Abstract: Laparoscopic rectal cancer surgery has technical difficulties with a higher complication rate than colon cancer. However, few studies have examined whether postoperative complications are associated with oncologic outcomes. The aim of this study is to evaluate the impact of postoperative complications on long-term oncologic outcomes after laparoscopic low anterior resection for rectal cancer.

Between January 2005 and December 2012, we evaluated 686 consecutive patients who underwent laparoscopic low anterior resection for stage I-III rectal cancer. Patients were divided into complication (n = 175) and noncomplication (n = 511) groups. The median follow-up period was 38 months (range, 2–118). We compared perioperative clinicopathologic outcomes, 5-year survival, and local recurrence between groups and evaluated prognostic factors.

Five-year overall survival rates were 91.4% and 89.2% (P = 0.234) and 5-year disease-free survival rates were 83.2% and 77.7% (P = 0.002) in the noncomplication and complication groups for all stages, respectively. For stage I cancer, both the 5-year overall survival and the 5-year disease-free survival rate of the complication group were lower than the noncomplication group. Local recurrence rates were 3.1% and 7.8% in the noncomplication and complication groups, respectively (P = 0.002). In multivariate analysis, the presence of postoperative complications was a significant predictor of 5-year disease-free survival (hazard ratio, 1.65; P = 0.012).

Postoperative complications had a negative impact on 5-year disease-free survival after laparoscopic low anterior resection for rectal cancer. The rate of local recurrence in the complication group increased more than the noncomplication group. In particular, postoperative complications were associated with poorer oncologic outcomes for stage I cancer. Laparoscopic surgery is preferred for early-stage rectal cancer so careful attention should be paid to avoid postoperative complications.

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excluded, because the different surgical procedures used for the perineal wound could confound postoperative outcomes. Seven patients who were lost to follow-up and 6 who died within 1 month after surgery (postoperative mortality cases) were excluded. Finally, 686 patients were divided into 2 groups according to the occurrence of postoperative complications: the complication group (CG, n = 175) and the noncomplication group (NCG, n = 511).

All data were collected from the Yonsei Colorectal Cancer Database, and data completeness was ensured by electronic medical chart review and telephone interviews. This study was approved by the Institutional Review Board of Severance Hospital.

**Evaluation Parameters**

The patients were divided into 2 groups (CG and NCG) and were evaluated for the following parameters: age, sex, weight, height, body mass index (BMI), and the American Society of Anesthesiologists (ASA) classification.

Tumor location was classified as low (≤5 cm), mid (5.1–10 cm), or upper rectal (10.1–15 cm), according to the tumor’s distance from the anal verge. Patients who had undergone abdominal surgery before the rectal cancer surgery were considered to have a history of abdominal surgery.

The perioperative outcomes evaluated operation time and the amount of intraoperative bleeding. Diverting ileostomy was performed in patients with a high risk of postoperative leakage (male patients with mid-low rectal cancer and patients who received preoperative chemoradiotherapy), a positive air-leak test, or a hand-sewn colo-anal anastomosis. The criterion for conversion to open surgery was an unintended extension (by more than 4 cm) of the incisional site during surgery. Length of hospital stay was calculated from the date of surgery to the date of discharge.

Pathologic outcomes were assessed according to the tumor node metastasis (TNM) stage (American Joint Committee on Cancer, seventh edition). On the basis of histologic findings, tumors were considered to have a well, moderate, poor, or mucinous differentiation. The surgical specimen was analyzed to determine the number of harvested lymph nodes, lymphovascular invasion, and the circumferential resection margin (CRM). CRM involvement was defined as the presence of tumor cells within 1 mm of the CRM. Tumor size, the proximal resection margin, and the distal resection margin were determined in the operating room, and pathologic reports were reviewed to obtain additional information.

The oncologic outcomes were evaluated by overall survival, disease-free survival, and local recurrence. Overall survival was calculated from the date of surgery to the date of death. Disease-free survival was calculated from the date of surgery to the date of death or recurrence. Local recurrence was defined when recurrence was observed at the primary site on radiologic or histologic examination. Recurrence beyond the primary site was considered to be distant metastasis. Five-year survival rates were compared between the CG and NCG.

**Postoperative Complications and Their Grading**

Complications that occurred after surgery were considered to be postoperative complications. These were classified according to the Clavien-Dindo classification as summarized in Table 3. In cases of multiple complications in a patient, the one with the highest Clavien-Dindo classification was recorded for analysis. We then compared oncologic outcomes between patients with grade I-II complications and those with grade III-IV complications (Figure 1).

**Neoadjuvant Therapy and Postoperative Surveillance**

Patients with T3/4 mid or low rectal cancer or positive lymph nodes were treated with preoperative chemoradiotherapy.
level of the dentate line and proximal colon was performed. After resecting the tumor, anastomosis between the anal canal at the level of the dentate line and rectum was reached at the level of the dentate line. After performing the double-stapling method and hand-sewn anastomosis between the proximal colon and distal rectum was performed using the end-to-end anastomosis (EEA) anvil into the proximal colon, intracorporeal anastomosis was performed within 6 to 8 weeks after the completion of preoperative chemoradiotherapy. If preoperative chemoradiotherapy did not differ significantly between the 2 groups (P = 0.234). The rate of a history of abdominal surgery was higher in the CG (15.1%) than in the NCG (8.6%; P = 0.029). Age, the ASA score, and the administration of preoperative chemoradiotherapy were compared between the CG and NCG. Tumors located 0–5 cm from the anal verge were the most common in both groups. The distributions of tumor location were not significantly different between the 2 groups (P = 0.224); mid-rectal cancers, located 5.1 to 10 cm, were the most common in both groups (Table 1).

**Surgical Technique**

Laparoscopic LAR was performed by high ligation of the inferior mesenteric vessel, left colon mobilization, and splenic flexure mobilization. Pelvic dissection was performed according to the principles of total mesorectal excision. The avascular plane between the presacral fascia and proper fascia of the rectum was dissected. The specimen was extracted through a mini-laparotomy, 3 to 4 cm from the trocar site in the lower left quadrant area. After inserting an end-to-end anastomosis (EEA) anvil into the proximal colon, intracorporeal anastomosis between the proximal colon and distal rectum was performed using the double-stapling method and hand-sewn colo-anal anastomosis. For colo-anal anastomosis, dissection of the rectum was reached at the level of the dentate line. After resecting the tumor, anastomosis between the anal canal at the level of the dentate line and proximal colon was performed.

**TABLE 1. Patient Characteristics**

|                        | Noncomplication Group (n = 511) | Complication Group (n = 175) | P       |
|------------------------|---------------------------------|------------------------------|---------|
| Age (years)            | 62.0 ± 10.3 (28–87)             | 62.4 ± 10.2 (31–89)          | 0.602*  |
| Sex                    |                                 |                              | 0.001†  |
| Male                   | 295 (57.7)                      | 126 (72.0)                   |         |
| Female                 | 216 (42.3)                      | 49 (28.0)                    |         |
| Weight (kg)            | 61.1 ± 9.5 (36–87)              | 63.7 ± 10.6 (43–94)          | 0.003‡  |
| Height (cm)            | 161.9 ± 8.6 (140–184)           | 164.2 ± 8.9 (135–182)        | 0.003‡  |
| BMI (kg/m²)            | 23.3 ± 3.0 (14.5–38.0)          | 23.6 ± 3.3 (16.7–34.9)       | 0.234‡  |
| ASA score              |                                 |                              | 0.640†  |
| 1                      | 215 (42.1)                      | 67 (38.3)                    | 0.224‡  |
| 2                      | 282 (55.2)                      | 102 (58.3)                   |         |
| 3                      | 14 (2.7)                        | 6 (3.4)                      |         |
| Tumor location from anal verge |                         |                              |         |
| Low (0–5 cm)           | 87 (17.0)                       | 34 (19.4)                    |         |
| Mid (5.1–10 cm)        | 276 (54.0)                      | 102 (58.3)                   |         |
| High (10.1–15 cm)      | 148 (29.0)                      | 39 (22.3)                    |         |
| History of abdominal surgery |                         |                              | 0.029†  |
| Yes                    | 77 (15.1)                       | 15 (8.6)                     |         |
| No                     | 434 (84.9)                      | 160 (91.4)                   |         |
| Preoperative chemoradiotherapy |                       |                              | 0.086†  |
| Yes                    | 124 (24.3)                      | 54 (30.9)                    |         |
| No                     | 387 (75.7)                      | 121 (69.1)                   |         |

Continuous variables are described as mean ± standard deviation (range); categorical variables are described as n (%).

ASA = American Society of Anesthesiologists; BMI = body mass index.

* Student t test.
† Chi-square test.
‡ t test.

Statistical Analysis

Statistical analysis was performed with SPSS v. 20 for Windows (SPSS Inc., Chicago, IL). Categorical variables were analyzed using the Chi-square test or Fisher exact test. Continuous variables were analyzed using the Student t test. The 5-year overall survival, 5-year disease-free survival, and local recurrence rates were evaluated using the Kaplan-Meier method. Comparisons of 5-year survival and local recurrence between the CG and NCG were made using the log-rank test. Univariate analysis to identify prognostic factors affecting 5-year survival was performed using the log-rank test. Variables found to be significant in univariate analysis were entered into the Cox proportional hazards regression model for multivariate analysis. A P value less than 0.05 was considered statistically significant for all parameters.

RESULTS

**Patient Characteristics**

Patient characteristics were compared between the CG and NCG. The proportion of men was higher in the CG than in the NCG (72.0% vs 57.7%, P = 0.001). Height and weight values were also higher in the CG than in the NCG. However, BMI was not significantly different between the 2 groups (P = 0.234). The rate of a history of abdominal surgery was higher in the NCG (15.1%) than in the CG (8.6%; P = 0.029). Age, the ASA score, and the administration of preoperative chemoradiotherapy did not differ significantly between the groups. The distributions of tumor location were not significantly different (P = 0.224); mid-rectal cancers, located 5.1 to 10 cm from the anal verge, were the most common in both groups (Table 1).
Perioperative and Pathologic Outcomes

With respect to perioperative outcomes, operation time was longer in the CG than in the NCG (292.8 ± 177.5 vs 250.9 ± 82.2 min, \( P = 0.003 \)). The amount of intraoperative bleeding was greater in the CG than in the NCG (187.6 ± 287.8 vs 124.4 ± 210.9 mL, \( P = 0.008 \)). Conversion to open surgery was significantly more frequent in the CG than in the NCG (4.6% vs 1.2%, \( P = 0.011 \)). The length of hospital stay was longer in the CG than in the NCG (16.1 ± 13.2 vs 9.1 ± 4.2 days, \( P < 0.001 \)). However, anastomosis type and the rate of diverting ileostomy were not significantly different between groups.

With respect to pathologic outcomes, there were no significant differences for any of the parameters. The distributions of TNM stage did not differ between the groups (\( P = 0.603 \)). Histologic differentiation, number of harvested lymph nodes, tumor size, lymphovascular invasion, and proximal and distal resection margins also did not differ significantly between the 2 groups. The rates of CRM involvement were 3.4% in the CG and 6.1% in the NCG, but this difference was not significant (\( P = 0.182 \)), as summarized in Table 2.

### TABLE 2. Perioperative and Pathologic Outcomes

|                          | Noncomplication Group (n = 511) | Complication Group (n = 175) | \( P \) |
|--------------------------|--------------------------------|-----------------------------|------|
| Operation time (min)     | 250.9 ± 82.2 (66–664)           | 292.8 ± 177.5 (98–2270)     | 0.003* |
| Intraoperative bleeding (mL) | 124.4 ± 210.9 (0–1550)       | 187.6 ± 287.8 (0–2300)     | 0.008* |
| Anastomotic type         |                                |                             | 0.132† |
| Double stapling method   | 464 (90.8)                     | 150 (85.7)                  |      |
| Colo-anal J-pouch        | 5 (1.0)                        | 2 (1.2)                     |      |
| Colo-anal-straight       | 42 (8.2)                       | 23 (13.1)                   |      |
| Diverting ileostomy      |                                |                             | 0.463† |
| Yes                      | 140 (27.4)                     | 53 (30.3)                   |      |
| No                       | 371 (72.6)                     | 122 (69.7)                  |      |
| Conversion               |                                |                             | 0.011† |
| Yes                      | 6 (1.2)                        | 8 (4.6)                     |      |
| No                       | 505 (98.8)                     | 167 (95.4)                  |      |
| Length of hospital stay (days) | 9.1 ± 4.2 (4–49)             | 16.1 ± 13.2 (5–92)         | <0.001* |
| TNM stage                |                                |                             | 0.603† |
| I                        | 226 (44.2)                     | 70 (40.0)                   |      |
| II                       | 129 (25.3)                     | 49 (28.0)                   |      |
| III                      | 156 (30.5)                     | 56 (32.0)                   |      |
| Histologic differentiation|                                |                             | 0.206† |
| Well                     | 134 (26.2)                     | 35 (20.0)                   |      |
| Moderate                 | 358 (70.1)                     | 137 (78.3)                  |      |
| Poor                     | 7 (1.4)                        | 1 (0.6)                     |      |
| Mucinous                 | 12 (2.3)                       | 2 (1.1)                     |      |
| Numbers of harvested lymph nodes | 15.7 ± 7.7 (3–49)   | 16.4 ± 8.8 (3–49)         | 0.340* |
| Tumor size (cm)          | 3.0 ± 1.8 (0.1–11.2)           | 3.1 ± 1.9 (0.1–10.0)       | 0.548* |
| Proximal resection margin (cm) | 12.2 ± 5.0 (5.0–35.0)          | 12.5 ± 4.9 (5.0–30.0)      | 0.427* |
| Distal resection margin (cm) | 2.6 ± 1.9 (0.1–12.0)          | 2.4 ± 1.5 (0.1–7.0)        | 0.110* |
| Lymphovascular invasion  | 76 (14.9)                      | 31 (17.7)                   | 0.371† |
| CRM                      |                                |                             | 0.182† |
| Noninvolved (>1 mm)      | 480 (93.9)                     | 169 (96.6)                  |      |
| Involved (≤1 mm)         | 31 (6.1)                       | 6 (3.4)                     |      |

Continuous variables are described as mean ± standard deviation (range); categorical variables are described as n (%).

* Student t test.
† Chi-square test.
\( ^{2} \) Fisher exact test.

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**Perioperative and Pathologic Outcomes**

With respect to perioperative outcomes, operation time was longer in the CG than in the NCG (292.8 ± 177.5 vs 250.9 ± 82.2 min, \( P = 0.003 \)). The amount of intraoperative bleeding was greater in the CG than in the NCG (187.6 ± 287.8 vs 124.4 ± 210.9 mL, \( P = 0.008 \)). Conversion to open surgery was significantly more frequent in the CG than in the NCG (4.6% vs 1.2%, \( P = 0.011 \)). The length of hospital stay was longer in the CG than in the NCG (16.1 ± 13.2 vs 9.1 ± 4.2 days, \( P < 0.001 \)). However, anastomosis type and the rate of diverting ileostomy were not significantly different between groups.

With respect to pathologic outcomes, there were no significant differences for any of the parameters. The distributions of TNM stage did not differ between the groups (\( P = 0.603 \)). Histologic differentiation, number of harvested lymph nodes, tumor size, lymphovascular invasion, and proximal and distal resection margins also did not differ significantly between the 2 groups. The rates of CRM involvement were 3.4% in the CG and 6.1% in the NCG, but this difference was not significant (\( P = 0.182 \)), as summarized in Table 2.

**Postoperative Complications According to Their Clavien-Dindo Classification**

Postoperative complications according to their Clavien-Dindo classification are listed in Table 3. The overall rate of postoperative complications was 25.4%. Of these, 6.3% were grade I complications. Voiding difficulty was the most common complication (3.5% of the patients), and ejaculation dysfunction was the second most common complication. In total, 2.6% of the patients had grade II complications that included intestinal obstruction (1.2%), ischemic colitis (0.3%), perianal abscess (0.1%), wound infection (0.1%), and anastomotic leakage (0.9%), which were treated by antibiotics. Overall, 1.7% of the patients had grade IIIa complications, and anastomotic stricture, which was treated by endoscopic balloon dilatation, was the most common complication among these. The rate of grade IIIb complications was 14.4%. Anastomotic leakage was the most common grade IIIb complication (7.0%) and intestinal obstruction was the second most common (3.1%). Nine patients had rectovaginal fistulas and 1 had a rectovesical fistula. There were 8 patients, who were treated by a diverting loop ileostomy.
(0.9%) or a colostomy formation (0.4%) due to anastomotic stricture. One patient with fecal incontinence underwent a diverting ileostomy, and the complication was classified as grade IIIb. Three patients had grade IV complications, which included pneumonia, strangulation of the intestine, and stress-induced cardiomyopathy.

**Oncologic Outcomes in the CG and NCG**

The mean follow-up period was 43.6 ± 0.9 months (interquartile range, 26–58 months), and the median follow-up period was 38 months (range, 2–118 months). As shown in Figure 2, the 5-year overall survival rate for all stages was not significantly different in the CG and NCG (89.2% and 91.4%, respectively; \( P = 0.234 \)). However, for stage I cancer, the 5-year overall survival rate was significantly higher in the NCG than in the CG (98.4% vs 97.4%, \( P = 0.009 \)). The proportions of patients with stage II and III cancer were not significantly different between the groups, as shown in Figure 2.

The 5-year disease-free survival rate for all stages was significantly different between the CG and NCG as described in Figure 3 (77.7% vs 83.2%; \( P = 0.002 \)). In addition, for stage I cancer, the 5-year disease-free survival rate was significantly lower in the CG (83.8%) than in the NCG (92.7%, \( P < 0.001 \)). There were no significant differences between groups in the 5-year disease-free survival rates for patients with stage II and III cancer (Figure 3).

The cumulative incidence of local recurrence was higher in the CG than in the NCG (7.8% vs 3.1%, \( P = 0.002 \)), as shown in Figure 4.

We compared oncologic outcomes between patients with grade I-II complications and patients with grade III-IV complications according to the Clavien-Dindo classification of surgical complications, as described in Figure 1.14 The 5-year disease-free survival rate among patients without postoperative complications was 91.9%. Patients with postoperative complications had a lower 5-year disease-free survival, which was 91.5% for grade I-II complications and 72.1% for grade III-IV complications (\( P < 0.001 \)). However, 5-year overall survival did not differ significantly according to the grade of postoperative complications.

**Prognostic Factors for the 5-year Survival Rate**

In univariate analysis, age, conversion to open surgery, TNM stage, histologic differentiation, number of harvested lymph nodes, lymphovascular invasion, and postoperative complications were prognostic factors for 5-year disease-free survival. With respect to 5-year overall survival, age, conversion to open surgery, TNM stage, histologic differentiation, lymphovascular invasion, and CRM involvement were prognostic factors (Table 4). Thus, age, conversion to open surgery, TNM stage, histologic differentiation, and lymphovascular invasion were the common prognostic factors for 5-year overall survival and 5-year disease-free survival.

In multivariate analysis, TNM stage, number of harvested lymph nodes, and postoperative complications were found to be prognostic factors for 5-year disease-free survival. The hazard ratio (HR) was lower for ≥12 harvested lymph nodes than for <12 harvested lymph nodes (≥12 vs <12, HR, 0.52; \( P = 0.001 \)). The HR for 5-year disease-free survival was higher in the CG than in the NCG (HR, 1.65; \( P = 0.012 \)). The prognostic factors for 5-year overall survival were age, TNM stage, and histologic differentiation in multivariate analysis. TNM stage was a common prognostic factor for 5-year disease-free survival and 5-year overall survival. Compared with patients with stage I cancer, the HR for disease-free survival among patients with stage III rectal cancer was 3.88 (\( P < 0.001 \)) and
that for overall survival was 3.27 ($P = 0.006$). However, the occurrence of postoperative complications was only the prognostic factor for 5-year disease-free survival (Table 5).

**DISCUSSION**

In this study, we investigated whether postoperative complications after laparoscopic LAR influence long-term oncologic outcomes in patients with rectal cancer. The most important finding was that patients in the NCG with stage I cancer had higher rates of both 5-year disease-free survival and overall survival than those in the CG. In addition, although there was no significant difference in the 5-year overall survival between the CG and NCG for all stages ($P = 0.234$); the 5-year disease-free survival rate was higher and the local recurrence rate was lower in the NCG than in the CG. The pathologic parameters related to cancer behavior were not found to be confounding factors in the interpretation of the present results, because there were no significant differences between the CG and NCG in terms of TNM stage, histologic differentiation, tumor size, resection margins, lymphovascular invasion, and CRM involvement.

Oncologic outcomes were not significantly different between the CG and NCG for patients with stage II and III rectal cancer. These results suggest that postoperative complications did not influence oncologic outcomes in patients with stage II or III rectal cancer. However, for stage I rectal cancer, oncologic outcomes were poorer in the CG than in the NCG. Thus, in the early stages of rectal cancer, postoperative complications may affect oncologic outcomes in the absence of pathologic tumor infiltration into perirectal fat or lymph node metastasis. Meanwhile, the effect of postoperative complications on oncologic outcomes might be diluted in patients with stage II-III rectal cancer because of the relatively higher pathologic stage and tumor aggressiveness than in patients with stage I rectal cancer. These results are supported by the fact that excessive systemic inflammatory responses (SIRs) due to
## TABLE 4. Prognostic Factors for 5-year Survivals by Univariate Analysis

| Factor                                | No. (n = 686) | DFS (%) | P     | OVS (%) | P     |
|---------------------------------------|---------------|---------|-------|---------|-------|
| Age (years)                           |               |         |       |         |       |
| ≤65                                   | 409           | 84.2    | 0.013 | 94.1    | 0.001 |
| >65                                   | 277           | 78.1    |       | 85.7    |       |
| Sex                                   |               |         |       |         |       |
| Male                                  | 421           | 80.1    | 0.284 | 89.6    | 0.364 |
| Female                                | 265           | 84.3    |       | 92.7    |       |
| BMI (kg/m²)                           |               |         |       |         |       |
| ≤25                                   | 507           | 80.5    | 0.178 | 90.9    | 0.845 |
| >25                                   | 179           | 85.1    |       | 90.6    |       |
| ASA score                             |               |         |       |         |       |
| ASA 1 ~ 2                             | 666           | 81.5    | 0.809 | 90.5    | 0.838 |
| ASA ≥ 3                               | 20            | 89.5    |       | 100.0   |       |
| Tumor location from anal verge        |               |         |       |         |       |
| Low (0 ~ 5 cm)                        | 121           | 81.6    | 0.400 | 94.1    | 0.070 |
| Mid (5.1 ~ 10 cm)                     | 378           | 79.5    |       | 86.6    |       |
| High (10.1 ~ 15 cm)                   | 187           | 85.9    |       | 95.7    |       |
| Preoperative chemoradiotherapy        |               |         |       |         |       |
| Yes                                   | 178           | 84.3    | 0.750 | 95.6    | 0.307 |
| No                                    | 508           | 81.2    |       | 89.9    |       |
| Operation time (min)                  |               |         |       |         |       |
| ≤265                                  | 393           | 83.6    | 0.500 | 90.7    | 0.938 |
| >265                                  | 293           | 79.6    |       | 91.0    |       |
| Anastomotic type                      |               |         |       |         |       |
| Double stapling method                | 614           | 81.8    | 0.855 | 90.2    | 0.446 |
| Colo-anal J-pouch                     | 7             | 80.0    |       | 100.0   |       |
| Colo-anal-straight                    | 65            | 83.0    |       | 95.5    |       |
| Diverting ileostomy                   |               |         |       |         |       |
| Yes                                   | 193           | 77.2    | 0.495 | 89.0    | 0.776 |
| No                                    | 493           | 83.1    |       | 91.0    |       |
| Conversion                            |               |         |       |         |       |
| Yes                                   | 14            | 64.3    | 0.030 | 84.4    | 0.022 |
| No                                    | 672           | 82.1    |       | 91.2    |       |
| TNM stage                             |               |         |       | <0.001  | <0.001 |
| I                                      | 296           | 90.4    |       | 98.1    |       |
| II                                     | 178           | 83.1    |       | 89.0    |       |
| III                                    | 212           | 68.3    |       | 83.0    |       |
| Histologic differentiation            |               |         | <0.001| <0.001  |       |
| Well                                   | 169           | 88.6    |       | 95.9    |       |
| Moderate                               | 495           | 80.4    |       | 90.1    |       |
| Poor                                   | 8             | 62.5    |       | 32.8    |       |
| Mucinous                               | 14            | 65.5    |       | 72.9    |       |
| Number of harvested lymph nodes       |               |         |       |         |       |
| <12                                    | 211           | 73.9    | 0.002 | 88.4    | 0.111 |
| ≥12                                    | 475           | 85.9    |       | 92.1    |       |
| Lymphovascular invasion               |               |         |       |         |       |
| Yes                                   | 107           | 71.4    | 0.001 | 82.8    | 0.002 |
| No                                    | 579           | 83.7    |       | 92.4    |       |
| CRM                                    |               |         |       |         |       |
| Noninvolved (>1 mm)                   | 649           | 82.3    | 0.129 | 91.1    | 0.030 |
| Involved (≤1 mm)                      | 37            | 72.6    |       | 85.4    |       |
| Postoperative complications           |               |         |       |         |       |
| Yes                                   | 175           | 77.7    | 0.002 | 89.2    | 0.234 |
| No                                    | 511           | 83.2    |       | 91.4    |       |

CRM = circumferential resection margin, DFS = disease-free survivals, OVS = overall survivals, TNM = tumor node metastasis.
Postoperative complications can influence oncologic outcomes. Interestingly, there are several reports of inflammation-based predictions of postoperative outcomes in patients with colorectal cancer. Ishuzuka et al asserted that the presence of a SIR can be associated with poor oncologic outcomes, because proinflammatory lymphocytes and hypercytokinemia, especially interleukin-6 level elevation, predispose the tumor to further progression, invasion, and metastasis through immunoreactive processes. In addition, an elevated Glasgow prognostic score (GPS), an inflammation-based prognostic score, is associated with postoperative mortality. Thus, oncologic outcomes are influenced not only by tumor-related pathologic characteristics but also by SIR-related characteristics. Accordingly, it is theoretically possible that SIR-related postoperative complications affect oncologic outcomes in stage I rectal cancer, which is less influenced by the pathologic factors of the tumor. Currently, several indicators are used to predict mortality in patients, such as the GPS or the Physiologic and Operative Severity Score for enUmeration of Mortality and morbidity (POSSUM). We expect that these indicators will be useful in providing a greater understanding of the effects of surgical complications and their association with oncologic outcomes after surgical procedures.

In this study, the occurrence of postoperative complications was an independent prognostic factor for 5-year disease-free survival. The results of a multivariate analysis showed that postoperative complications had a 1.65 HR for 5-year disease-free survival. In a previous study by Law et al, the occurrence of postoperative complications was an independent factor associated with poor overall survival and a high tumor recurrence rate in colorectal cancer. Because postoperative septic complications and immunosuppression adversely affect outcomes after surgery, the authors suggested that efforts to reduce postoperative complications in colorectal cancer could improve oncologic outcomes. Although our study focused on the outcomes of laparoscopic LAR, the clinical importance of reducing postoperative complications is consistent with the results of the study by Law et al. Our results suggest that careful attention during both surgery and postoperative management to avoid complications is crucial for favorable oncologic outcomes.

Patients with grade III-IV postoperative complications had a lower 5-year disease-free survival rate than those in the NCG and those with grade I-II complications. Patients in the NCG, those with grade I-II complications in the CG, and those with grade III-IV complications in the CG were compared to assess oncologic outcomes according to the severity of postoperative complications. In this study, the rate of anastomotic leakage was 7.0%, comparable with the 8 to 10% rates of anastomotic leakage following laparoscopic procedures reported in previous studies. Because anastomotic leakage may lead to extraluminal implantation of tumor cells, there were concerns that it could have a negative effect by diminishing survival through disease upstaging as well as by increasing inflammatory responses, which promote tumor spread. These findings suggest that surgeons should pay special attention to performing careful surgical procedures in order to prevent postoperative complications.

This study has limitations because it was retrospective in nature and conducted at a single institute. In addition, because open rectal cancer surgeries were excluded, the understanding about the oncologic effects of postoperative complications in rectal cancer surgeries cannot be generalized. In a future study, the impact of postoperative complications on oncologic outcomes in patients undergoing all types of colorectal surgeries should be investigated.

In conclusion, postoperative complications had a negative impact on 5-year disease-free survival after laparoscopic LAR for rectal cancer. The rate of local recurrence in the CG increased more than the NCG. In particular, for stage I cancer,
patients with postoperative complications had poorer oncologic outcomes. Because laparoscopic surgery is preferred in the early stages of rectal cancer, these findings suggest that careful attention is required to avoid postoperative complications following laparoscopic rectal cancer surgery because these could negatively affect long-term oncologic outcomes. Further large-scale, prospective randomized clinical trials are necessary to confirm the present findings.

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