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Safety and feasibility of laterally extended endopelvic resection for sarcoma in the female genital tract: a prospective cohort study

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Objective
This study aims to evaluate the safety and feasibility of laterally extended endopelvic resection (LEER) for sarcoma in the female genital tract.

Methods
We prospectively recruited gynecologic cancer patients with sarcoma arising from female genital tract who underwent LEER at Seoul National University Hospital from December 2016 to March 2021. Clinicopathologic characteristics, surgical outcomes including postoperative complications and pain control, and survival outcomes of the patients were investigated.

Results
A total of nine patients were registered for this study. The median age was 56 years. Carcinosarcoma (n=2, 22%), leiomyosarcoma (n=2, 22%), and undifferentiated uterine sarcoma (n=2, 22%) were common histology types. Complete resection was achieved in 88.9%. The most common location of pelvic sidewall tumors was infra-iliac acetabulum (66.7%). The pathologic outcome showed a median tumor size of 9.0 cm and internal iliac vessel resection with pelvic sidewall muscle was performed in all patients. The median estimated blood loss was 1,600 mL (range, 300-22,300), and the patients were postoperatively admitted to the intensive care unit for median 1 day (range, 0-8). Complete response was observed in 44.4% (4/9) in radiologic studies after LEER, and median progression-free survival, treatment-related survival, and overall survival were 3.3, 19.6, and 98.9 months, respectively.

Conclusion
LEER was feasible and safe in treating recurrent sarcoma presenting pelvic sidewall invasion with acceptable survival outcomes and manageable postoperative complications.

Keywords: Gynecologic surgical procedure; Pelvic exenteration; Sarcoma; Surgery

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Introduction

Sarcomas of the female genital tract are rare mesenchymal neoplasms, accounting for 1-3% of female genital tract malignancies [1]. Among them, uterine sarcomas contribute to 3-7% of uterine malignancies [2,3] and ovarian sarcomas contribute to 1% of ovarian malignancies [1,4,5]. Among gynecological sarcomas, uterine sarcoma is the most common (83%), followed by ovarian sarcoma (8%) [6]. Recent updates on female genital tract pathology have classified uterine sarcomas as mesenchymal tumors specific to the uterus, and the sub-classifications are as follows: leiomyosarcoma, endometrial stromal sarcoma (low grade), endometrial stromal sarcoma (high grade), and undifferentiated sarcoma [7]. Before the year 2014, carcinosarcoma had been classified as uterine sarcoma. However, in the 2014 World Health Organization classification it was reclassified as uterine carcinoma based on the tumor biology [8]. Nevertheless, due to its aggressive behavior, carcinosarcoma is still classified and analyzed together with sarcoma in several works of literature [3].

Five-year relative survival rate of uterine sarcoma is 40-50% [2], and poor survival rate of 37.33% and 12.25% have been reported in regional and distant stages, respectively [9]. Despite the poor prognosis, the role of surgery in the initial treatment stage of sarcoma patients is crucial in terms of diagnosis and survival. Preoperative diagnosis of sarcoma originating from female genital tract using imaging or cytology is difficult, and most gynecologic sarcomas can be diagnosed accurately only after surgery followed by careful pathologic examinations [10,11]. So far, the International Federation of Gynecology and Obstetrics (FIGO) staging and the absence of residual tumor after surgery are known prognostic factors for uterine sarcoma [10,12,13]. Furthermore, the role of adjuvant treatment, including radiotherapy or chemotherapy after surgery, is controversial [9,14,15]. Moreover, complete resection during secondary cytoreductive surgery has been shown to be effective for recurrent gynecologic sarcomas [16]. Therefore, complete cytoreduction is required for gynecologic sarcomas in both primary and recurrent settings.

Laterally extended endopelvic resection (LEER) was introduced in 1999 to treat recurrent cervical cancer involving the pelvic sidewall [17]. The LEER procedure enabled gynecologic surgeons to remove tumors at the pelvic sidewall, achieving R0 resection, which could not be achieved with pelvic exenteration alone. In previous studies, only heterogeneous data containing a small number of sarcomas were presented [18,19]. Therefore, this study aims to conduct an in-depth case review of gynecologic sarcoma who underwent LEER at Seoul National University Hospital.

Materials and methods

We prospectively collected data of patients with pelvic wall sarcoma who underwent LEER at Seoul National University Hospital between December 2016 and March 2021 (Fig. 1). This study was registered in the public registry (ClinicalTrials.gov identifier: NCT02986568). We included patients with the following features: 1) age of 20 years or older, 2) primary or recurrent pelvic wall sarcoma, 3) pelvic wall sarcoma without the involvement of the ipsilateral sciatic foramen, and 4) pelvic wall sarcoma expected to be cured by LEER. Among them, we excluded patients if they had bilateral pelvic wall sarcoma or any other available treatment options except LEER. We collected clinicopathologic data, including age, comorbidity, histologic type, disease status at the time of surgery, initial FIGO stage or American Joint Committee of Cancer soft tissue sarcoma staging system [20], preoperative lesion size of pelvic sidewall tumors, disease extent assessed by The TNM classification of malignant tumors (TNM) stage on radiologic imaging studies [21], topographic location of pelvic sidewall tumors, types of previous treatment, lines of prior chemotherapy, prior chemotherapy regimen and cycles, prior targeted-agent therapy, treatment-free interval before LEER, and median duration of follow-up. We also collected perioperative data associated with pathology and surgical outcomes, including surgery, pathologic tumor size, tumor grade, residual tumor, operation time, estimated blood loss (EBL), transfusion, intensive care unit (ICU) admission days, postoperative complications according to the Memorial Sloan Kettering Cancer Center (MSKCC) criteria, pre- and postoperative pain intensity assessed by numerical rating scale (NRS) and morphine milligram equivalents (MME), and types of postoperative adjuvant treatment provided. Data on survival outcomes were also collected, including treatment response at postoperative 3 months by radiologic examination, including computed tomography (CT) or magnetic resonance imaging, progression free survival (PFS), treatment-related survival (TRS), and overall survival (OS) from the day of diagnosis of the disease.

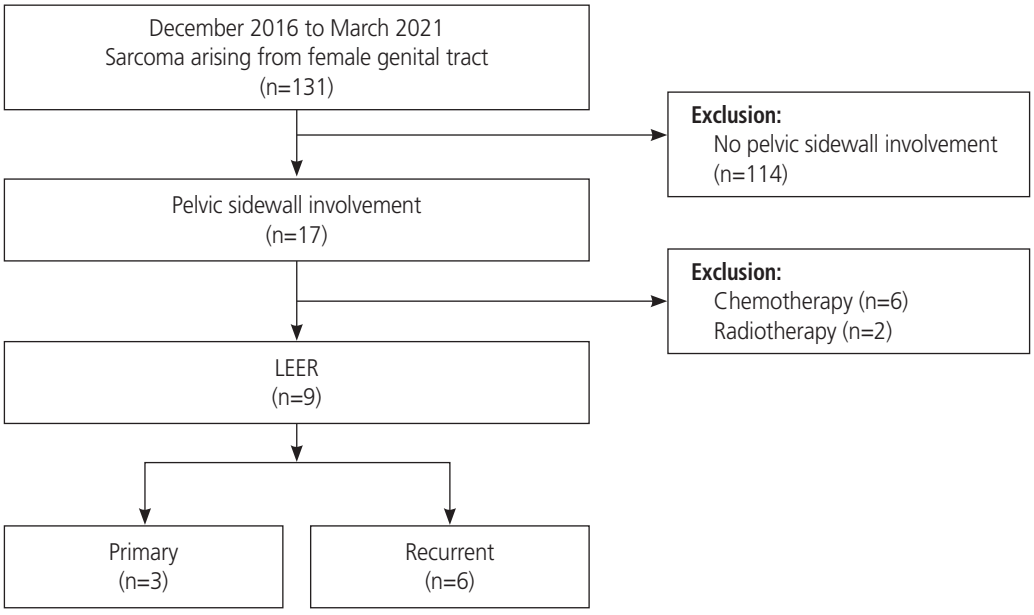

Fig. 1. Patient flowchart. LEER, laterally extended endopelvic resection.

1. Procedures and treatment

LEER was performed as previously described [22-24]. The main procedures are as follows: 1) midline incision; 2) bowel mobilization; 3) dissection of both ureters; 4) skeletonization of the mesosigmoid colon and mesorectum; 5) *en bloc* resection of pelvic sidewall tumors with ligation of the internal iliac artery and vein below the bifurcation level of the common iliac artery; 6) pelvic muscle (obturator internus muscle, coccygeus muscle, pubococcygeus muscle, and iliococcygeus muscle) resection depending on tumor involvement and topography; 7) resection of urethra, lower vagina, and anus through vulva incision; and 8) permanent colostomy or ileal conduit. Organ preservation was considered if the resection margin was negative in the frozen section. Complete resection (R0) was defined as the absence of tumor in the lateral margins of all the resected tissues on the pathologic report. Postoperative complications were assessed by the MSKCC criteria [25]. Then, we performed adjuvant radiotherapy according to the radiation oncologist's suggestion and administered chemotherapy to patients with distant metastasis.

2. Outcomes

The primary outcomes were tumor response at postoperative 3 months after LEER, PFS after LEER, TRS after LEER, and OS. Tumor response at postoperative 3 months after LEER was defined as disease status on abdominal or pelvic CT at 3 months after LEER. In this study, PFS after LEER was defined as the duration from operation to the day of first encountering disease progression, as confirmed by radiologic imaging studies. TRS after LEER was defined as the duration from the day of operation to the day of the last follow-up or death. OS was defined as the duration from the day of diagnosis of the disease to the day of the last follow-up or the day of death of the patient. We assumed all patients died a month after the last follow-up if they had a hopeless discharge with progressive disease. The secondary outcomes were perioperative characteristics: residual tumor, operation time, EBL, transfusion, postoperative ICU admission days, postoperative complications, and pre- and postoperative pain intensity. We assessed tumor response using the revised Response Evaluation Criteria in Solid Tumors version 1.1 [26]. Pelvic pain intensity was evaluated using both NRS and MME dose [27].

3. Statistical analysis

We analyzed patients' clinicopathologic characteristics and surgical outcomes via descriptive statistics. Survival data, including PFS, TRS, and OS, were calculated by Kaplan-Meier survival analysis. SPSS software version 26.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis in this study.

Table 1. Patient characteristics

Characteristic	Value (n=9)
Age (yr)	56 (22-65)
Comorbidity	
Yes[a]	5 (55.5)
None	4 (44.4)
Histology	
Carcinosarcoma	2 (22.2)
Leiomyosarcoma	2 (22.2)
Undifferentiated uterine sarcoma	2 (22.2)
Low-grade endometrial stromal sarcoma	1 (11.1)
Mullerian adenosarcoma	1 (11.1)
Synovial sarcoma	1 (11.1)
Disease status at the time of LEER	
Primary disease	3 (33.3)
Recurrent disease	6 (66.7)
Initial FIGO stage	
I	4 (44.4)
II	1 (11.1)
III	2 (22.2)[b]
IV	2 (22.2)
Preoperative radiologic TNM stage	
T staging	
T2b	5 (55.6)
T4	4 (44.4)
N staging	
N0	6 (66.7)
N1	3 (33.3)
M staging	
M0	7 (77.8)
M1	2 (22.2)
Largest radiologic tumor size prior to LEER (cm)	10 (2-17.5)
Neoadjuvant chemotherapy[c]	2 (22.2)[c]
Types of prior treatment[d]	
Systemic therapy	5 (55.5)
Radiotherapy	2 (22.2)
Surgery+chemotherapy	4 (44.4)
Surgery+radiotherapy	2 (22.2)
Lines of prior chemotherapy	2 (0-5)
Prior systemic treatment regimen[d],[e]	
Ifosfamide-combined	4 (44.4)
Doxorubicin only or combined	3 (33.3)
Gemcitabine-docetaxel	1 (11.1)

Table 1. Continued

Characteristic	Value (n=9)
Paclitaxel-carboplatin	1 (11.1)
Targeted therapy	1 (11.1)
Treatment-free interval before LEER (months)	3.9 (1.1-38.2)
Best response of last treatment before LEER	
Complete response	2 (22.2)
Partial response	2 (22.2)
Stable disease	1 (11.1)
Progressive disease	3 (33.3)
Not available	1 (11.1)
Pelvic sidewall tumor location[d]	
Infra-iliac acetabulum	6 (66.7)
Infra-iliac ischiopubic	2 (22.2)
Infra-iliac sacrococcygeal	4 (44.4)
Duration of follow-up (months)	52.7 (11.4-130.4)

Values are presented as median (range) or number (%).
LEER, laterally extended endopelvic resection; FIGO, International Federation of Gynecology and Obstetrics; TNM, The TNM classification of malignant tumors.
[a]Comorbidities included hypertension (n=1, 11.1%), diabetes (n=1, 11.1%), dyslipidemia (n=2, 22.2%), thyroid disease (n=1, 11.1%), thromboembolic disease (n=1, 11.1%), and hepatitis (n=1, 11,1%), overlapping conditions included; [b]Stage of the patient with synovial sarcoma was classified according to American Joint Committee of Cancer staging system (8th edition); [c]Neoadjuvant treatment among primary cases; [d]Overlapping cases were included; [e]Cases with neoadjuvant chemotherapy were included.

Results

1. Study population

In total, nine patients were included in this study. Table 1 shows patient characteristics. The median age of the study participants was 56 years (range, 22-65). Carcinosarcoma (n=2, 22%), leiomyosarcoma (n=2, 22%), and undifferentiated uterine sarcoma (n=2, 22%) were the common histologic types. Before surgery, the largest median radiologic tumor size was 10 cm (range, 2-17.5). Most patients with recurrent disease had received adjuvant chemotherapy or radiotherapy along with or without surgery. The median lines of prior chemotherapy before LEER were two (range, 0-5). The common chemotherapy regimen before LEER was an ifosfamide-combined regimen (n=5, 62.5%), such as doxorubicin-ifosfamide, paclitaxel-ifosfamide, and ifosfamide-cisplatin. One patient (11.1%) had received targeted agent therapy (pazopanib). The median treatment free interval before LEER was 3.9 months (range, 1.1-38.2). The most common location of the pelvic sidewall tumor was the infra-iliac acetabulum (66.7%). Distant metastasis was observed in one patient (11.1%). The median duration of follow-up was 54.7 months (range, 11.4-130.4).

2. Surgical outcomes and perioperative complications

Surgical outcomes are shown in Table 2. The median tumor size in the pathologic report was 9.0 cm (range, 1.8-19.0). Complete resection was achieved in seven patients (88.9%). Organ preservation was achieved in eight patients (77.8%). Most patients showed high-grade pathology (n=8, 88.9%). The median operation time was 300 minutes (range, 135-1,320 minutes) with a median EBL of 1,600 mL (range, 300-22,300). Patients who underwent LEER were postoperatively admitted to the ICU for a median of 1 day (range, 0-8). The most common postoperative complication was peripheral neuropathy of grade 1 or 2 (44.4%), categorized as a nervous system complication according to the MSKCC criteria. Grade 1 or 2 genitourinary complications and infections were the next common postoperative complications (22.2%). Preoperative median pain intensity assessed by NRS was 4 (range, 0-7), and postoperative NRS was 2 (range, 1-3). The median preoperative MME was 0 mg/day (range, 0-105) and

Table 2. Clinicopathologic and treatment outcomes of LEER and adjuvant treatment

Characteristic	Value (n=9)
Organ preservation	
No	2 (22.2)
Rectum alone	2 (22.2)
Bladder alone	0 (0.0)
Rectum and bladder both	5 (55.6)
Surgical extent	
Hysterectomy	2 (22.2)
BSO	2 (22.2)
PLND	7 (77.8)
PALND	7 (77.8)
Cystectomy	4 (44.4)
Vaginectomy	4 (44.4)
Internal iliac vessel resection	9 (100.0)
Pelvic sidewall muscle resection	8 (88.9)
Obturator internus muscle	6 (66.7)
Iliococcygeus muscle	3 (33.3)
Pubococcygeus muscle	5 (55.6)
Coccygeus muscle	3 (33.3)
Ureter ligation and resection	8 (88.9)
Vulvectomy (perineum)	4 (44.4)
Bowel resection	5 (55.6)
Ileal conduit	4 (44.4)
Colostomy	2 (22.2)
Others[a)]	5 (55.5)
Pathologic tumor size (cm)	9.0 (1.8-19.0)
Pathologic extent	
Uterus	2 (22.2)
Vagina	4 (44.4)
Perineum	0 (0.0)
Bladder and urethra	7 (77.8)
Anus and rectum	5 (55.6)
Pelvic sidewall muscle	7 (77.8)
Internal iliac vessel	6 (66.7)
Tumor grade	
Low-grade	1 (11.1)
High-grade	8 (88.9)
Residual tumor	
R0	8 (88.9)
R1	1 (11.1)
Operation time (minutes)	300 (135-1,320)
Estimated blood loss (mL)	1,600 (300-22,300)

Table 2. Continued

Characteristic	Value (n=9)
Transfusion	
RBC	3 (0-42)
FFP	0 (0-34)
PC	0 (0-24)
Postoperative ICU admission (days)	1 (0-8)
Postoperative complications (according to MSKCC grading system)	
Gastrointestinal system (ileus)	
Grade 1/2	2 (22.2)
Grade 3/4	0 (0.0)
Genitourinary system (urinary incontinence, voiding difficulty)	
Grade 1/2	2 (22.2)
Grade 3/4	0 (0.0)
Infection	
Grade 1/2	0 (0.0)
Grade 3/4	3 (33.3)
Nervous system	
Grade 1/2	4 (44.4)
Grade 3/4	0 (0.0)
Pelvic pain severity	
Preoperative NRS	4 (0-7)
Postoperative NRS	2 (1-3)
Preoperative MME (mg/day)	0 (0-105)
Postoperative MME (mg/day)	0 (0-15)
Postoperative adjuvant treatment	
No adjuvant treatment	3 (33.3)
Concurrent chemoradiation followed by hormone therapy	1 (11.1)
Chemotherapy	4 (44.4)
Concurrent chemoradiation	1 (11.1)
Treatment response at postoperative 3 months	
Complete response	4 (44.4)
Partial response	0 (0.0)
Stable disease	0 (0.0)
Progression or recurrence	4 (44.4)
Not assessable	1 (11.1)
Recurrence	6 (66.7)
Death	5 (55.6)

Values are presented as median (range) or number (%).
LEER, laterally extended endopelvic resection; BSO, bilateral-salpingo-oophorectomy; PLND, pelvic lymph node dissection; PALND, para-aortic lymph node dissection; RBC, red blood cell; FFP, fresh frozen plasma; PC, platelet concentrate; ICU, intensive care unit; MSKCC, Memorial Sloan Kettering Cancer Center; NRS, numeric rating scale; MME, morphine milligram equivalents.
[a]Included partial cystectomy (n=3, 33.3%), liver resection (n=1, 11.1%), and video-assisted thoracoscopic lung lobectomy (n=1, 11.1%).

Table 3. Individual treatment information and outcomes of patients

Patient No.	Cancer type	Age at LEER	Histology	Tumor grade	Initial FIGO stage	Radiologic TNM stage	Primary or recurrent	Preoperative treatment	Postoperative adjuvant treatment
No progression at last follow-up									
1	UC	25	Low-grade endometrial stromal sarcoma	Low-grade	IVA	T4N1M0	Primary	Chemotherapy (doxorubicin-ifosfamide), CCRT (cisplatin)	CCRT (cisplatin), hormone therapy (letrozole)
2	UC	22	Synovial sarcoma	High-grade	III (AJCC)	T2bN0M0	Primary	None	Chemotherapy (ifosfamide-doxorubicin), CCRT (cisplatin)
Progression or not assessable at last follow-up									
3	OC	45	Mullerian adenosarcoma	High-grade	IIIC	T4N0M0	Recurrent	Chemotherapy (paditaxel-carboplatin)	Chemotherapy, targeted therapy (liposomal doxorubicin-carboplatin; topotecan-bevacizumab; gemcitabine), radiotherapy
4	UC	55	Carcinosarco-ma	High-grade	IB	T4N1M0	Recurrent	Chemotherapy (paditaxel-Carboplatin), radiotherapy	Chemotherapy (5 FU-cisplatin; ifosfamide-cisplatin)
5	UC	60	Leiomyosarco-ma	High-grade	IB	T4N0M1	Recurrent	Chemotherapy (gemcitabine-docetaxel)	Targeted therapy (pazopanib), chemotherapy (doxorubicin-cisplatin; ifosfamide-cisplatin; eribulin)
6	UC	59	Carcinosarco-ma	High-grade	IB	T2bN0M1	Recurrent	Chemotherapy (ifosfamide-paclitaxel), CCRT (cisplatin)	Chemotherapy (doxorubicin-cisplatin, 5 FU-cisplatin)
7	UC	56	Undifferentiated uterine sarcoma	High-grade	IVA	T4N1M0	Recurrent	CCRT (cisplatin)	None
8	UC	59	Undifferentiated uterine sarcoma	High-grade	IIB	T2bN0M0	Primary	Chemotherapy (doxorubicin-cisplatin)	Chemotherapy (doxorubicin-cisplatin; ifosfamide-cisplatin)
9	UC	65	Leiomyosarco-ma	High-grade	IB	T2bN0M0	Recurrent	Chemotherapy (ifosfamide-cisplatin), targeted therapy (pazopanib), CCRT (cisplatin)	Chemotherapy (gemcitabine-docetaxel)

LEER, laterally extended endopelvic resection; FIGO, International Federation of Gynecology and Obstetrics; TNM, the TNM classification of malignant tumors; TFI, treatment free survival; PFS, progression free survival; TRS, treatment-related survival; OS, overall survival; UC, uterine cancer; CCRT, concurrent chemoradiation; CR, complete response; AJCC, American Joint Committee of Cancer; OC, ovarian cancer; PD, progressive disease; FU, follow up; Lt, left; Rt, right; NA, not available.

Table 3. Continued

TFI (months)	Tumor sites on pelvic sidewall	Residual tumor	Disease status at the last follow-up	Treatment responses at postoperative three months	Recurrence	Death	PFS after LEER (months)	TRS after LEER (months)	OS after diagnosis (months)
0	Infra-iliac sacrococcygeal	R1 (margin+)	CR	CR	No	No	68.7	68.7	69.2
0	Infra-iliac acetabular, infra-iliac sacrococcygeal	R0	CR	CR	No	No	9.9	9.9	10.3
11.7	Infra-iliac sacrococcygeal	R0	PD	CR	Yes	No	10.2	40.2	98.9
1.3	Infra-iliac acetabular	R0	PD	CR	Yes	Yes	3.3	7.0	20.6
38.2	Infra-iliac sacrococcygeal	R0	PD	PD	Yes	Yes	0.3	20.6	65.0
6.5	Infra-iliac ischiopubic, infra-iliac acetabular (Lt), infra-iliac ischiopubic (Rt)	R0	PD	PD	Yes	Yes	2.6	19.6	42.2
1.1	Infra-iliac ischiopubic (Lt), infra-iliac acetabular (Rt)	R0	PD	PD	Yes	Yes	2.0	3.4	10.0
0	Infra-iliac acetabular	R0	PD	PD	Yes	Yes	3.1	6.0	9.6
1.2	Infra-iliac acetabular	R0	NA	NA	NA	No	2.2	2.2	82.9

the postoperative MME was 0 mg/day (range, 0-15). Chemotherapy was the most favored postoperative adjuvant treatment (44.4%).

3. Treatment response and survival

Treatment response and survival outcomes after LEER are shown in Table 3. Treatment response at postoperative three months after LEER assessed by imaging studies showed a

complete response (CR) in four (44.4%) patients, progressive disease (PD) in four patients (44.4%) and was not assessable in one patient. The median PFS after LEER was 3.3 months (95% confidence interval [CI], 2.4-4.1 months). The median OS was 98.9 months (95% CI could not be calculated due to censoring). The median TRS was 19.6 months (95% CI, 0-50.8).

All nine patients were individually investigated to identify potential risk factors for poor survival associated with LEER, as presented in Table 3. Two patients showed no progression until their last follow-up, and two achieved CR (22.2%). Their histologic types were low-grade endometrial stromal sarcoma (LGESS) and synovial sarcoma. Notably, the patient with LGESS did not achieve complete resection due to positive resection margin but showed CR at follow-up with no recurrence yet. Synovial sarcoma patient was the only one in this study who achieved CR just after surgery. Both patients were at an advanced stage. However, they were much younger than the patients with progressive disease, and aged 25 and 22 years, respectively. Although not described in the table, three patients (33.3%) were treated for pelvic sidewall recurrence with a targeted agent or chemotherapy before LEER. All these patients showed PD as their best response.

Discussion

This study shows the clinical outcome of LEER in female genital tract sarcoma patients with pelvic sidewall invasion and various histologic types. A high R0 rate of 88.9% was achieved without severe complications. While the involvement of major vessels and the pelvic sidewall often impedes the decision of surgical resection, the LEER procedure enables gynecologic surgeons to resect pelvic sidewall tumors to achieve a higher rate of R0 resection [18,27]. Surgical resection of localized recurrent disease has significantly improved the local control of soft tissue sarcoma [28,29]. However, till date, there is insufficient evidence regarding the role and safety of aggressive surgery in the localized recurrences of female genital tract sarcomas. Moreover, previous reports on LEER mainly focused on carcinoma patients, and in a study with sarcoma patients, the surgical and survival outcomes were not specifically reported [18].

The importance and indication of LEER surgery in sarcoma is described in the following text. First, R0 *en bloc* resection is essential for improving prognosis in sarcoma [30,31]. In particular, it is known that sarcomas grow in anatomic compartments and do not easily invade local anatomical boundaries [32,33]. The biological features of sarcomas enable R0 resection, coincidentally in accordance with Michel Höckel's ontogenetic field theory [34]. In our prospective cohort study, eight patients achieved microscopic R0 in all surgical specimens, however, one patient (patient 1) with LGESS showed a positive resection margin. However, patient 1 was successfully treated with adjuvant hormonal therapy with letrozole and survived for 68.7 months without recurrence after LEER.

Second, the histologic type should be considered before surgery. We included various histologic types of recurrent disease, including leiomyosarcoma, undifferentiated uterine sarcoma, carcinosarcoma, and adenosarcoma. Leiomyosarcoma is the most common uterine sarcoma; and the beneficial effect of secondary surgical resection of uterine leiomyosarcoma has been shown in comparative retrospective cohort studies [16,35]. In our study, two patients with leiomyosarcoma were included: one had an OS of 65 months, and the other showed loss of follow-up but no evidence of recurrence. However, undifferentiated uterine sarcoma is a rare histologic type with an aggressive nature compared to other histologies [36]. Two patients (patients 7 and 8) with undifferentiated uterine sarcoma were included in our study, and they showed rapid progression within 2 months and 3.1 months, respectively, after LEER. Recurrent uterine carcinosarcoma also presents a poor prognosis. Systemic treatment showed a median PFS of 1.8 months [37], while patients 4 and 6 showed 3.3 and 2.6 months of PFS after LEER. Therefore, the decision for surgical excision in recurrent sarcoma should be appropriately made according to the surgeon's judgment in consideration of the histologic type and the extent of surgery.

Third, tumors in the pelvic sidewall cause neuropathic pain due to sciatic nerve compression or irritation [27,38]. In this study, we found no statistically significant reduction in pain due to the small sample size. However, in our previous study, we reported that LEER significantly reduced pelvic sciatic pain and morphine requirements in patients with recurrent cervical cancer compared to chemotherapy [27]. However, before surgery, 55.9% of patients complained of moderate to severe pain with an NRS score ≥4; after surgery, the pain intensity decreased to an NRS score ≤3. Moreover, there were no grade 3/4 complications requiring invasive intervention in our

cohort in terms of postoperative complications. A previous study had reported 22-28% of grade 4 complications after LEER [39,40].

Based on our clinical experience with a prospective cohort of patients with sarcoma and recurrent cervical cancer [24], R0 resection can be achieved after careful review of physical and radiologic findings. As described by Höckel [17], LEER is contraindicated in pelvic sidewall tumors involving the external iliac vessels. In addition, patients showing rectovaginal or vesicovaginal fistula may be candidates for LEER as palliative intent with or without distant metastasis [24]. Finally, uncontrolled pain requiring excessive opioids may be an indication for LEER based on our recurrent cervical cancer cohort study [24].

The strength of our study is the prospective nature of the studied cohort. Our study is of substantial value because gynecologic sarcomas and pelvic sidewall recurrences are rare. The limitations of our study are as follows: first, the sample size of the study was small, histologic types were heterogeneous, and primary and recurrent diseases were analyzed together. It was difficult to evaluate the potential prognostic factors of sarcoma treatment involving the pelvic sidewall. Second, it was challenging to compare the efficacy in terms of oncologic outcomes and treatment related complications due to the lack of a comparison cohort. Therefore, a multicenter, large-scale, cohort-based study of gynecologic sarcoma is warranted.

To date, there is no literature on the surgical treatment of sarcoma invading the pelvic sidewall, and this is the first prospective cohort study on LEER. In conclusion, LEER may be a feasible treatment option for gynecologic sarcoma and R0 resection can be attempted in tumors with pelvic sidewall invasion with acceptable oncologic and safety outcomes.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Jae-Weon Kim has been an Editorial Board of Obstetrics & Gynecology Science; however, he was not involved in the peer reviewer selection, evaluation, or decision process of this article. Otherwise, no other potential conflicts of interest relevant to this article were reported.

Ethical approval

Seoul National University Institutional Review Board has approved this study (IRB No: 1506-113-682).

Patient consent

All patients signed the informed consent form.

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