Laparoscopic versus open lateral pelvic lymph node dissection in locally advanced rectal cancer: multicentre retrospective cohort study

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Abstract

**Background:** Lateral pelvic lymph node dissection (LPLND) is an option in the treatment of rectal cancer and may reduce local recurrence/improve disease-free survival. Advancements in minimally invasive technology have improved the ability to identify anatomy and neurovascular structures that may help in LPLND. The aim of this retrospective study was to evaluate the technical feasibility and oncological safety of laparoscopic LPLND compared with the open LPLND.

**Method:** Between July 2010 and July 2019, patients from three tertiary referral hospitals who underwent LPLND with total mesorectal excision for primary rectal cancer were included. Baseline patient characteristics, perioperative outcomes, pathologic results, recurrence, and survival were compared between the laparoscopic and open groups.

**Results:** There were 126 and 70 patients in the laparoscopic and open groups respectively. The laparoscopic group had less estimated blood loss (100 ml versus 300 ml, P < 0.001) and lower transfusion rate (0.8 per cent versus 10.0 per cent; P = 0.003) but longer operating times (318 min versus 270 min, P = 0.004). The laparoscopic group had fewer wound infections (1.6 per cent versus 10.0 per cent, P = 0.011) and neuropathy (0 per cent versus 4.3 per cent, P = 0.044). Lateral pelvic recurrence rate was 7.6 per cent in the laparoscopic group and 19.6 per cent in the open group (P = 0.053). Recurrence-free survival (72.2 per cent versus 63.5 per cent; P = 0.190) and overall survival (93.3 per cent versus 85.0 per cent; P = 0.118) were not significantly different.

**Conclusion:** Laparoscopic LPLND was associated with improved perioperative outcomes and non-inferior oncological outcomes.

Introduction

Locoregional recurrence after curative resection of locally advanced rectal cancer reduces patient survival and impairs quality of life. Over the last 30 years, improvements in technique, including total mesorectal excision (TME), have decreased local recurrence in patients with rectal cancer. In addition to the adoption of the TME technique, neoadjuvant chemoradiotherapy further reduces local recurrence. However, chemoradiotherapy followed by TME still has a significant risk of local recurrence of 5–9 per cent. Recent studies have reported that local recurrences that occur after preoperative chemoradiotherapy and TME mainly recur in the lateral pelvic lymph nodes (LPLNs), with more than 50 per cent of all local recurrences occurring only in the lateral compartment. Laparoscopic LPLND (LPLND) was developed with the aim of reducing local recurrence. The oncological benefits of LPLND performed for patients with suspicious metastatic LPLNs based on pre-treatment radiology have been reported in patients who received preoperative chemoradiotherapy. A large international pooled analysis demonstrated that 5-year lateral local recurrence was reduced from 19.5 to 5.7 per cent with LPLND in patients with LPLNs of more than or equal to 7 mm in the short axis. Other studies reported that local recurrence was 3–5.39 per cent (with LPLND) versus 11–20.13 per cent (without LPLND) in patients with LPLNs of more than or equal to 5 mm in the short axis and preoperative chemoradiotherapy. LPLND with TME after preoperative chemoradiotherapy is an option for managing local recurrence in advanced rectal cancer with enlarged LPLNs; however, LPLND is considered a challenging procedure due to the complex neurovascular anatomy of the lateral pelvis, which leads to longer operative times, greater blood loss and increased urinary/sexual dysfunction. To date, several studies have evaluated the outcomes of the laparoscopic LPLND technique and
reported this technique to have better short-term results, such as reduced blood loss and shorter duration of hospital stay, than the open approach\textsuperscript{21-27}. However, in most studies, LPLND was performed in all patients according to Japanese guidelines, and only a small number of patients who received preoperative chemoradiotherapy were included. Therefore, it has been difficult to directly apply these results to institutions that implement Western radiotherapy-based neoadjuvant therapy. Presently, studies reporting short-term results and long-term oncological safety of laparoscopic LPLND with preoperative chemoradiotherapy for locally advanced rectal cancer are lacking.

Since 2010, the institutions of Seoul Colorectal Research Group (SECOG) has been using radiation therapy-based treatment for advanced rectal cancer, and LPLND was selectively performed based on pre-treatment MRI. Based on this treatment strategy, the present study aimed to evaluate the technical feasibility and oncological safety of laparoscopic LPLND performed in patients with locally advanced rectal cancer by comparing its short-term and long-term outcomes with those undergoing an open approach.

Methods

Study design

This was a retrospective study based on prospectively collected databases of three tertiary referral hospitals. The study protocol was approved by the Institutional Review Board of Seoul National University Hospital (institutional review board number 2107-195-1237) and conformed with the Declaration of Helsinki. The institutional review board waived the need for informed consent due to the study’s retrospective nature.

Patients

Consecutive patients who had undergone LPLND with TME for primary rectal cancer with curative intent between July 2010 and July 2019 at three different tertiary referral hospitals, performing more than 700 laparoscopic surgeries and more than 200 rectal cancer surgeries annually, were eligible for this study. Patients with a histologically proven primary rectal adenocarcinoma located within 15 cm of the anal verge, radiologically suspected LPLN metastasis, and without M1 disease were included. Patients who had undergone palliative surgery with a history of other malignancies or synchronous multiple cancer were excluded.

The collected variables were the baseline patient characteristics, perioperative outcomes, pathological examination results, all types of recurrence, including local and metastatic, and survival.

Preoperative investigations

All patients underwent digital rectal examination (DRE), colonoscopy, chest X-ray, CT of the abdomen and pelvis, and rectal MRI before surgery to evaluate the preoperative cancer stage. The tumour height from the anal verge was determined by pathological results obtained by surgical examination. The tumour height was further divided into three operation types based on the tumour height and whether the anal sphincter complex or pelvic floor structures were invaded: low anterior resection with hand-sewn coloanal anastomosis, and abdominoperineal resection. As reported in the previous study of Seoul Colorectal Research Group (SECOG), LPLND was performed in patients with a LPLN more than or equal to 5 mm in the short axis on preoperative MRI, regardless of the chemoradiotherapy response\textsuperscript{15}. The procedure was performed by complete LPLNs removal in the adipose tissue located in the pelvic cavity, lateral to the pelvic plexus. All internal and external iliac and obturator nodes on the side of radiologically suspected LPLN metastasis were cleared, and the autonomic nerves and pelvic vessels were preserved unless they were invaded by the metastatic LPLN. The anatomical landmarks of LPLND were the external iliac artery and obturator muscle on the lateral side, pelvic plexus on the medial side, sciatic nerves on the dorsal side, and levator ani muscle on the caudal side\textsuperscript{29}. One patient group underwent both proctectomy and LPLND laparoscopically (laparoscopic group), while the others underwent both proctectomy and LPLND by laparotomy (open group).

Pathological examination findings

Surgical specimens were evaluated by a board-certified pathologist who determined the pathological stage of all specimens based on the eighth edition of the American Joint Committee on Cancer Staging System\textsuperscript{30}. Pathological outcomes that could affect the quality of the surgical procedure and oncological results, including the number of collected lymph nodes and resection margin status, were evaluated. Circumferential and distal resection margins were considered positive if the distance from the tumour to the surgical resection margin was microscopically less than 1 mm\textsuperscript{31,32}.

Postoperative and oncological outcomes

Postoperative outcomes, including morbidity and mortality within 30 days after surgery, were evaluated. The severity of complications was evaluated according to the modified Clavien–Dindo classification\textsuperscript{33}. Patient follow-up was performed every 3 months for the first 2 years after surgery, then every 6 months for up to 5 years, and once every year thereafter. Recurrence was demonstrated by pathological results obtained by surgical resection, biopsy, or cytology of the recurrent tumour and/or
radiological findings of an increase in the size of the tumour over time. Lateral pelvic recurrence was defined as the detection of tumour recurrence within the pelvic cavity, except for anastomotic and mesorectal recurrences. Finally, systemic recurrence was defined as any recurrence outside the pelvic cavity.

Statistical analysis
The characteristics of patients in the laparoscopic and open groups were compared with a Student’s t test or the Mann–Whitney U test for continuous variables, and the chi-squared test or Fisher’s exact test for categorical variables. Survival curves were estimated with the Kaplan–Meier method and comparisons between curves were performed with a log rank test.

For the time to the lateral pelvic recurrence, the first lateral pelvic recurrence was defined as an event and death due to any cause after surgery for overall survival (OS). In the determination of recurrence-free survival (RFS), any local, metastatic recurrence, or death, due to any cause after surgery was defined as an event. The impact of potential risk factors for lateral pelvic recurrence, RFS, and OS were analysed by way of univariable and multivariable Cox proportional hazard regression models. Variables remaining in the multivariable model were selected with a backward selection method. A P value ≤0.1 was used for inclusion of variable in the multivariable analysis.

Statistical significance was defined as a P value <0.050. All statistical analyses were performed with SPSS® version 25 (IBM, Armonk, New York, USA).

Results
A total of 196 patients were enrolled and analysed with a median age of 58.0 (30–82) years; 84 (42.9 per cent) were women. There were 126 patients in the laparoscopic group and 70 in the open group (Fig. 1). The patient baseline and operative characteristics are listed in Table 1 and were similar between the two groups. Preoperative chemoradiotherapy was administered to 108 of 126 patients (85.7 per cent) in the laparoscopic group and 53 (75.7 per cent) patients in the open group (P=0.080). Operation type, diverting stoma rate, and extent of LPLND were not statistically different between the two groups. The conversion from laparoscopic to open surgery occurred in 3 out of 126 patients (2.4 per cent) in the laparoscopic group. The reasons for conversion to open surgery were difficulty in securing adequate distal resection margins for rectal cancer (n=2) and T4 disease (n=1).

The laparoscopic group had longer operating times, less estimated blood loss, and lower transfusion rates than the open group (Table 2). In the subgroup analysis of estimated blood loss according to the extent of LPLND, the laparoscopic group had less blood loss than the open group in both unilateral LPLND (median 100 (range 10–1000) ml versus median 255

Fig. 1 Flow chart of the study population
TME, total mesorectal excision; LPLND, lateral pelvic lymph node dissection; LPLN, lateral pelvic lymph node.
Table 1 Baseline and surgical characteristics

| Variables                   | Lap (n = 126) | Open (n = 70) | P  |
|-----------------------------|--------------|--------------|----|
| Age, (years) median (range) | 58 (30–81)   | 59 (31–82)   | 0.950 |
| Sex                         |              |              | 0.763 |
| Male                        | 73 (57.9)    | 39 (55.7)    | |
| Female                      | 53 (42.1)    | 31 (44.3)    | |
| BMI, median (range)         | 24.1 (17.9–34.8) | 22.9 (17.8–35.0) | 0.070 |
| ASA PS                      |              |              | 0.351 |
| I–II                        | 124 (98.4)   | 67 (95.7)    | |
| III–IV                      | 2 (1.6)      | 3 (4.3)      | |
| Previous abdominal surgery  | 38 (30.2)    | 31 (20.0)    | |
| Tumour distance from AV, median (range) | 5.0 (0–15.0) | 5.0 (0–15.0) | 0.410 |
| Preoperative CRT            |              |              | |
| No                          | 18 (14.3)    | 17 (24.3)    | 0.080 |
| Yes                         | 108 (85.7)   | 53 (75.7)    | |
| Pretreatment CEA level, median (range) | 3.3 (0–703.7) | 3.7 (0.5–250.7) | 0.285 |
| Operation type              |              |              | 0.095 |
| Low anterior resection      | 93 (73.8)    | 43 (61.4)    | |
| Intersphincteric resection  | 22 (17.5)    | 14 (20.0)    | |
| Abdominoperineal resection  | 11 (8.7)     | 8 (11.4)     | |
| Diverting stoma             |              |              | |
| Unilateral                  | 103 (81.7)   | 48 (68.6)    | 0.050 |
| Bilateral                   | 23 (18.3)    | 22 (31.4)    | |
| Conversion rate             | 3 (2.4)      | NA           | |

Lap, laparoscopic; PS, physical status classification; AV, anal verge; CRT, chemoradiotherapy; CEA, carcinoembryonic antigen; LPLN, lateral pelvic lymph node dissection; NA, not applicable.

Table 2 Perioperative outcomes of laparoscopic versus open lateral pelvic lymph node dissection

| Variables                              | Lap (n = 126) | Open (n = 70) | P  |
|----------------------------------------|--------------|--------------|----|
| Operative time, (mins) median (range)  | 318 (145–650) | 270 (150–675) | 0.004 |
| Estimated blood loss, (ml) median (range) | 100 (10–1000) | 300 (20–2000) | <0.001 |
| Transfusion                            |              |              | |
| Intraoperative adverse event           |              |              | >0.999 |
| Bleeding                               | 5 (4)        | 2 (2.9)      | >0.999 |
| Urerter injury                         | 1 (0.8)      | 1 (1.4)      | >0.999 |
| Postoperative complication             |              |              | |
| Urinary retention                      | 12 (9.5)     | 6 (5.1)      | 0.351 |
| Pelvic abcess                          | 4 (3.2)      | 5 (7.1)      | 0.286 |
| Anomastatic leakage                    | 5 (4.0)      | 4 (5.7)      | 0.724 |
| Bleeding                               | 3 (2.4)      | 0 (0)        | 0.554 |
| Neupathy                               | 0 (0)        | 3 (4.3)      | 0.044 |
| Pulmonary-related complication         | 3 (2.4)      | 2 (2.9)      | >0.999 |
| Stoma-related complication             | 3 (2.4)      | 0 (0)        | 0.554 |
| Clavien–Dindo classification           |              |              | 0.889 |
| Grade <3                                | 31 (24.6)    | 19 (27.1)    | |
| Grade ≥3                                | 9 (7.1)      | 6 (8.6)      | |
| Postoperative duration of hospital stay, median (range) | 9 (3–46) | 9 (5–64) | 0.454 |
| Mortality                              | 0 (0)        | 0 (0)        | |

Lap, laparoscopic; NA, not applicable.

Table 3 Pathological outcomes of laparoscopic versus open lateral pelvic lymph node dissection

| Variables                              | Lap (n = 126) | Open (n = 70) | P  |
|----------------------------------------|--------------|--------------|----|
| p/ypT category                         |              |              | 0.121 |
| T0–2                                   | 48 (38.1)    | 19 (27.1)    | |
| T3–4                                   | 78 (61.9)    | 51 (72.9)    | |
| p/ypN category                         |              |              | 0.443 |
| NO                                     | 63 (50.0)    | 31 (44.3)    | |
| N1–2                                   | 63 (50.0)    | 39 (55.7)    | |
| Differentiation                        |              |              | 0.307 |
| WD/MD                                  | 117 (92.9)   | 61 (88.6)    | |
| PD/mucinous/SRC                        | 9 (7.1)      | 8 (11.4)     | |
| Positive resection margin              |              |              | 0.673 |
| CRM involvement (<1 mm)                | 10 (8.1)     | 7 (10.3)     | |
| DRM involvement (<1 mm)                | 2 (1.6)      | 1 (1.5)      | |
| Pathologic complete response           |              |              | 0.138 |
| Pathological LPLN metastasis           |              |              | |
| Unilateral                             | 30 (23.8)    | 24 (34.3)    | |
| Bilateral                              | 2 (1.6)      | 1 (1.4)      | >0.999 |
| Number of metastatic LPLNs, median (range) | 0 (0–7)     | 0 (0–7)     | 0.098 |
| Unilateral                             | 0 (0–4)      | 0 (0–3)      | 0.238 |
| Bilateral                              | 0 (0–7)      | 0 (0–7)      | 0.482 |
| Number of collected LPLNs, median (range) | 7 (0–23)    | 10 (0–46)   | 0.027 |
| Unilateral                             | 6 (0–16)     | 9 (0–29)     | 0.001 |
| Bilateral                              | 14 (2–23)    | 12 (3–46)    | 0.459 |
| Mesorectal LN metastasis               |              |              | 0.260 |
| Number of metastatic mesorectal LNs, median (range) | 58 (46.0)   | 26 (37.7)   | |
| Unilateral                             | 0 (0–9)      | 0 (0–8)      | 0.370 |
| Bilateral                              | 15 (20–62)   | 16 (25–70)   | |

Lap, laparoscopic; pCR, pathologic complete response; WD, well differentiated; MD, moderately differentiated; PD, poorly differentiated; SRC, signet ring cell; CRM, circumferential resection margin; DRM, distal resection margin; LPLN, lateral pelvic lymph node; LN, lymph node.

*p values were calculated using the Mann–Whitney U test for continuous variables and the chi-squared test for categorical variables. Values are n (%) unless otherwise indicated.

(p range 20–2000) ml; P < 0.001) and bilateral LPLN (median 150 (range 30–500) ml versus median 325 (range 30–2000) ml; P = 0.008). Intraoperative adverse events occurred in 6 out of 126 patients (4.8 per cent) in the laparoscopic group and in 3 out of 70 patients (4.3 per cent) in the open group (P > 0.999). Most of the adverse events were intraoperative bleeding during lymph node dissection in 5 of 126 patients (4.0 per cent) (laparoscopic group) versus 2 of 70 patients (2.9 per cent) (open group). The laparoscopic group had similar overall morbidity rates (40 of 126 patients (31.7 per cent) versus 25 of 70 (35.7 per cent); P = 0.572) and Clavien–Dindo classification (grade I and II, 31 of 126 patients (24.6 per cent) versus 19 of 70 (27.1 per cent); grade III and IV, 9 of 126 patients (7.1 per cent) versus 6 of 70 (8.6 per cent); P = 0.889) compared with the open group (Table 2). Wound infection (2 of 126 patients (1.6 per cent) versus 7 of 70 (10.0 per cent); P = 0.011) and neuropathy (0 of 126 patients (0 per cent) versus 3 of 70 (4.3 per cent); P = 0.044) were significantly lower in the laparoscopic group. Three patients had neuropathy in the open group, of whom two had sciatic neuropathy and one had obturator neuropathy. All three patients with postoperative bleeding in the laparoscopic group were found to have intraluminal anastomotic bleeding, which was not related to the LPLND site. Postoperative duration of hospital stay was similar between the two groups (9 (3–46) days versus 9 (5–64) days; P = 0.454), and no postoperative mortality within postoperative 30 days occurred in either group.

The p/ypT category, p/ypN category, tumour differentiation, resection margin status, and pathological complete response

*p values were calculated using the Mann–Whitney U test for continuous variables and the chi-squared test for categorical variables. Values are n (%) unless otherwise indicated.
rate of the laparoscopic group were comparable to the open group (Table 3). The overall pathological LPLN metastasis rate of the study population was 29.1 per cent (57 of 196 patients), of which 27.6 per cent (54 of 196) had unilateral metastasis, and 1.5 per cent (3 of 196) had bilateral metastases. The pathological LPLN metastasis rate (32 of 126 patients (25.4 per cent) versus 25/70 (35.7 per cent); \( P = 0.128 \)) and the median number of metastatic LPLNs (0 (0–7) versus 0 (0–7); \( P = 0.098 \)) were comparable between the groups. The median number of collected LPLNs was significantly higher in the open group than in the laparoscopic group (overall 7 (0–23) versus 10 (0–46); \( P = 0.027 \); unilateral 6 (0–16) versus 9 (0–29); \( P = 0.021 \)). The mesorectal lymph node metastasis rate, number of metastatic, and collected mesorectal lymph nodes were also similar between the two groups.

Kaplan–Meier curves of the lateral pelvic recurrence rate, recurrence-free survival, and overall survival according to surgical approach (Fig. 2). Rates were similar between the laparoscopic group and the open group. Lap, laparoscopic.

Oncological outcomes, including the lateral pelvic recurrence rate (3-years, 7.6 per cent versus 19.6 per cent; \( P = 0.053 \); Fig. 2a), RFS (3-years, 72.2 per cent versus 63.5 per cent; \( P = 0.190 \); Fig. 2b), and OS (3-years, 93.3 per cent versus 85.0 per cent; \( P = 0.118 \); Fig. 2c), were comparable between the two groups. Subgroup analysis of oncological outcomes in patients with pathological LPLN metastasis was performed and the lateral pelvic recurrence rate (3-years, 7.2 per cent versus 26.5 per cent; \( P = 0.114 \)), RFS (3-years, 65.1 per cent versus 50.0 per cent; \( P = 0.141 \)), and OS (3-years, 91.6 per cent versus 73.1 per cent; \( P = 0.063 \)) were also comparable between the two groups.

Cox regression analysis for variables associated with lateral pelvic recurrence, RFS, and OS is shown in Table 4 and Table S1. Multivariable analysis revealed that preoperative CEA (HR 1.003, 95 per cent c.i. 1.001 to 1.006; \( P = 0.018 \)), transfusion rate (HR 11.886, 95 per cent c.i. 2.376 to 59.463; \( P = 0.003 \)), and p/ypN category (HR 7.513, 95 per cent c.i. 1.588 to 35.555; \( P = 0.011 \)) were independent prognostic factors for lateral pelvic recurrence, whereas estimated blood loss (HR 1.001, 95 per cent c.i. 1.000 to 1.002; \( P = 0.025 \)) and p/ypN category (HR 5.072, 95...
Table 4 Multivariable Cox proportional hazard regression model analysis for lateral pelvic recurrence, recurrence-free survival, and overall survival

| Surgical approach | Lateral pelvic recurrence | Recurrence-free survival | Overall survival |
|-------------------|--------------------------|--------------------------|-----------------|
| Open              | Reference                | Reference                | Reference       |
| Lap               | 0.547 (0.166–1.805)      | 0.980 (0.451–2.129)      | 0.880 (0.283–2.730) |
| Pretreatment CEA level |                      |                          |                 |
| Yes               | 1.003 (1.001–1.006)      | 1.001 (1.000–1.002)      | 1.001 (1.000–1.003) |
| No                | Reference                | Reference                | Reference       |
| Estimated blood loss |                          |                          |                 |
| No                |                          | 1.001 (1.000–1.002)      | 1.001 (1.000–1.003) |
| Yes               |                          | 1.003 (1.001–1.006)      | 1.003 (1.001–1.006) |
| Transfusion       |                          |                          |                 |
| No                | Reference                | Reference                | Reference       |
| Yes               | 11.886 (2.376–59.463)    | 1.042 (1.008–1.078)      | 1.042 (1.008–1.078) |
| Postoperative hospital stay |              |                          |                 |
| No                | Reference                | Reference                | Reference       |
| Yes               | 7.513 (1.588–35.555)     | 5.072 (2.219–11.596)     | 5.072 (2.219–11.596) |
| p/ypN category    |                          |                          |                 |
| No                | Reference                | Reference                | Reference       |
| Yes               | 27.513 (2.376–59.463)    | 7.513 (1.588–35.555)     | 7.513 (1.588–35.555) |
| N1–2              | 5.072 (2.219–11.596)     | <0.001                   | <0.001          |
| Mesorectal LN metastasis |                  |                          |                 |
| No                | Reference                | Reference                | Reference       |
| Yes               | 3.408 (1.062–10.937)     | 3.408 (1.062–10.937)     | 3.408 (1.062–10.937) |

Lap, laparoscopic; CEA, carcinoembryonic antigen; LN, lymph node.

per cent c.i. 2.219 to 11.596; \( P < 0.001 \) were prognostic factors for RFS. Estimated blood loss (HR 1.001, 95 per cent c.i. 1.000 to 1.003; \( P = 0.025 \)), postoperative hospital stay (HR 1.042, 95 per cent c.i. 1.008 to 1.078; \( P = 0.015 \)), and mesorectal lymph node metastasis (HR 3.408, 95 per cent c.i. 1.062 to 10.937; \( P = 0.039 \)) were predictors of OS. Surgical approaches, laparoscopy, or laparotomy were not prognostic factors for lateral pelvic recurrence, RFS, and OS.

**Discussion**

Laparoscopic LPLND enabled better perioperative results by preserving the neurovascular structures of the lateral pelvis more meticulously and resulted in better outcomes in rectal cancer patients with LPLN size larger or equal to 5 mm before treatment. Laparoscopic LPLND resulted in better outcomes in terms of intraoperative bleeding and neuropathy compared with those observed with the open approach. The pathological and oncological outcomes of laparoscopic LPLND were similar to those of the open approach.

In 2011, three technical notes retrospectively reviewed the feasibility of laparoscopic LPLND in 11–34 patients and reported morbidity rates of 20.6–35.7 per cent and local recurrence rates of 6.1–11.2 per cent\(^{21–25} \). Three retrospective studies demonstrated that patients in the laparoscopic LPLND group had significantly less haemorrhage and similar recurrence and survival rates to those in the open group\(^{24–26} \). Although laparoscopic LPLND of locally advanced rectal cancer is not yet widely performed because of its technical difficulty and the anatomical complexity of the lateral pelvic compartment, previous studies suggest that laparoscopic LPLND might be superior to open LPLND.

Laparoscopic LPLND can be more technically challenging in patients after chemoradiotherapy with tissue fibrosis, oedema, and neural degeneration\(^{34,35} \). Tissue fibrosis interferes with dissection in the correct anatomical plane and tissue oedema can cause misting, further reducing visibility of structures\(^{27} \). Therefore, without considerable caution during surgery, damage to blood vessels, nerves, or ureters may increase, leading to postoperative complications. Despite these concerns, the findings of this study confirm the safety and oncological adequacy of laparoscopic LPLND with preoperative chemoradiotherapy. In the present study, intraoperative adverse events occurred at similar rates in the laparoscopic and open groups. Moreover, only three cases (2.4 per cent) required conversion to open surgery in the laparoscopic group, all of which occurred during the proctectomy procedure. Furthermore, the short-term outcomes in the laparoscopic group, overall morbidity rate (31.7 per cent) were comparable to those of the open group. Among the short-term outcomes, wound infection, blood loss, and neuropathy, were significantly better, and among the long-term outcomes, lateral pelvic recurrence rate, although not statistically significant, tended to be better in the laparoscopic group in the present study.

Considering that the extent of LPLND may affect the amount of blood loss, unilateral LPLND and bilateral LPLND were further analysed separately in the subgroup analysis and the laparoscopic group still demonstrated less blood loss than the open group.

These favourable results of laparoscopic LPLND may have been facilitated with advanced laparoscopic devices that allow for more meticulous node dissection with a magnified surgical view. Advanced laparoscopes provide better visualization of the obturator foramen and Alcock’s canal, wherein 85 per cent of LPLN metastases occur, and are located in the deepest pelvis when approached from the abdomen\(^{36} \). Advanced energy devices that utilize ultrasonic and bipolar energy may have reduced lymphatic spillage and cancer cell contamination. Other possible explanations include recent increased understanding of lateral pelvic anatomy with the advent of laparoscopic approaches and possibly less tumour growth stimulation due to a decrease in perioperative surgical stress\(^{37} \). Consequently, this may have led to better operative outcomes, including reduced blood loss and neuropathy.

In the present study, the median number of collected LPLNs, which can measure adequate lymph node dissection, was significantly lower in the laparoscopic group (7 versus 10; \( P = 0.027 \)). This may have resulted from the greater number of patients who underwent preoperative chemoradiotherapy in the laparoscopic group, although the difference was not statistically significant (108 of 126 patients (85.7 per cent) versus 53 of 70 (75.7 per cent); \( P = 0.080 \)). Previous studies have reported that the number of lymph nodes retrieved after preoperative chemoradiotherapy for rectal cancer significantly decrease by...
28.9–32.6 per cent due to apoptosis and degeneration. Meanwhile, the pathological LPLN metastasis rate reported in a previous study as 13.9 per cent was similar between two groups (32 of 126 patients (25.4 per cent) versus 25 of 70 (35.7 per cent); P = 0.128). Therefore, it can be concluded that LPLND to retrieve the metastatic lymph nodes was performed appropriately.

This study had limitations. Firstly, because of its retrospective design, the possibility of selection bias cannot be excluded. Although this study was based on a prospectively maintained cohort from three institutions, this study was not a randomized clinical trial, and the inherent limitations were inevitable because surgeons determined whether the operation would be performed laparoscopically or not. Therefore, multivariable analysis was used to assess the individual effect of the surgical approach on the oncological outcomes and confirmed that the surgical approach was not an independent prognostic factor for all oncological outcomes. Further prospective randomized studies are needed to overcome this limitation. Secondly, due to the variety of regimens, doses, and completion statuses of preoperative chemoradiotherapy, which can influence the oncological outcomes, could not be stratified and analysed. Finally, sexual dysfunction caused by nerve injury could not be assessed due to a lack of data on postoperative functional outcomes. Despite these limitations, considering the limited number of institutions performing laparoscopic LPLND, this study reports clinically important messages regarding the possible benefits of laparoscopic LPLND in intraoperative and postoperative outcomes and the long-term safety of LPLND after preoperative chemoradiotherapy.

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**Disclosure**. The authors declare no conflict of interest

**Supplementary material**

Supplementary material is available at BJS online.

**Data availability**

The data described in the manuscript are not provided due to privacy and ethical restrictions; however, anonymous data necessary to reproduce the results will be available from the corresponding author on reasonable request.

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