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Clinical outcomes of tissue expanders on adjuvant radiotherapy of resected retroperitoneal sarcoma

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Abstract

We investigated the efficacy and safety of a tissue expander (TE) for adjuvant radiotherapy (RT) of resected retroperitoneal sarcoma (RPS).

This study was conducted with 37 patients with RPS who received resection with or without TE insertion followed by RT from August 2006 to June 2012 at Samsung Medical Center. Among the 37 patients, TE was inserted in 19. The quality of TE insertion was evaluated according to the correlation of clinical target volume and retroperitoneal surface volume covered by TE and was defined as follows: excellent, ≥85%; good, 70% to 85%; fair, 50% to 70%; and poor, <50%. The median follow-up period after surgery was 47.9 months (range, 5.5–85.5 months).

The quality of TE insertion was excellent in 7 (36.8%), good in 5 (26.3%), fair in 4 (21.0%), and poor in 3 (16.7%) patients. A significantly higher biologically equivalent dose (BED, $\alpha/\beta = 10$) was used in patients who had TE insertion (median, 64.8 vs. 60.0 Gy, $P = 0.01$). Local control was 39.7%, and overall survival was 76.4% at 5 years. Local control was significantly higher in patients who received ≥65 Gy of BED, 100.0% in contrast to 22.8% ($P = 0.01$). One patient with a history of multiple tumor resections showed abdominal infection with duodenal perforation of uncertain cause but had the potential of being related to TE and/or RT. Otherwise there were no ≥grade III acute or late toxicities.

TE for adjuvant RT in RPS is feasible for delivering a higher RT dose with acceptable toxicity.

Abbreviations: BED = biologically equivalent dose, CT = computed tomography, CTV = clinical target volume, DM = distant metastasis, IMRT = intensity-modulated radiotherapy, LR = local recurrence, LRFS = local recurrence-free survival, OS = overall survival, RPS = retroperitoneal sarcoma, RT = radiotherapy, TE = tissue expander.

Keywords: radiotherapy, recurrence, retroperitoneal sarcoma, tissue expander, toxicity

1. Introduction

Retroperitoneal sarcoma (RPS) is a rare tumor, accounting for 10% of all soft tissue sarcomas and 1% of all malignancies.[1] Although surgical removal is the only accepted therapeutic management, local failure is common.[2–4] Although rapid advancement of surgery techniques is ongoing, local recurrence (LR) is reported in more than half of patients with RPS after resection.[2,5,6]

Radiotherapy (RT) is one of the main modalities in oncology as well as an adjunctive of surgery.[7] Although the real efficacy of adjuvant RT in RPS has not been confirmed by randomized controlled trials, the local control advantage from adding RT has repeatedly been reported in retrospective and prospective studies.[8–11] It is difficult to deliver a sufficient RT dose for this disease when it is located near critical structures, especially the bowel; however, it is easier to deliver RT to sarcomas of the extremities.[12,13] To achieve sufficient local control, several methods, including intensity-modulated RT (IMRT), proton beam RT, and/or preoperative or intraoperative RT, have been studied with promising results.[14–18] As 1 approach to safely increase RT dose in RPS, starting in 2006, our group inserted a tissue expander (TE) in the tumor bed for patients who expected a high risk of LR and consented to the procedure.[19]

In this study, we evaluated the efficacy and safety of TE insertion in RPS for adjuvant RT to determine which patients might benefit from TE insertion.

2. Methods

The present retrospective study from the prospectively collected registry of Samsung Medical Center Radiation Oncology was conducted with patients with RPS who underwent surgical resections and received adjuvant RT in our institution from

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Table 1

Baseline patient characteristics.

Variables	TE (n = 19)	No TE (n = 18)	*P*
Age, y			
Median	52	59	0.28
Range	35–74	37–75	
Sex, n (%)			
Male	9 (47.1)	8 (44.4)	>0.99
Presentation			
Primary	12 (63.2)	16 (88.9)	0.12
Recurrent	7 (36.8)	2 (11.1)	
Tumor size, cm			
Median	17	11	0.04
Range	3–60	3–39	
Tumor volume, cm^3			
Median	1,575	630	0.06
Range	12–75,000	19.5–11,856	
Completeness of resection			
R0	2 (10.5)	5 (27.8)	0.15
R1	3 (15.8)	6 (33.3)	
R2	2 (10.5)	0 (0.0)	
Unknown	12 (63.2)	7 (38.9)	
FNCLCC tumor grade			
Low	5 (26.3)	2 (11.8)	0.43
Intermediate	8 (42.1)	6 (35.3)	
High	6 (31.6)	9 (52.9)	
Unknown	—	1 (5.6)	
Histology			
Well-differentiated liposarcoma	7 (36.8)	2 (11.1)	0.02
Dedifferentiated liposarcoma	8 (42.1)	5 (27.8)	
Leiomyosarcoma	1 (5.3)	5 (27.8)	
MFH	1 (5.3)	2 (11.1)	
Undifferentiated sarcoma	2 (10.5)	—	
Other	—	4 (22.2)	
Technique of RT			
3D-CRT	12 (63.2)	16 (57.1)	0.12
IMRT	7 (36.8)	2 (11.1)	
BED ($\alpha/\beta = 10$)			
Median, Gy	64.8	60.0	0.01
Range, Gy	26.4–79.2	52.8–72.0	

BED = biologically equivalent dose, 3D-CRT = 3-dimensional conformal radiotherapy, FNCLCC = French Fédération Nationale des Centres de Lutte Contre le Cancer, IMRT = intensity-modulated radiotherapy, MFH = malignant fibrous histiocytoma, RT = radiotherapy, TE = tissue expander.

August 2006 to June 2012. The Institutional Review Board of Samsung Medical Center, Sungkyunkwan University School of Medicine (SMC IRB 2016-02-101), approved the present study.

During this period, 379 patients were treated with RT because of sarcoma. Among them, 342 patients were excluded from the present study for the following reasons: 245 with extremity sarcoma, 62 with intrapelvic sarcoma, 1 with chest wall sarcoma, 28 with presence of distant metastasis (DM) or gross peritoneal seeding, 1 with pediatric sarcoma, 1 with follicular dendritic cell sarcoma, 1 with abdominal RT history, 2 with LR before RT, and 1 because RT was administered before surgical resection. Finally, 37patients were analyzed in the present study.

All patients enrolled in the present study had received informed consent about surgical resection with TE insertion and adjuvant RT. The TE insertion was recommended to patients who were likely to need adjuvant RT and had a potential barrier to increase RT dose including recurrent tumor with multiple resection history and tumor >10 cm. Because the cost of TE was not covered by the national insurance program, TE insertion was limited to patients who provided consent. Then, the patients underwent curative intent surgical resection. En bloc resection was performed including adjacent organs invaded by the tumor. In the case of tumor invading a major vessel, however, vascular resection was not performed. Although a minimal gross lesion remained, the patient was not excluded if maximal tumor resection was performed with curative intent. Among 37 patients, incomplete resection was detected in 11 patients (29.7%, R1 in 9 and R2 in 2 patients), and unknown margin status was shown in 19 patients (51.4%). During the study period, 19 patients (51.4%) underwent insertion of TE for adjuvant RT.

Table 1 displays the differences in baseline clinicopathological characteristics between the patients with and without TE. The median patient age was 52 years (range, 35–74) in patients who received TE insertion (TE group) and 59 years (range, 37–75) in patients who did not receive TE insertion (no TE group). Depending on TE insertion, a significant difference in size ($P = 0.04$) and a tendency for volume difference ($P = 0.06$) were observed. There was also a tendency for a higher rate of recurrence in the TE group compared to that in the no TE group ($P = 0.12$). R0 resection was slightly higher in the no TE group, although the difference was not significant. Tumor grade was not significantly different between the groups. TE was inserted more frequently in liposarcoma histology cases of both well-differentiated and dedifferentiated types and less frequently in leiomyosarcoma ($P = 0.02$).

The quality of TE insertion was evaluated using the computed tomography (CT) images acquired for RT planning. Evaluation was performed based on the correlation of clinical target volume (CTV) and retroperitoneal surface volume covered by TE. And the CTV of the present study was defined as the abutting site of tumor on the retroperitoneal surface except for the bowel and the upper half of flank side of abdominal cavity. Each volume was delineated and calculated from the planning CT images registered in the Pinnacle (Philips Radiation Oncology Systems, Milpitas, CA) treatment planning system. The TE insertion quality was classified as follows: excellent, >85%; good, 70% to 85%; fair, 50% to 70%; and poor, <50% of retroperitoneal tumor surface delineated as CTV was covered by TE.

Patients received adjuvant RT at 4 to 9 weeks (median 5 weeks) after surgical resection. All patients underwent CT scans with intravenous contrast agent for RT planning. All except 1 patient who showed limited lesion invading the left diaphragmatic crus were placed in the supine position to maintain stability and minimize respiration uncertainty. The prone position was used in the 1 patient to maximize the gap between the tumor bed and the stomach wall. Gross tumor volume was defined as gross tumor on CT or positive area of resection margin, and CTV was defined as previously described. The planning target volume was defined as CTV +5 to 10 mm. The delivered radiation dose was 60 to 66 Gy in 2-Gy fractions on positive or unknown resection margin and 54 Gy in 2-Gy fractions in completely resected patients. However, the prescribed RT dose was limited because of the constraint of bowel dose exposure to either maximum or a volume >45 Gy. IMRT was applied in 5 patients (13.5%) who consented to use it to deliver the intentional dose beyond the constraint of the bowel dose exposure, and 3-dimensional conformal RT was used in other patients. The median RT dose was 50 Gy (range, 22–66 Gy).

A higher radiation dose (biologically equivalent dose [BED] with $\alpha/\beta = 10$) was delivered to patients with TE (median, 64.8 vs. 60.0 Gy, $P = 0.01$). Although there was no statistical significance, IMRT was more frequently applied to the patients with TE (36.8% vs. 11.1%, $P = 0.12$).

Adjuvant chemotherapy was not routinely recommended. One patient for whom curative surgery was thought to be impossible received 4 cycles of neoadjuvant chemotherapy. Two patients with gross and microscopic residual tumor received 3 cycles of chemotherapy after RT. The chemotherapy agents were doxorubicin and ifosfamide in all 3 patients.

Patients were examined at least once a week during the RT, after which regular follow-up was performed. Follow-up was conducted every 3 months in the first year, every 6 months in the second year, and then yearly. Surveillance of LR was assessed using CT scans at every follow-up visit. Acute and late toxicities were evaluated at every follow-up visit during and after treatments, and the Common Terminology Criteria for Adverse Events v. 4.0 were used to grade the toxicity.

For evaluating the patterns of failure, LR was defined as tumor recurrence within the CTV, and other recurrence was defined as DM. Simultaneous recurrence was defined as the detection of >2 sites of recurrence within 4 weeks.

The χ^2, Fisher's exact, or Mann–Whitney test was used to compare the correlation of clinicopathological variables and TE insertion. The quality of TE insertion, possible related factors, and incidence of adverse events were also evaluated by these tests. The Kaplan–Meier product-limit method was used to estimate the survival rates. Overall survival (OS) and LR-free survival (LRFS) were measured from the date of surgical resection to the date of the event (death and LR, respectively) or to the final follow-up visit. The log-rank test was used to compare the OS/LRFS and other clinicopathological variables including TE insertion. The Cox proportional hazard model tested using the Schoenfeld residuals method was used in multivariate analysis with variables that had a P-value <0.1 in the univariate analysis. The PASW 22.0 software for Windows (IBM, Armonk, NY) was used in the statistical analysis. All P-values were 2-sided, and $P < 0.05$ was considered statistically significant.

3. Results

3.1. Quality of TE insertion

Fig. 1 shows an example of TE insertion quality evaluation using the RT treatment planning system. The median CTV and retroperitoneal surface volume of TE were 249.5 cm^3 (range, 46.9–667.8) and 187.5 cm^3 (range, 0–538.3), respectively. The median percentage of CTV covered by retroperitoneal tumor surface of the inserted TE was 80.8% (range, 0%–100%). Among 19 patients who received insertion of TE, 7 patients (36.8%) had excellent, 5 (26.3%) had good, 4 (21.0%) had fair, and 3 had poor (15.8%) insertion.

Although there was no significant difference ($P = 0.09$), a >65 Gy of BED was used more frequently in patients with excellent (5/8, 71.4%) TE insertion than in the others (2/10, 20%).

3.2. Adverse events

In the 3 patients who showed poor TE insertion, failed inflation of TE was noticed in 1 patient (5.3%), and a change in TE position from the initial site positioned by the surgeon was observed in 2 patients.

The toxicity profile related to surgical resection with TE insertion and adjuvant RT is displayed in Table 2. During adjuvant RT, only 1 patient suffered from grade III toxicity of nausea with vomiting and abdominal pain that needed general ward admission and medical intervention. Otherwise, toxicities were generally tolerable as grade I or II in both groups, although the incidence was slightly higher in the TE group. Grade IV late complication required multiple surgical interventions due to duodenal perforation in 1 patient in the TE group who had a history of multiple recurrences with multiple surgical resections. He had a 9 cm perforation in all 3 parts of the duodenum at 1 month after adjuvant RT. There was also 1 patient who needed surgical intervention for TE removal because of persistent abdominal pain related to the TE.

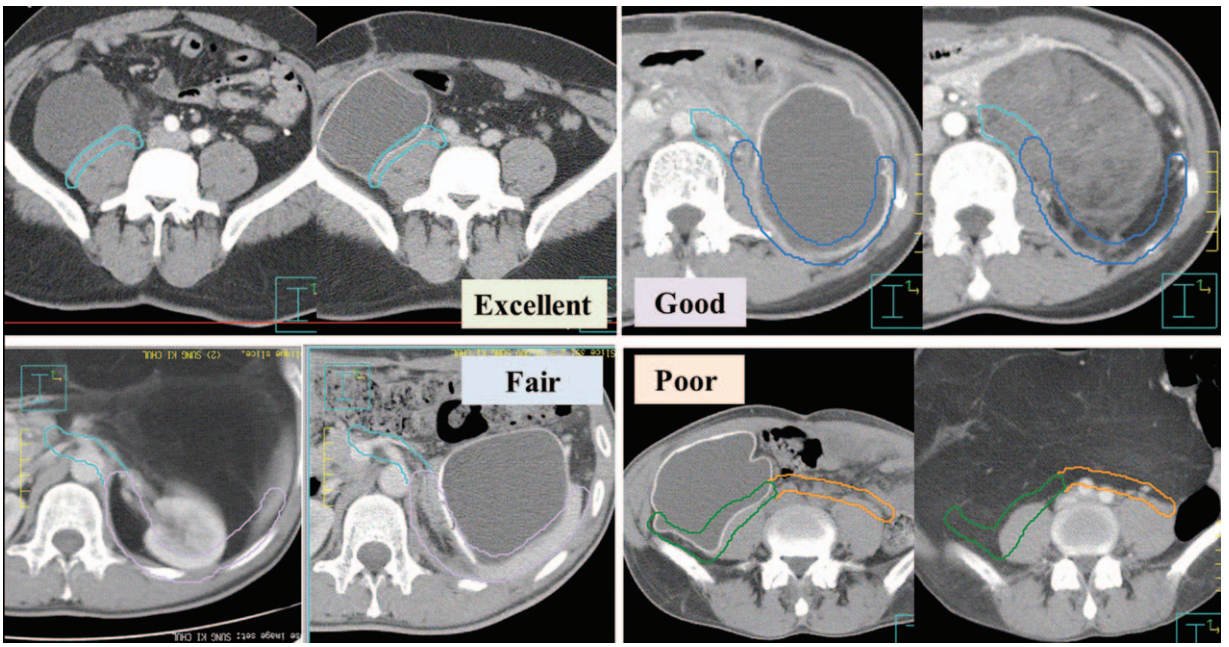

Figure 1. Example of TE insertion quality evaluation: the correlation of CTV and retroperitoneal surface volume covered by TE was the evaluation tool. Examples of excellent (A, ≥85%), good (B, 70%–85%), fair (C, 50%–70%), and poor (D, <50%) TE insertion are shown. CTV = clinical target volume, TE = tissue expander.

Table 2

Toxicity profile during and after surgical resection with TE insertion and adjuvant RT.

Grade	TE group (n = 19)				No TE group (n = 18)			
	I, %	II, %	III, %	IV, %	I, %	II, %	III, %	IV, %
Acute complication (from RT start to follow-up after RT completion)								
Fatigue	9 (47.4)	2 (10.5)	—	—	3 (16.7)	1 (5.6)	—	—
Anorexia	3 (15.8)	8 (42.1)	—	—	4 (22.2)	6 (33.3)	—	—
Nausea	3 (15.8)	11 (57.9)	—	—	5 (27.8)	2 (11.1)	1 (5.6)	—
Vomiting	5 (26.3)	2 (10.5)	—	—	—	1 (5.6)	1 (5.6)	—
Diarrhea	3 (15.8)	2 (10.5)	—	—	1 (5.6)	—	—	—
Abdominal pain	8 (42.1)	6 (31.6)	—	—	6 (33.3)	2 (11.1)	1 (5.6)	—
Late complication								
Abdominal pain	—	3 (15.8)	1 (5.3)	1 (5.3)	—	1 (5.6)	—	—
Leg edema	—	2 (10.5)	—	—	—	—	—	—
Inguinal hernia	—	—	1 (5.3)	—	—	—	—	—

RT = radiotherapy, TE = tissue expander.

In the analysis of the TE inserted subgroup, there was no statistically significant difference in the incidence of the grade II or higher toxicities between high quality of TE inserted group (excellent and good) and low quality of TE inserted group (fair or poor) ($P = 0.60$)

3.3. Patterns of first site of failure

During the follow-up, there were 22 recurrences (56.4%) overall. Among them, isolated LR was shown in 13 patients (33.3%), and isolated DM was noticed in 6 patients (15.4%) as the first site of failure. The other 3 patients showed simultaneous LR and DM. Among the 16 patients who showed LR with or without DM, 6 received insertion of TE.

3.4. Local recurrence-free survival and probable prognostic factors

At a median follow-up of 47.9 months (range, 5.5–85.5), ultimate LR had developed in 17 patients (43.6%). The Kaplan–Meier curve of LRFS is displayed in Fig. 2A. The 3- and 5-year estimated LRFS values were 66.5% and 39.7%, respectively.

The prognostic factors probably related to LRFS are shown in Table 3. In the univariate analysis, liposarcoma histology ($P = 0.03$) and >65 Gy of BED ($P = 0.01$) were the significant prognostic factors in LRFS. TE insertion showed marginal significance on LRFS ($P = 0.06$). In the analysis of the TE inserted subgroup, there was a tendency of higher LRFS in high quality of TE inserted group than low quality of TE inserted group ($P = 0.12$). The Kaplan–Meier curve of LRFS according to these prognostic factors is shown in Fig. 3. In the multivariate analysis, however, none of the 3 factors was statistically significant.

In the χ^2 test to evaluate the correlations between the prognostic factors that showed statistical significance in univariate analysis, there was a significant correlation between liposarcoma histology and TE insertion ($P = 0.02$) and between >65 Gy of BED and TE insertion ($P = 0.04$).

3.5. Overall survival and probable prognostic factors

During the follow-up, 6 patients (15.4%) died because of the RPS. The Kaplan–Meier curve of OS is displayed in Fig. 2B. The 3- and 5-year estimated OS rates were 88.9% and 76.4%, respectively.

The prognostic factors probably related to OS are shown in Table 4. Larger than 17 cm of maximum tumor diameter (75.0% vs. 95.7% at 3 years, $P = 0.06$), >1000 cm^3 of tumor volume (76.9% vs. 95.5% at 3 years, $P = 0.08$), and LR (75.6% vs. 100.0% at 3 years, $P = 0.05$) showed a tendency for poor OS in univariate analysis. A marginally significant OS difference was also noticed in high-quality than in low-quality TE inserted group in the subgroup analysis (100.0% vs. 71.4%, $P = 0.05$). Although

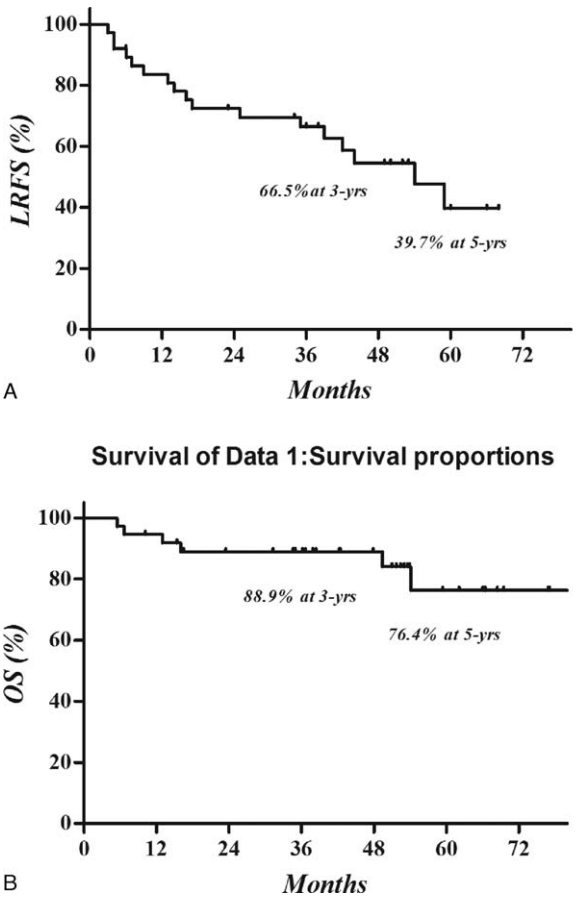

Figure 2. The Kaplan–Meier curves of LRFS (A) and OS (B): the estimated LRFS and OS were 66.5% and 88.9%, respectively, at 3 years and 39.7% and 76.4%, respectively, at 5 years. LRFS = local recurrence-free survival, OS = overall survival.

Table 3

Possible prognostic factors that predict local recurrence-free survival.

Variables	No. of patients	3-y LPFS %	*P* value	
			UVA	MVA
Sex				
Male	17	63.3	0.35	
Female	20	73.3		
Age, y				
≤55	17	75.6	0.35	
>55	20	63.6		
Presentation				
Primary	30	71.8	0.72	
Recurrent	7	57.1		
Pathology				
Liposarcoma	22	80.2	0.03	0.12
Others	15	53.3		
Tumor size, cm				
≤18	25	74.3	0.11	
>18	12	58.3		
Multiplicity				
No	11	72.4	0.89	
Yes	26	60.6		
Grade				
I–II	21	71.4	0.24	
III	15	64.6		
Differentiation				
Low–mid	12	83.3	>0.99	
Poor	14	69.9		
Completeness of resection				
R0	7	71.4	0.29	
R1–2/unknown	30	68.4		
TE insertion				
No	18	52.5	0.06	0.50
Yes	19	84.2		
BED ($\alpha/\beta=10$), Gy				
<65	29	61.4	0.01	0.14
≥65	8	100.0		

BED = biologically equivalent dose, LPFS = local progression-free surviva, MVA = multivariate anaysis, TE = tissue expander, UVA = Univariate analysis.

Table 4

Possible prognostic factors that predict OS.

Variables	No. of patients	3-y OS, %	*P* value	
			UVA	MVA
Sex				
Male	17	87.8	0.71	
Female	20	87.7		
Age, y				
≤55	17	93.8	0.59	
>55	20	84.7		
Presentation				
Primary	30	92.9	0.79	
Recurrent	7	77.8		
Pathology				
Liposarcoma	22	95.5	0.18	
Others	15	79.0		
Tumor size, cm				
≤18	25	95.7	0.06	
>18	12	75.0		
Multiplicity				
No	26	88.0	0.94	
Yes	11	90.9		
FNCLCC grade				
I–II	21	90.5	0.62	
III	15	85.1		
Differentiation				
Low–mid	12	91.7	0.36	
Poor	14	92.9		
Completeness of resection				
R0	7	100.0	0.73	
R1–2/unknown	30	86.3		
TE insertion				
No	18	88.9	0.40	
Yes	19	89.5		
BED ($\alpha/\beta=10$), Gy				
≤65	29	85.9	0.20	
>65	8	100.0		
Local recurrence				
No	20	100.0	0.05	
Yes	17	75.6		

BED = biologically equivalent dose, FNCLCC = French Fédération Nationale des Centres de Lutte Contre le Cancer, OS = overall survival, TE = tissue expander.

there were no deaths among patients who received >65 Gy of BED, this factor was not statistically significant ($P=0.20$). In multivariate analysis using the 3 factors that showed marginal significance on OS in univariate analysis, there was no statistically significant prognostic factor. The Kaplan–Meier curve of OS according to these factors is displayed in Fig. 4.

4. Discussion

In the present study, we evaluated the efficacy and safety of TE insertion in RPS for adjuvant RT and found that TE insertion achieved a marginally higher LRFS with higher dose of RT and acceptable toxicity. The quality of TE insertion was favorable in >80% of the patients, and they showed a tendency for higher prescribed dose of adjuvant RT.

Although the backbone of the treatment of RPS is complete surgical resection, obtaining complete resection with adequate margin is challenging or even impossible sometimes because of the proximity to vital structures.[20] Due to the nature of the disease, it is well known that local failure ultimately occurs in more than half of patients after complete resection.[21] Because of the unacceptably high rate of local failure, addition of adjuvant RT has been recommended, although the concrete evidence of its benefit in local control in RPS is lacking.[22]

Despite the proven efficacy of the addition of RT, which improves local control (approximately 90%) in soft tissue sarcoma of the extremity,[23] there is still controversy around the real efficacy of RT in RPS. The advantage of RT in RPS is generally modest, although somewhat higher local control rates have been reported with the addition of RT.[8] Considering the histological type of RPS that shows a similar spectrum with extremity, this limited benefit of RT addition on RPS is probably related to the suboptimal RT dose restricted by critical structure, such as the small/large bowel.[20] To enhance local control by RT dose escalation while controlling the probability of bowel toxicity, several modalities and/or techniques minimizing radiation exposure to the bowel have been explored.[15–18]

Recently, neoadjuvant or preoperative RT for RPS has been preferred to postoperative RT for several reasons, including clear target volume definition, more oxygenated status of tumor cells, and theoretical reduction of intraoperative tumor seeding.[24] Most of all, RT exposure to the bowel could be minimized because the tumor itself pushes the bowel away. In preoperative RT, however, the possibility of inappropriate or overtreatment could be problematic because of the limitation of histological

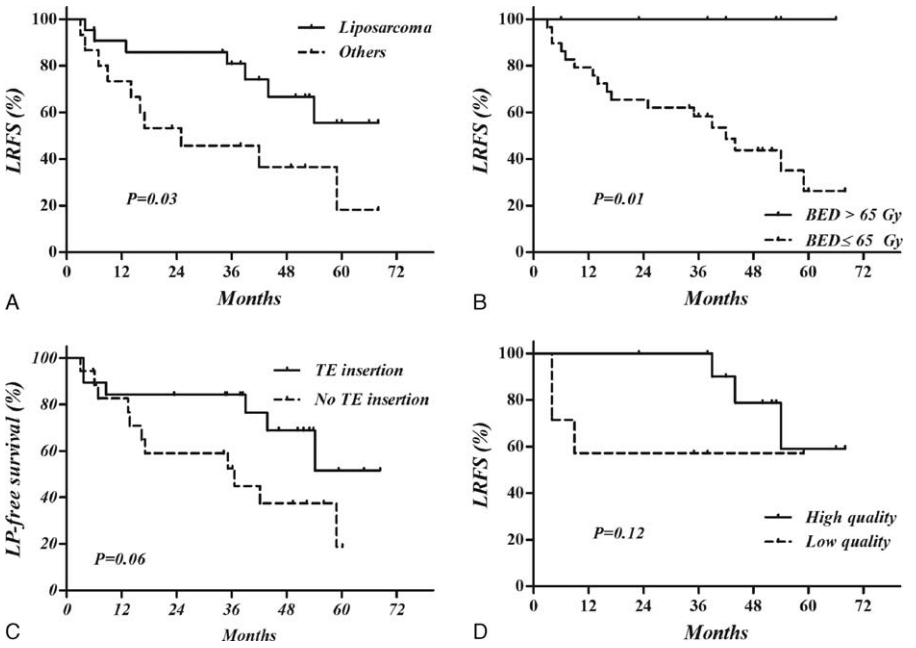

Figure 3. The Kaplan–Meier curves of LRFS according to prognostic factor: significant differences were noted between the curves according to liposarcoma histology (A) and ≥65 Gy biologically equivalent dose (B). A marginal difference in LRFS curves was detected by TE insertion (C) and quality of TE insertion, (D). LP = Local progression, LRFS = local recurrence-free survival, TE = tissue expander.

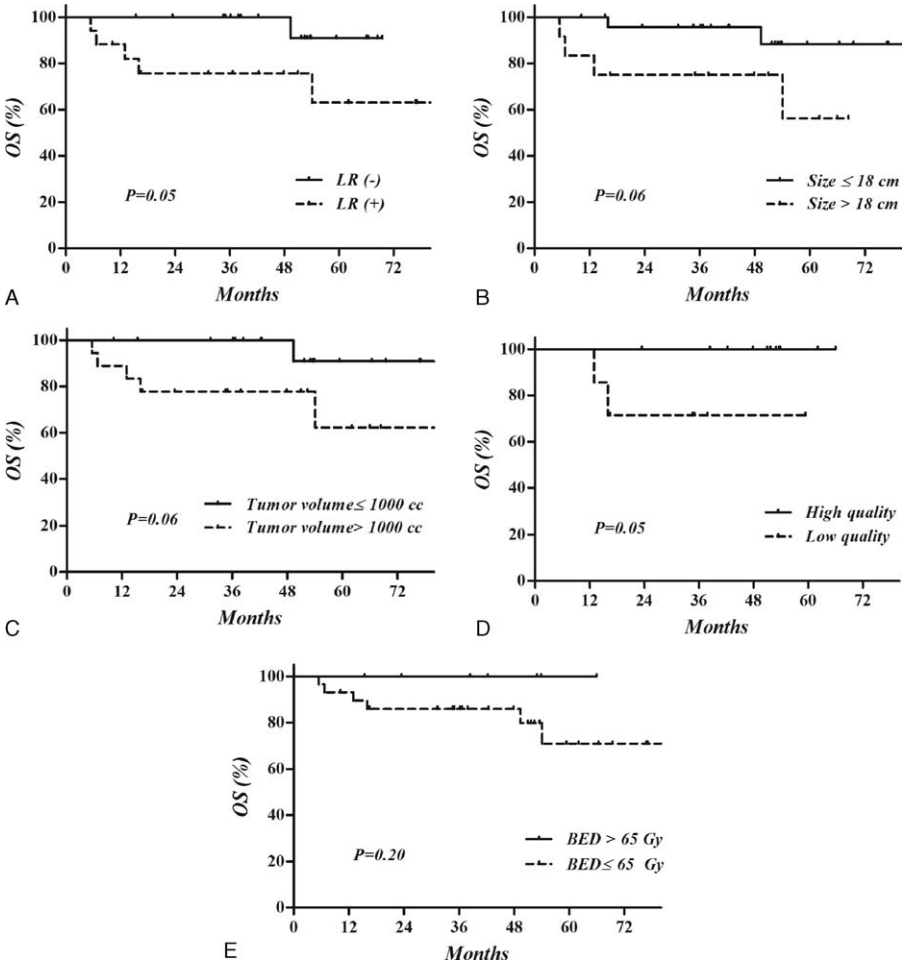

Figure 4. The Kaplan–Meier curves of OS according to prognostic factor: local recurrence (A), maximum tumor diameter (>17 cm, B), tumor volume (>1000 cm^3, C), and low quality of TE insertion (D) showed a tendency for poor OS. Although there was no death in patients who received ≥65 Gy of BED, this factor was not statistically significant (E). BED = biologically equivalent dose, OS = overall survival, TE = tissue expander.

sampling and patient anxiety due to the delay of definitive surgery. Intraoperative RT, IMRT, and particle beam RT are other valid solutions for local control maximization from RT dose escalation without elevating the risk of normal tissue toxicities, especially bowel toxicity.[15–18] In fact, a favorable outcome was reported with local control for >90% of primary RPS who received neoadjuvant proton or IMRT with or without intraoperative RT by Yoon et al.[18]

TE insertion is another potentially beneficial method to reduce the volume of bowel exposure in adjuvant RT.[19] There are several potential advantages of TE insertion. The primary advantage is that the surgeon can separate the bowel from the surrounding area with a high risk of LR and/or the area requiring a higher RT dose. Second, RT dose can be specified according to the pathological risk of recurrence without interrupting treatment. Third, acute complications related to RT can be reduced by minimizing radiation bowel exposure volume.[25] Finally, LR can be easily detected in imaging follow-up.

Although there are potential advantages of TE insertion, there are also concerns to be considered. TE insertion could cause infection and may be uncomfortable and/or cause pain in the abdomen. The position of the TE can also change after the surgery. Finally, the removal of TE after adjuvant RT is not trivial.

To escalate adjuvant RT dose without increasing the normal tissue toxicities, our institution inserted TE during surgery after resection of RPS. The results of the present study provide important information about the potential advantages and disadvantages about TE insertion in RPS for adjuvant RT. First, TE covers ≥50% of the retroperitoneal surface, where the tumor is located in >80% of patients. Second, TE insertion is significantly related to higher radiation dose (≥65 Gy of BED). TE insertion enables the delivery of a higher RT dose in patients with RPS. The patients who received >65 Gy of BED had acceptably high local control at 100%, as reported in the literature.[9] Third, acute complication during RT was not reduced or increased by TE insertion. There was 1 patient with grade IV late complication that was probably related to multiple surgeries and RT rather than TE insertion itself, although the exact cause of the complication could not be assessed. Additionally, surgical TE removal was needed in 1 patient who had persistent abdominal pain related to the TE. Although more cases are needed to evaluate the safety of TE insertion in RPS for adjuvant RT, our results showed acceptable toxicities while achieving a relatively higher RT dose.

The present study has some limitations. First, there was a selection bias due to the nature of the retrospective design performed in a single institution. Especially, TE insertion was conducted more frequently in larger tumors, mainly liposarcoma, because of the concern about acute and late RT toxicities. Second, the small number of enrolled cases, especially in the TE group, might not have been sufficient to derive concrete conclusions of the safety and efficacy of TE insertion. Finally, direct comparison of local control between the TE and the no TE insertion groups might be inappropriate because of the differences in baseline characteristics between the 2 groups.

Despite these limitations, to our knowledge, this is the first study to evaluate TE insertion for adjuvant RT in RPS. In our study, TE insertion was significantly related to a higher RT dose, which has demonstrated excellent local control in RPS in the literature. We found that the rates of acute and late toxicities related to TE insertion were acceptably low. TE insertion might be a valid option for safely increasing RT dose in RPS.

5. Conclusions

TE insertion in RPS is a feasible approach to increase adjuvant RT dose with acceptable acute and late toxicities. Furthermore, a higher local control rate was achieved in patients with resected RPS who received >65 Gy of BED adjuvant RT. TE insertion for adjuvant RT in resected RPS might be a valid option for achieving sufficient RT dose and higher local control. Larger prospective studies are needed to expand on the findings of this study.

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