Original Article

Robot-Assisted versus Laparoscopic Surgery for Pelvic Lymph Node Dissection in Patients with Gynecologic Malignancies

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Abstract

Objectives: The objective of this study was to compare the surgical outcomes for pelvic lymph node dissection (PLND) performed through conventional laparoscopic surgery (CLS) versus robot-assisted surgery (RAS) in patients with gynecologic malignancies.
Materials and Methods: Perioperative data, including operative time, estimated blood loss, and complications, were retrospectively analyzed in 731 patients with gynecologic malignancies who underwent transperitoneal PLND, including 460 and 271 in the CLS and RAS groups, respectively. Data were statistically analyzed using the Chi-square test or Student's *t*-test as appropriate. $P < 0.05$ was considered statistically significant.
Results: The mean age was 50 ± 14 years and 53 ± 13 years in the RAS and CLS groups ($P < 0.01$), respectively. The mean body mass index was 23.4 ± 4.8 kg/m^2 and 22.4 ± 3.6 kg/m^2 in the RAS group and CLS groups ($P < 0.01$), respectively. The operative time, blood loss, and number of resected lymph nodes were 52 ± 15 min, 110 ± 88 mL, and 45 ± 17, respectively, in the RAS group and 46 ± 15 min, 89 ± 78 mL, and 38 ± 16, respectively, in the CLS group (all $P < 0.01$). The rate of Clavien-Dindo Grade ≥ III complications was 6.3% and 8.7% in the RAS and CLS groups, respectively ($P = 0.17$).
Conclusion: Shorter operative time and lower blood loss are achieved when PLND for gynecologic malignancies is performed through CLS rather than RAS. However, RAS results in the resection of a greater number of pelvic lymph nodes.

Keywords: Gynecologic cancer, laparoscopy, lymphadenectomy, minimally invasive surgery, robotic surgery

Introduction

Pelvic lymph node dissection (PLND) is both standard and crucial for staging gynecologic malignancies and is performed to determine if a patient requires adjuvant therapy. While its therapeutic significance has not yet been fully established, some studies have shown that PLND improves the prognosis of patients with uterine cancer, who have an intermediate and high risk of recurrence,[1-3] with the prognosis being dependent on the number of lymph nodes resected during the procedure.[4-7] As lymph node metastasis (LNM) is an important predictor of prognosis in patients with gynecologic cancers,[8] the Japanese guidelines for uterine and ovarian cancer recommend PLND for accurate surgical staging.[9-11] Currently, there is no established, complete, and reliable system for diagnosing preoperative LNM.[9]

PLND was originally performed through laparotomy; however, in 1989, Dargent and Salvat first reported a laparoscopic approach for PLND that could be successfully applied in patients with cervical cancer.[12] Since then, minimally invasive surgery (MIS) for gynecological cancers has become more prevalent worldwide. Prospective randomized controlled trials and other studies have already shown that both laparoscopic

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and open surgeries result in comparable numbers of resected lymph nodes.[13-17] A recent prospective study of conservative surgery suggested that conization, followed by lymph node assessment, may be sufficient for early-stage, low-risk cervical cancer.[18] It was considered that even as conservative, less radical surgery becomes preferable, the role of the PLND remains clinically very important.

Robot-assisted surgery (RAS) is a relatively new MIS with some advantages over other surgical techniques, including improved visualization through three-dimensional imaging, greater precision, more accurate control of instrumentation, and improved surgical ergonomics.[19] Despite the successful development of MIS, the literature showing the surgical outcomes of PLND alone between MIS modalities is lacking. Therefore, in this study, we aimed to compare the outcomes of PLND in patients with gynecologic malignancies between RAS and conventional laparoscopic surgery (CLS).

Materials and Methods

Study population

We retrospectively analyzed the data of patients who underwent laparoscopic or robotic PLND for gynecologic cancer from January 2010 to December 2018 at our hospital. Indications for PLND as surgical staging included cervical, endometrial, and ovarian cancers. Preoperative evaluations included physical examinations, vaginal pelvic examinations, chest radiography, computed tomography, and pelvic magnetic resonance imaging. All patients were informed of the risks and possible complications of the surgery. This study was conducted in accordance with the principles embodied in the Declaration of Helsinki and was approved by the Institutional Review Board of our hospital (IRB no. blinded for peer review). Written informed consent was obtained from all patients.

Surgical strategy

All surgical procedures were performed by an expert surgeon and our MIS team. The da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) was employed for RAS, while a conventional two-dimensional laparoscopic surgical system was used for CLS. We performed transperitoneal systematic PLND in six steps as follows: (1) port placement [Figure 1], (2) development of the paravesical and pararectal spaces, (3) suspension of the lateral umbilical ligament (vesicohypogastric fascia) [Figure 2a], (4) dissection between the psoas major muscle and external iliac vessels, (5) dissection of the external iliac and obturator nodes [Figure 2b], and (6) dissection of the internal iliac nodes [Figure 2c]. In the RAS group, the camera port was placed midline, approximately 3 cm above the umbilicus; then, three robotic ports and one assistant port were placed [Figure 1].

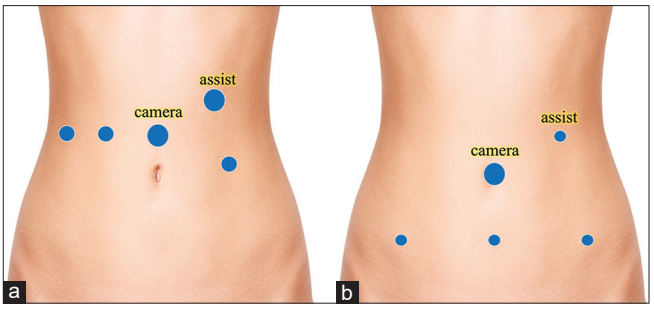

Figure 1: Port placement used for each surgical approach. (a) robot-assisted surgery, (b) conventional laparoscopic surgery

Lateral umbilical ligament suspension is a technique for securing the operative field; this technique broadly expands the paravesical space while keeping the intestines outside the operative field. The PLND field of dissection ranged from the level of the bifurcation of the internal and external iliac arteries (cranial) to the deep circumflex iliac vein (caudal) [Figure 2d]. The lateral suprainguinal nodes were spared because they are associated with a low LNM risk[20] and due to the potential for lower-limb lymphedema.[21,22] The external iliac and obturator nodes were dissected *en bloc* to a depth at which the pelvic wall structures (the levator ani and obturator internus muscles and lumbosacral trunk) could be identified. In Japan, sentinel lymph node navigation surgery was not covered by medical insurance and is only permitted as part of a clinical study; therefore, we performed systematic lymph node dissection during this period. CLS was performed with scissor forceps, a Probe Plus II system, and an ENSEAL device (Ethicon, Johnson and Johnson, OH, USA). RAS was performed using monopolar curved scissors, fenestrated bipolar forceps, Maryland bipolar forceps, and a vessel sealer instrument (Intuitive Surgical).

All resected nodal tissues were either retrieved in a collection bag or harvested through a laparoscopic reducer sleeve (Jarit, Rietheim-Weilheim, Germany). A single retroperitoneal drain was inserted at the end of the surgery.

Data collection and analysis

Data were collected from the patients' medical records, including patients' characteristics such as age, body mass index, and indication for surgery and perioperative outcomes such as estimated blood loss (EBL), operative time, number of removed lymph nodes, conversion to laparotomy, blood transfusion, and intra- and postoperative complications. Lymphedema was included if it was Grade 2 or higher in severity according to the International Society of Lymphology classification.[23]

Surgical data were collected from steps 4 to 6 of the PLND procedure. We analyzed the data from intrapelvic surgery alone because para-aortic lymph node dissection was performed through a conventional endoscopic extraperitoneal approach

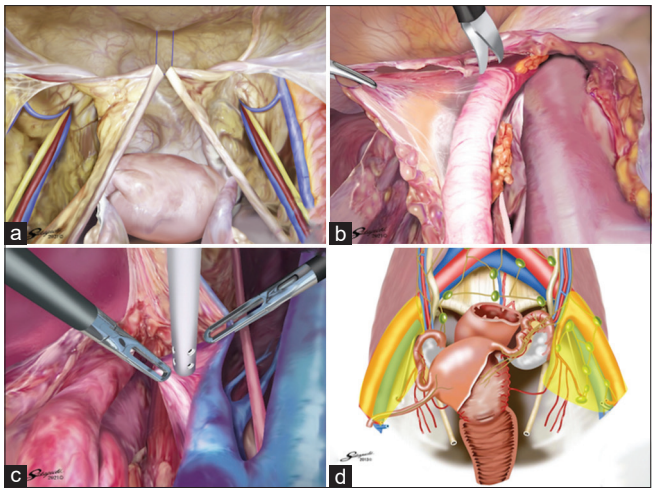

Figure 2: (a) Lateral umbilical ligament suspension technique, (b) dissection of the external iliac lymph nodes, (c) dissection of the internal iliac lymph nodes, and (d) dissection area of the pelvic lymph nodes

without robot for both groups. Continuous data are presented as means ± standard deviations, while categorical data are presented as numbers. Categorical variables were compared using the Chi-square test, while variables with a normal distribution were compared using the Student's *t*-test. All analyses were performed using the Statistical Package for the Social Sciences software version 16.0 (SPSS Inc., Cary, NC, USA). Statistical significance was set at $P < 0.05$.

Results

Of the 731 patients included in this study, 460 and 271 underwent PLND through CLS and RAS, respectively. The patients' characteristics are shown in Table 1. The mean patient age was 50 ± 14 years and 53 ± 13 years in the RAS and CLS groups ($P < 0.01$), respectively. The mean body mass index was 23.4 ± 4.8 kg/m^2 and 22.4 ± 3.6 kg/m^2 in the RAS group and CLS groups ($P < 0.01$), respectively. The proportions of patients with a history of surgery were comparable between the groups (CLS, 25.0%; RAS, 29.7%). The operative time was shorter in the CLS groups than in the RAS group (means, 46 vs. 52 min, $P < 0.01$), while the EBL was lower (89 vs. 110 mL, $P < 0.01$). A greater number of lymph nodes were resected in the RAS group than in the CLS group (45 vs. 38, $P < 0.01$) [Table 2]. In patients with endometrial cancer, no significant differences were observed between the groups in terms of the number of lymph nodes resected (39 vs. 42, $P = 0.11$); however, in patients with cervical cancer, significantly more lymph nodes were removed in the RAS group than in the CLS group (48 vs. 38, $P < 0.01$) [Table 2]. The numbers of dissected lymph nodes were also compared based on the anatomical sites and sides (left/right). A significantly greater number of the external iliac and obturator lymph nodes were removed on both the left and right sides in the RAS group than in the CLS group; however, no left–right differences in the total number of resected lymph nodes (i.e., the total number of internal iliac, common iliac, and cardinal lymph nodes) were observed within each group [Table 3].

Table 1: Baseline characteristics of the patients in the study ($n=732$)

	Number of patients (%)		*P*
	CLS ($n=460$)	RAS ($n=271$)	
Age (year), mean±SD	53±13	50±14	<0.01*
BMI (kg/m^2), mean±SD	22.4±3.6	23.4±4.8	<0.01*
BMI (>30 kg/m^2) (*n*)	11 (2.3)	32 (11.8)	<0.01†
Previous abdominal surgery (*n*)	115 (25.0)	81 (29.7)	0.15*
Indication for surgery (*n*)			
Uterine cervical cancer	144 (31.3)	125 (46.0)	<0.05†
Uterine corpus cancer‡	231 (50.2)	143 (52.6)	
Ovarian cancer§	85 (18.5)	3 (1.1)	
Surgical stage (*n*)			
Uterine cervical cancer (FIGO2008)			
I	119 (82.6)	108 (86.4)	0.43†
II	22 (15.3)	16 (4.8)	
III and IV	3 (2.0)	1 (0.7)	
Uterine corpus cancer‡ (FIGO2008)			
I	190 (82.2)	114 (79.7)	0.47†
II	21 (9.1)	14 (9.8)	
III and IV	20 (8.7)	15 (10.4)	
Ovarian cancer§ (FIGO2014)			
I	41 (48.2)	2 (66.7)	0.87†
II	12 (14.1)	0	
III and IV	31 (37.7)	1 (33.3)	

*Student's *t*-test, †Chi-square test, ‡Endometrial stromal sarcoma (n=2) and carcinosarcoma (n=3), §Fallopian tube and peritoneal cancer. BMI: Body mass index, CLS: Conventional laparoscopic surgery, FIGO: International Federation of Gynecology and Obstetrics, RAS: Robot-assisted surgery, SD: Standard deviation

Twelve cases were required to achieve a proficient operative time in RAS [Supplementary Figure 1]. The rates of Clavien-Dindo Grade ≥ III complications were 8.7% in the CLS group and 6.3% in the RAS group ($P = 0.17$). Intraoperative complications occurred in 6 (1.3%) patients in the CLS group (two had injuries of the obturator nerve, and four had injuries of the external iliac vein) and in 1 (0.4%) patient in the RAS group, who had injury of the external iliac artery. These complications were managed endoscopically, and none of the patients required blood transfusion or conversion to laparotomy. Moreover, postoperative complications occurred in 34 (7.4%) patients in the CLS group, including 19 (4.1%) with lower-extremity lymphedema and 15 (3.3%) with symptomatic lymphoceles. In the RAS group, 16 (5.9%) patients experienced postoperative complications, including 10 (3.7%) with lower-extremity lymphedema and 6 (2%) with symptomatic lymphoceles [Table 2]. The rates of postoperative complications were not significantly different between the two groups ($P = 0.43$).

Table 2: Surgical outcomes

	Number of patients (%)		*P*
	CLS (*n*=460)	RAS (*n*=271)	
Operative time (min), mean±SD	46±15	52±15	<0.01†
EBL (mL), mean±SD	89±78	110±88	<0.01†
Surgical complications (*n*)‡	40 (8.7)	17 (6.3)	0.17*
Intraoperative complications (*n*)‡			
Bowel injury	0	0	0.21*
Bladder/ureteral injury	0	0	
Vascular injury	4 (0.9)	1 (0.4)	
Nerve injury	2 (0.4)	0	
Postoperative complications (*n*)‡			
Symptomatic lymphocele	15 (3.3)	6 (2.2)	0.43*
Total number of lymphocysts	34 (7.4)	24 (8.8)	
Lower-extremity lymphedema	19 (4.1)	10 (3.7)	
Venous thromboembolism	0	0	
Blood transfusion (*n*)	0	0	
Conversion to laparotomy (*n*)	0	0	
Pelvic lymphadenectomy			
Number of lymph nodes (*n*), mean±SD	38±16	41±16	<0.01†
Number of lymph nodes (*n*), median (range)	36 (8–95)	43 (11–113)	
Uterine corpus cancer	CLS (*n*=231)	RAS (*n*=143)	
Number of lymph nodes (*n*), mean±SD	39±16	42±16	0.11†
Number of lymph nodes (*n*), median (range)	40 (8–95)	42 (11–96)	
Uterine cervical cancer	CLS (*n*=144)	RAS (*n*=125)	
Number of lymph nodes (*n*), mean±SD	38±16	48±18	<0.01†
Number of lymph nodes (*n*), median (range)	35 (11–88)	47 (17–113)	

*Student's *t*-test, †Chi-square test, ‡Clavien-Dindo classification grade ≥III (only due to pelvic lymphadenectomy). CLS: Conventional laparoscopic surgery, RAS: Robot-assisted surgery, SD: Standard deviation, EBL: Estimated blood loss

Table 3: Number of lymph nodes dissected (*n*; mean±standard deviation) in each group

	Number of patients (%)		*P*
	CLS (*n*=144)	RAS (*n*=125)	
Left side			
External iliac and obturator lymph nodes	12.7±5.9	19.2±7.3	<0.01*
Internal iliac lymph nodes	2.1±2.6	2.8±2.7	0.25*
Common iliac lymph nodes	0.6±1.9	1.0±2.3	0.37*
Cardinal lymph nodes	1.7±1.8	1.1±1.5	0.11*
Right side			
External iliac and obturator lymph nodes	13.0±6.2	20.2±8.3	<0.01*
Internal iliac lymph nodes	3.1±3.8	2.6±2.5	0.47*
Common iliac lymph nodes	0.5±1.2	1.1±2.9	0.25*
Cardinal lymph nodes	1.9±2.6	1.4±1.8	0.31*

*Student's *t*-test. CLS: Conventional laparoscopic surgery, RAS: Robot-assisted surgery

Discussion

PLND is critical for accurately staging gynecologic malignancies and guiding treatment decisions regarding adjuvant therapy. Even though less radical surgery has become preferable in recent years,[18] PLND likely remains of critical importance. Furthermore, despite the successful development of MIS, the literature lacks studies showing the outcomes of PLND alone between MIS modalities.

One noteworthy finding of our study is that a significantly higher number of lymph nodes were dissected in the RAS group than in the CLS group. Although the number of lymph nodes was statistically similar between the two MIS modalities in patients with endometrial cancer, these counts were significantly higher in the RAS group than in the CLS group in patients with cervical cancer. Systematic reviews and meta-analyses have shown that the numbers of dissected lymph nodes in patients with endometrial versus cervical cancers are comparable;[24-29] however, several studies also found that RAS results in higher numbers of dissected lymph nodes among patients undergoing radical hysterectomy for cervical cancer.[30-32] Perhaps, the more advanced technology might have contributed to this discrepancy, as the da Vinci robotic surgical system provides surgeons with a greater range of instrument movement, enhanced dexterity, and improved three-dimensional visualization. These advantages might enable surgeons to overcome some of the limitations of conventional laparoscopy, especially when performing

complex procedures like radical hysterectomy. However, based on our current data, we could not identify plausible reasons for our finding that a higher number of lymph nodes was resected in the RAS group than in the CLS group. Although a greater number of the external iliac and obturator lymph nodes was removed in the RAS group, there was no difference in the number of internal iliac lymph nodes removed (the removal of the internal iliac lymph nodes requires skillful manipulation deep within the pelvic cavity) [Supplementary Figure 2]. Further investigation will be necessary.

Systematic reviews and meta-analyses have also indicated that RAS is generally associated with a longer operative time and lower blood loss than CLS, although RAS and CLS have comparable complication rates.[17,24-29] Our findings with respect to operative time and complications were consistent with those studies. However, we found that blood loss was statistically lower in the CLS group than in the RAS group; this discrepancy can be attributed to the different devices used.[33,34] For CLS, we have used the Probe Plus II for many years, which was a suction irrigator probe with a built-in integrated monopolar electrode. Although this device enables the immediate detection of bleeding points, followed by prompt hemostasis without exchanging forceps, no equivalent instrument was used for RAS. However, it was considered that the difference in blood loss (approximately 20 mL) was within a clinically acceptable range.

The patients in our study experienced lymphatic complications such as lymphoceles and lower-extremity lymphedema with rates comparable to those reported in previous studies;[35-38] moreover, there was no difference in the incidence rates of these complications between the CLS and RAS groups. All patients had a retroperitoneal drainage tube inserted at the end of the surgery. A recent study found that the drainage tube offered no benefit in lymphocele prevention;[39] however, our goal was not to prevent lymphoceles but to use it as a rapid indicator of any postoperative bleeding that occurred.

The learning curve and experience of the surgeon could be the important factors in the number of lymph nodes retrieved.[40,41] With respect to the learning curve for robotic PLND, 12 cases were required to achieve a proficient operative time using RAS [Supplementary Figure 1], which is much lower than the 55 cases required in a previous study.[42] Because we had mastered laparoscopic techniques owing to several years of experience, the learning curve for CLS was not measured in this study. Our department began performing laparoscopic PLND in 1998; thus, by the time we introduced robotic PLND in 2013, the surgeon had ample experience with this procedure. We cannot rule out the possibility that our experience in performing laparoscopic PLND had a positive influence on proficiency with robotic PLND because the procedure and surgical steps were completely the same.

One of the limitations of this study was that the possibility of selection bias could not be ruled out owing to its retrospective design. The experiences and preferences of the surgeons could play a major role in the bias. Moreover, given the prolonged interval between the introduction of laparoscopic PLND and that of robotic PLND at our center, there may be differences in the proficiency of surgeons in applying these two MIS methods. However, as the learning curve for robotic PLND was determined to be 12 cases, mature data were available and analyzed for both groups. One notable strength of our study is that, to the best of our knowledge, it is the first to compare the surgical outcomes of PLND alone as performed through RAS versus CLS in patients with gynecologic malignancies.

Conclusion

The operative time was significantly longer and EBL was significantly greater when RAS was used to achieve PLND instead of CLS. While it remains unclear whether the prognosis is directly affected by the number of dissected lymph nodes, a significantly greater number of lymph nodes was dissected in the RAS group than in the CLS group. Additional studies, including prospective randomized controlled trials, are needed to examine postoperative pain and quality of life among patients who undergo MIS-PLND.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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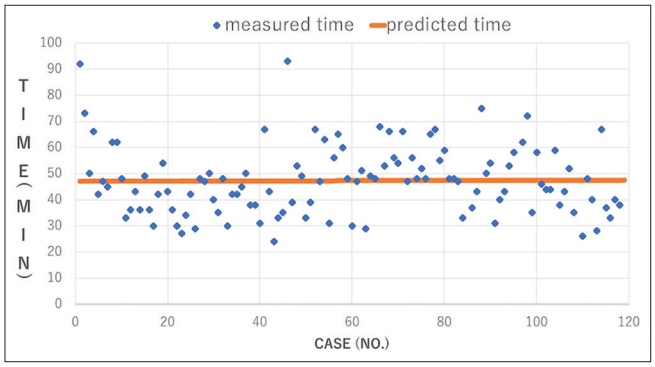
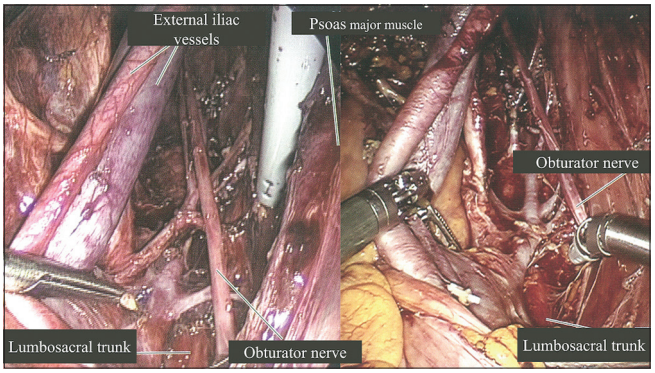
Supplementary Material



Supplementary Figure 1: Learning curve for robotic pelvic lymph node dissection in patients with endometrial cancer; trends in operative time; $y = 0.003774x + 47.0445$, $x = 12$ cases, average = 47 min



Supplementary Figure 2: Difference in pelvic lymph node dissection between conventional laparoscopic hysterectomy and robot-assisted surgery for cervical cancer; no visual difference was found in postdissection status between conventional laparoscopic surgery and robot-assisted surgery (the external iliac and obturator area)