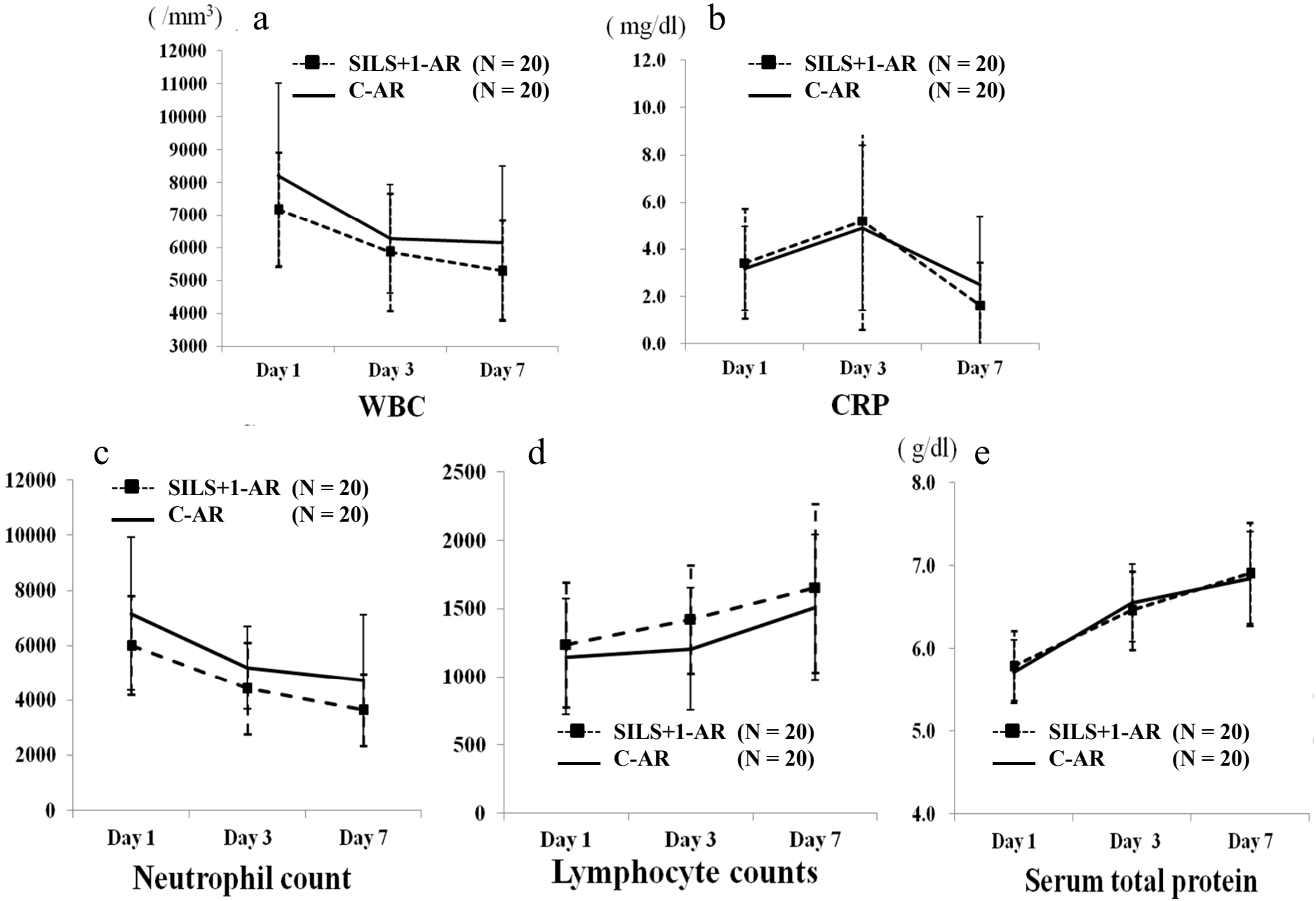
SILS+1-AR (N = 20)
C-AR (N = 20)
Day 1 Day 2 Day 3 Day 4 Day 5 Day 6
Systolic body pressure

Figure 3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C-AR (N = 20)
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Day 1
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SILS+1-AR (N = 20)
C-AR (N = 20)
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SILS+1-AR (N = 20)
C-AR (N = 20)
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6000
4000
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Day 1
Day 3
Day 7
Neutrophil count
d
2500
2000
1500
1000
500
0
SILS+1-AR (N = 20)
C-AR (N = 20)
Day 1
Day 3
Day 7
Lymphocyte counts
(g/dl)
e
8.0
7.0
6.0
5.0
4.0
SILS+1-AR (N = 20)
C-AR (N = 20)
Day 1
Day 3
Day 7
Serum total protein

Table.1 Demographics and clinical characteristics of the SILS+1-AR and C-AR groups

Parameter	SILS+1-AR (n = 20)	C-AR (n = 20)	P value
1. Age(y)	66.4 ± 6.6	68.7± 11.1	0.449
2. Sex			
Male	14	13	1.000
Female	6	7	
3. BMI (kg/m^2)	23.5± 2.9	23.9 ± 3.6	0.673
4. Operation history (yes/no)	1/19	2/18	1.000
5. Tumor size (cm)	36.5± 21.2	33.8 ± 17.7	0.665
6. Stage			
0 - I	7	8	1.000
II - III	13	12	
7. Tumor location			
Rs	8	8	
Ra	10	9	1.000
Rb	2	3	

Stage and Tumor location were determined according to the Japanese Society for Cancer of the Colon and Rectum (JSCCR)

The localization of the tumor was categorized as rectosigmoid (Rs), rectum above the peritoneal reflection (Ra), and rectum below the peritoneal reflection (Rb).

BMI: body mass index, Values are reported as mean (SD) or percentages (%)

Table. 2 Operative variables in SILS+1-AR and C-AR groups

Parameter	SILS+1-AR (n = 20)	C-AR (n = 20)	P value
1. Operation time (min)	187 (126 - 308)	222 (139 - 385)	0.062
2. Blood loss (ml)	22.5 (0 - 190)	34.8 (0 - 355)	0.574
3. The number of lymph node dissection	13.3 ± 7.3	14.5 ± 7.5	0.627
4. Sub-serosal invasion (%)	12 (60.0)	9 (45.0)	0.527
5. Lymph node metastasis (%)	5 (25.0)	6 (30.0)	1.000
6. Distal resection margin (mm)	32.0 ± 14.4	28.6 ± 14.8	0.466
7. Adding further port	0 (0.0)	0 (0.0)	1.000
8. Intraoperative complication	0 (0.0)	0 (0.0)	1.000
9. Conversion rate (%)	2 (10.0)	0 (0.0)	0.487
10. Ileostomies (%)	2(10.0)	2(10.0)	1.000
11. Complications	0 (0.0)	0 (0.0)	1.000
12. Hospital stay (days)	11.3 (7 - 18)	11.2 (7 - 23)	0.927

Values are reported as mean (SD) or percentages (%)

Table 3. Summary of 3 patients with recurrence after laparoscopy-assisted anterior resection

Case No.	Operation	Age	Sex	Location	Histological classification	Invasion depth	pN-factor	pStage	Lymphatic permeation	Blood vessel permeation	Adjuvant chemotherapy	Site of recurrence (month)	Outcome (month)
1	SILS+1-AR	68	M	Ra	tub2	SM	0	I	negative (0)	positive (1)	XELOX	liver (25)	alive (39)
2	SILS+1-AR	75	M	Ra	tub2	SS	1	III	negative (0)	positive (1)	mFOLFOX6	liver (10)	alive (29)
3	C-AR	40	F	Ra	mod	SM	0	I	positive (2)	positive (1)	mFOLFOX6	lung (18)	alive (46)

Lymphatic and blood vessel permeation: (1): mild, (2): moderate, (3) severe