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Anterior Approach to *En Bloc* Resection in Left-Sided Retroperitoneal Sarcoma with Adjacent Organ Involvement: A Study of 25 Patients in a Single Center

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Background: There is no standard surgical approach for the management of retroperitoneal sarcoma. The aim of this clinical study was to describe the experience of an anterior approach to *en bloc* resection in left-sided retroperitoneal sarcoma with adjacent organ involvement.

Material/Methods: This retrospective clinical study included 25 patients who were diagnosed with left-sided retroperitoneal sarcoma and underwent tumor resection at a single center between May 2012 and July 2017. All patients had tumors that were adjacent to the left colon, pancreas, left kidney, left adrenal gland, and psoas major; some of the tumors were adjacent to the diaphragm, stomach, and small intestine. An anterior approach was used to remove the left-sided retroperitoneal tumor with the adhesive organs *en bloc*, an approach that is described in detail. The value of this surgical approach was evaluated based on the histopathological findings, postoperative complications, and patient follow-up.

Results: The median number of resected organs, in addition to the retroperitoneal tumor, was 8 (range, 6–10). Complete macroscopic tumor resection was achieved in 23 cases (92%). Twenty-four patients (96%) had tumor infiltration of at least one organ or the surrounding fat. Three patients (12%) experienced Grade III and IV postoperative morbidities. The one-year disease-free survival rate was 91.3% among patients with macroscopically complete resections. The one-year overall survival rate was 83.2%.

Conclusions: In selected patients, left-sided retroperitoneal sarcoma associated with local organ involvement can be surgically managed using an anterior approach with *en bloc* resection of adjacent organs.

MeSH Keywords: Retroperitoneal Space • Sarcoma • Surgical Procedures, Operative

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Background

Retroperitoneal sarcoma includes a large group of tumors of mesenchymal origin arising from the retroperitoneum, with the most common histological type of retroperitoneal sarcoma being liposarcoma [1]. Surgical resection remains the main curative treatment for retroperitoneal sarcoma, although local recurrence is the leading cause of mortality in these cases [1,2]. Histopathological evaluation of the surgical margins is a major predictor of local recurrence [1,3,4], and extended *en bloc* resection of the tumor and adjacent organs has been recommended to achieve negative surgical margins and minimize the risk of local recurrence [5–7]. Although multiple centers perform *en bloc* surgical resection for retroperitoneal sarcoma, the varied anatomical locations of the primary tumor within the retroperitoneum result in local invasion to different adjacent organs, and there is no standard surgical approach or procedure for treating retroperitoneal sarcoma. However, in cases of primary retroperitoneal sarcoma at specific anatomical locations, certain surgical approaches may help shorten the operation time, reduce postoperative morbidity, achieve negative surgical margins, and prevent postoperative recurrence. These approaches could help make extended *en bloc* resection a viable treatment option for retroperitoneal sarcoma, especially at less experienced surgical centers.

The aim of this clinical study, at a single center, was to describe the experience of an anterior approach to *en bloc* resection in left-sided retroperitoneal sarcoma with adjacent organ involvement, based on the pathological findings, postoperative complications, and patient follow-up.

Material and Methods

Patients

A retrospective clinical study was undertaken, with date retrieved on 25 consecutive patients with left-sided retroperitoneal sarcoma who were treated at the Peking University Cancer Hospital Sarcoma Center between May 2012 and July 2017. The median follow-up time was 11 months (range, 6–22 months). All tumors originated from the left side of the retroperitoneum (inferior to the diaphragm, superior to the iliac vessels, lateral to the mid-axillary line, and medial to the vertebral column). All tumors were adjacent to the left colon, pancreas, left kidney, left adrenal gland, and psoas major. Some tumors were adjacent to the diaphragm, stomach, and small intestine. Pre-operative computed tomography (CT) imaging from a representative patient who presented with a left-sided retroperitoneal sarcoma is shown in Figure 1.

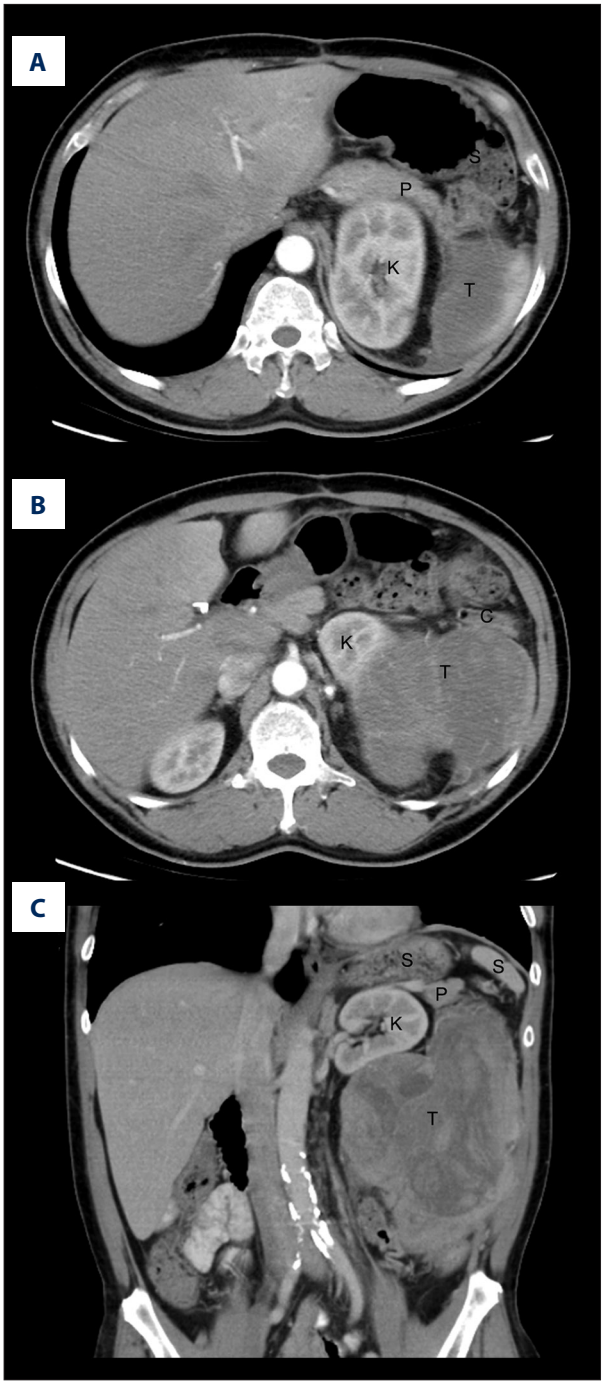

Figure 1. Preoperative computed tomography (CT) findings from a patient with a left-sided retroperitoneal tumor that is adjacent to the left kidney, tail of the pancreas, spleen, and left colon. (**A, B**) Axial view of the preoperative computed tomography (CT) findings from a patient with a left-sided retroperitoneal tumor. (**C**) Coronal view of the preoperative computed tomography (CT) findings from a patient with a left-sided retroperitoneal tumor. T – tumor; P – pancreas; S – spleen; K – kidney; C – colon.

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Surgical technique used

All 25 patients underwent surgery with curative intent. The patients were placed in the supine position after induction of general anesthesia. A midline incision was performed, and the operative field was exposed using self-retaining retractors. The entire abdominopelvic cavity was carefully explored for signs of tumor invasion to the adjacent organs, as well as signs of peritoneal metastasis. The gastrocolic ligament was opened, and the gastrocolic and spleno-gastric ligaments were divided up to the superior pole of the spleen to determine whether the tumor had infiltrated into the posterior wall of the stomach and spleen. The hepato-duodenal ligament was subsequently dissected to expose the common hepatic artery, the celiac trunk, and the splenic artery.

The splenic artery was ligated approximately 1–2 cm from the splenic artery origin (Figure 2A). The transverse mesocolon was dissected along the left section of the medial colic artery, and the transverse colon was then separated. The inferior margin of the pancreas was located along the middle colic vein and separated from the dorsal aspect of the pancreas. The pancreas, splenic vein, and splenic artery were separated along the left side of the pancreatic neck, and then the pancreatic stump was closed (Figure 2B).

The ligament of Treitz was opened to examine the relationship between the tumor and the distal duodenum and proximal jejunum, with the intestinal segments being resected if tumor infiltration was identified. The peritoneum lateral to the sigmoid colon was distally detached from the tumor and separated from the sigmoid colon. A horizontal opening was made in the mesocolon at the level of the iliac artery, which was dissected from the abdominal aorta along the iliac artery. The left ureter and left sections of the blood vessels supplying the reproductive system were separated.

The abdominal aorta was freed from the distal end to the proximal end along the left side by separating the entire abdominal aorta from the surrounding adipose tissue and tumor, which exposed the entire left side of the abdominal aorta. The inferior mesenteric artery, left renal artery, and left renal vein were successively dissected and ligated, with care taken to protect the superior mesenteric artery and celiac trunk.

The tumor was then separated from the retroperitoneal space along its posterior edge. The relationship between the tumor and the psoas major was examined, and the psoas fascia and part of the psoas major were resected, if necessary. The tumor was subsequently freed towards the superior end, along the posterior tumor aspect, with the left retroperitoneal adipose tissue being completely removed (Figure 2C). The relationship between the tumor and the diaphragm was then examined and resection was performed if infiltration was observed, with a synthetic patch repair performed, if necessary. Tumor specimens were completely resected (Figure 2D), and the digestive tract was reconstructed after achieving adequate hemostasis. If required, the iliac vessels were removed and replaced using polytetrafluoroethylene (PTFE) grafts (Figure 2E).

Histopathological examination of the resected surgical specimens

All surgically excised *en bloc* surgical specimens were orientated by the surgeon before being submitted for pathological evaluation. Overall tumor size was defined as the sum of the maximum perpendicular diameters of the primary tumor, which were recorded at the resection. All margins were sampled perpendicularly, with two or more sections taken from all margins. Additional sections were taken from the closest margin. Serial sampling was performed for all resected organs and the surrounding fat tissue, and tissues between the tumor and organs were sampled at every 2 cm. Two specialist sarcoma pathologists independently performed the histopathological diagnosis, with the diagnostic criteria based on the current World Health Organization (WHO) classification system for soft tissue sarcoma [8]. Tumor grading was performed based on the three-tier Federation Nationale des Centres de Lutte Contre le Cancer criteria [9]. Inflammatory myofibroblastic tumor is a borderline malignant tumor, which tends to recur locally. The biological behavior and surgical treatment of retroperitoneal inflammatory myofibroblastic tumor are similar with retroperitoneal liposarcoma. Therefore, besides sarcoma, a case of inflammatory myofibroblastic tumor was included in study.

Definitions of categories of resection, organ infiltration and surrounding fat infiltration

Left abdominal *en bloc* evisceration was defined as resection of the left colon, pancreatic body and tail, spleen, left kidney, left adrenal gland, and left ureter, with or without other visceral organs (stomach, psoas major, diaphragm, small intestine, and iliac vessels). The resection patterns were divided into Category 1 (the left colon, pancreatic body and tail, spleen, left kidney, left adrenal gland, and left ureter), or Category 2 (Category 1 plus stomach, psoas major, diaphragm, small intestine, and iliac vessels). The surgical resection specimens were categorized as macroscopically complete (R0 or R1) or incomplete (R2), based on the pathological findings [3], and intraoperative tumor rupture was categorized as R2. Surrounding fat was defined as the adipose tissue within 1 mm from the organ surface. The infiltration patterns were classified as organ infiltration or surrounding fat infiltration. Organ infiltration was identified based on infiltration of the bowel or solid organ parenchyma. Surrounding fat infiltration was identified if infiltration of the surrounding fat was observed in the absence of organ infiltration.

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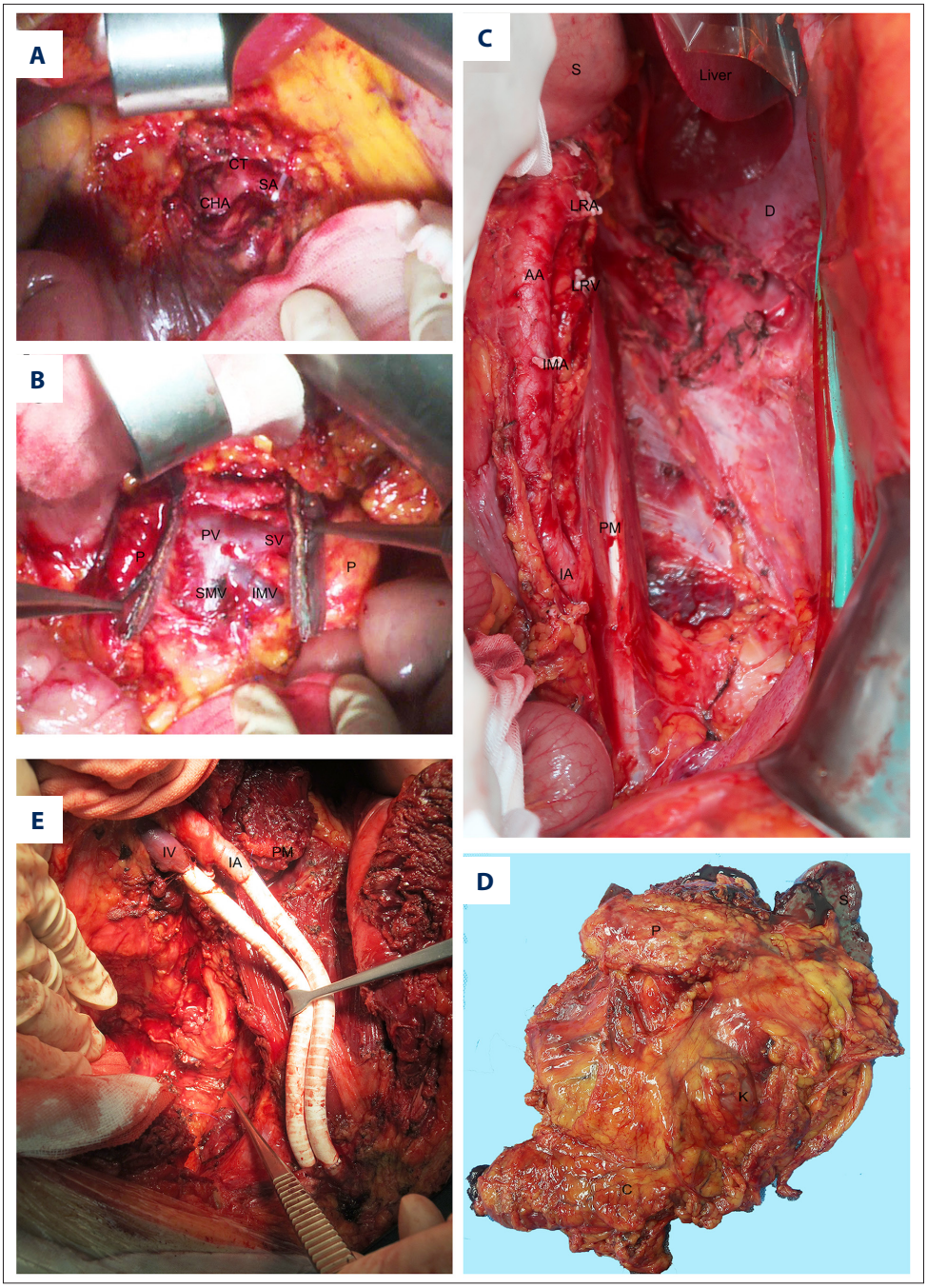

Figure 2. The surgical procedure of the anterior approach to *en bloc* resection of the left-sided retroperitoneal sarcoma with adjacent organ involvement. (**A**) The hepatoduodenal ligament is dissected to expose the common hepatic artery, celiac trunk, and splenic artery. The splenic artery is ligated approximately 1–2 cm from the splenic artery's origin. (**B**) The pancreas, splenic vein, and splenic artery are separated on the left side of the pancreatic neck, and the pancreatic stump is closed. (**C**) The operative field after the specimen is completely removed. The abdominal aorta is freed along the left side from the distal end to the proximal end, which exposes the entire left side of the abdominal aorta. The inferior mesenteric artery, left renal artery, and left renal vein are successively dissected and ligated. The retroperitoneal fat on the left side is completely removed. (**D**) The resected specimen. The tumor and adjacent organs are resected *en bloc*. (**E**) The iliac vessels are removed and replaced using polytetrafluoroethylene (PTFE) grafts (white vascular grafts). T – tumor; P – pancreas; S – spleen; K – kidney; PM – psoas major; C – colon; D – diaphragm; CHA – common hepatic artery; CT – celiac trunk; SA – splenic artery; PV – portal vein; SV – splenic vein; IMV – inferior mesenteric vein; IMA – inferior mesenteric artery; AA – abdominal aorta; IV – iliac vein; IA – iliac artery; LRA – left renal artery; LRV – left renal vein.

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Postoperative complications and follow-up

Postoperative complications were graded according to the seven grades of the Clavien-Dindo classification (I, II, IIIa, IIIb, IVa, IVb, and V) [10]. All patients were prospectively followed-up using clinical examination, chest radiography, and abdominopelvic computed tomography (CT) or magnetic resonance imaging (MRI). Patient follow-up was scheduled every three months for the first two years, every six months for the subsequent three years, and then annually.

Statistical analysis

Data were presented as the mean, median, and range, or number and percentage, as appropriate. For patients who underwent macroscopically complete surgical resection (R0 or R1), the local disease-free survival (DFS) was analyzed from the date of the operation to the date of recurrence, or the last clinical follow-up. Statistical analysis was performed using SPSS software version 24.0 (IBM Corp., Armonk, NY, USA). $P<0.05$ was considered as statistically significant.

Results

Patient characteristics

This retrospective clinical study included 25 patients. The most common histological type of retroperitoneal tumor was liposarcoma in 68% (17/25), undifferentiated pleomorphic sarcoma in 16% (four cases), leiomyosarcoma in 12% (three cases), and inflammatory myofibroblastic tumor in 4% (one case). Two patients underwent preoperative therapy, and one patient underwent radiotherapy followed by chemotherapy before surgery. In this study, 17 patients (68%) underwent surgery as their primary treatment, and eight patients underwent surgery after tumor recurrence.

The median time interval from excision of the primary retroperitoneal tumor to tumor recurrence was eight months (range, 2–34 months). None of the patients underwent postoperative chemotherapy or radiotherapy. The clinicopathological characteristics of the patients in the study are shown in Table 1.

Overview of the surgical procedure

All patients underwent an anterior approach to *en bloc* resection of the left-sided retroperitoneal tumors, all of which had adjacent organ involvement, with a median number of eight resected organs (range, 6–10), and a median operation time of 7.5 hours (range, 4–13 hours). The median estimated blood loss was 600 mL (range, 200–3,500 mL), with a median intraoperative transfusion of 2 units of packed red blood cells (range,

Table 1. Patient characteristics.

Characteristics	N (%)
Median age in years (IQR)	56 (48–62.5)
Sex	
Male	17 (68.0)
Female	8 (32.0)
Presentation	
Primary	17 (68.0)
Recurrent	8 (32.0)
Preoperative radiotherapy/chemotherapy	
Yes	3 (12.0)
No	22 (88.0)
Tumor number	
Single	22 (88.0)
Multiple	3 (12.0)
Tumor size	
<15 cm	5 (20.0)
15–30 cm	17 (68.0)
>30 cm	3 (12.0)
Number of organs resected	
6	4 (16.0)
7	2 (8.0)
8	10 (40.0)
9	8 (32.0)
10	1 (4.0)
Histological subtype	
Liposarcoma	17 (68.0)
Undifferentiated pleomorphic sarcoma	4 (16.0)
Leiomyosarcoma	3 (12.0)
Inflammatory myofibroblastic tumor	1 (4.0)
Resection margins	
Macroscopically complete	23 (92.0)
Macroscopically incomplete	2 (8.0)
FNCLCC grade	
G1	4 (16.0)
G2	10 (40.0)
G3	11 (44.0)

IQR – interquartile range; FNCLCC – Federation Nationale des Centres de Lutte Contre le Cancer criteria.

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Table 2. Patterns of resection.

Patterns of resection	N (%)
Category 1 + psoas major + diaphragm	6 (24.0)
Category 1	4 (16.0)
Category 1 + psoas major + diaphragm + small intestine	3 (12.0)
Category 1 + psoas major + small intestine	2 (8.0)
Category 1+ psoas major	2 (8.0)
Category 1 + psoas major + diaphragm + stomach	2 (8.0)
Category 1 + psoas major + iliac vessels	2 (8.0)
Category 1 + psoas major + stomach	1 (4.0)
Category 1 + diaphragm + stomach	1 (4.0)
Category 1 + diaphragm + small intestine + stomach	1 (4.0)
Category 1 + psoas major + diaphragm + iliac vessels	1 (4.0)

Category 1: resection of left colon + pancreatic body and tail + spleen + left kidney + left adrenal + left ureter.

0–14 units), although 12 patients (48%) did not receive transfusions during the surgical procedure.

Complete macroscopic resection (R0 or R1) was achieved in 23 patients (92%). One of the two remaining patients experienced tumor rupture during surgery (R2), and the other patient had spinal invasion and underwent intraoperative radiotherapy based on visible tumor near the spine (R2). All patients underwent left hemicolectomy, distal pancreatectomy, splenectomy, left nephrectomy, left adrenalectomy, and left ureter resection. Other visceral organs were resected in 21 patients (84%), which included the psoas major in 19 patients (76%), the diaphragm in 14 patients (56%), the small intestine in six patients (24%), the stomach in five patients (20%), and iliac blood vessels in three patients (2%). Among the 14 patients who underwent resection of the diaphragm, six patients (42.9%) required repair using an artificial patch. All patients who underwent iliac vessel resection also underwent polytetrafluoroethylene (PTFE) graft replacement. The patterns of the surgical procedure are shown in Table 2.

Overview of the patterns of retroperitoneal tumor infiltration

Twenty-four patients (96%) had tumor infiltration of at least one adjacent organ or the surrounding fat tissue. In 22 patients (88%), organ infiltration was found in 72 out of 200 resected organs (36%) and most of the fat surrounding the organs was also infiltrated. In 19 patients (76%), surrounding fat infiltration was found in 21 out of 200 resected organs (10.5%). In the 25 patients who underwent nephrectomy, 11 patients (44%) had infiltration of the renal parenchyma and one patient (4%) had only infiltration of the perirenal fat. Among the patients who underwent pancreatic resection, six patients (24%) had infiltration of the pancreatic parenchyma and nine patients (36%) only had infiltration of the surrounding fat. Among the patients who underwent left-sided colectomy, 11 patients (44%) had infiltration of the bowel and nine patients (36%) only had infiltration of the surrounding. Among the 14 patients who underwent resection of the diaphragm, organ infiltration was detected in 6 patients (42.9%). The details of the tumor infiltration patterns are shown in Figure 3.

Postoperative morbidity

Grade III and IV postoperative morbidity occurred in three out of 25 patients (12%), with two patients developing grade B postoperative pancreatic fistulas and one patient developing an abdominal infection that required surgical intervention. Two patients (8%) died because of postoperative complications within 90 days after surgery. One of these patients underwent a second operation for the abdominal infection and died because of a pulmonary embolism. The other death was related to renal failure at 69 days after the operation. There were no complications related to resection of the diaphragm. The occurrence of postoperative complications was not associated with preoperative chemotherapy or radiotherapy (P=0.33).

Post-operative patient follow-up

Among the 23 patients who underwent macroscopically complete resection (R0 or R1), one patient (4.3%) experienced local recurrence at 28 months after surgery and subsequently died. Among patients who underwent macroscopically complete resections, the one-year disease-free survival (DFS) rate was 91.3% (95% CI, 80.5–100.0%). Both patients who underwent R2 resection subsequently died because of tumor progression. Among all patients who underwent an anterior approach to *en bloc* resection of the left retroperitoneum for sarcoma with adjacent organ involvement, the one-year overall survival (OS) rate was 83.2% (95% CI, 69.4–99.7%).

Discussion

Resection of retroperitoneal sarcoma with resection of any involved organs has been recommended in several previous publications [5,7,11–13]. However, the present study was the first to examine the application of an anterior approach to *en bloc* resection for left-sided retroperitoneal sarcoma with adjacent organ involvement. The results showed that complete

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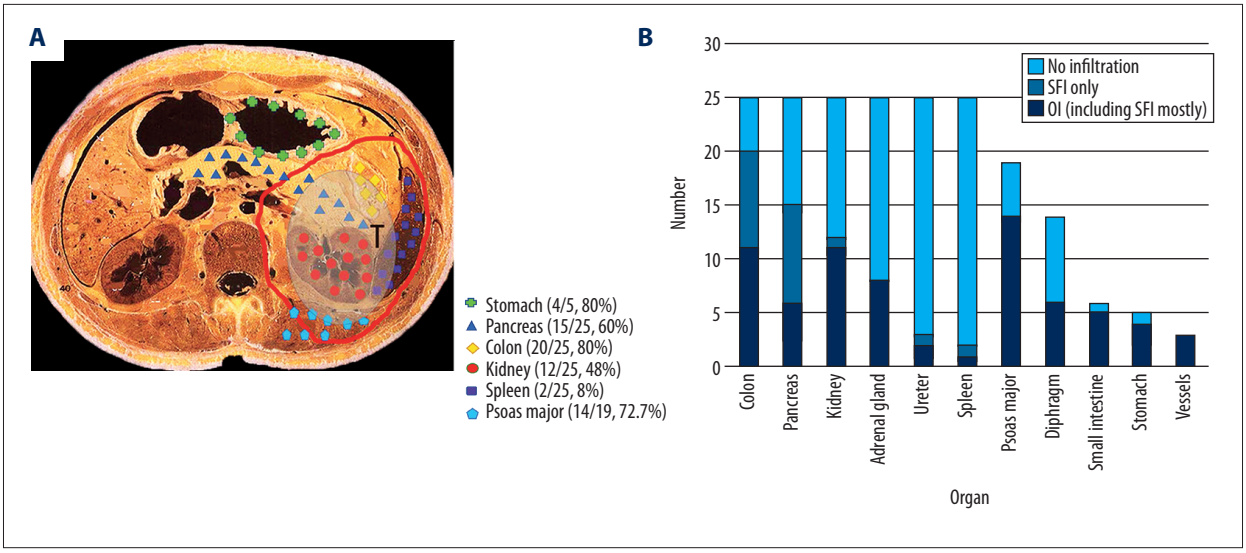

Figure 3. Patterns of tumor infiltration of the left retroperitoneal sarcoma including organ infiltration and surrounding fat infiltration. (**A**) The infiltration probability for partially resected organs according to the extent of resection. The infiltration probability is reported as a percentage (infiltrated organs/resected organs), and both organ infiltration and surrounding fat infiltration are counted as infiltrated organs in this figure. The extent of the resection is indicated by the red line. (**B**) The proportion of organ infiltration and surrounding fat infiltration in the resected organs. Organ infiltration (including surrounding fat infiltration in most cases): organ infiltration. When the organ is infiltrated by the tumor, most of the fat surrounding the organ is also infiltrated. Surrounding fat infiltration (SFI) only: infiltration of the surrounding fat is observed in the absence of organ infiltration.

macroscopic resection (R0 or R1) was achieved in 92% of cases and that the operation time, blood loss, and transfusion volumes were within acceptable ranges. Also, the histopathological results of this study showed that 96% of patients had tumor infiltration of at least one organ, or of the surrounding fat. Also, out of 200 resected organs, 93 (46.5%) had organ involvement and/or surrounding fat involvement, with the proportions of organ involvement and/or surrounding fat infiltration being >40% for most organs, except the ureter, adrenal gland, and spleen. These findings are supported by a previously published study by Mussi et al., who reported that 80% of patients had tumor infiltration of at least one visceral organ, with infiltrative growth patterns being observed in 39 of 92 organs (42.4%) [12]. Therefore, retroperitoneal sarcoma has a strong tendency for local invasion, and *en bloc* resection of the tumor and any involved adjacent organs is necessary to achieve negative surgical margins.

Previously published studies have indicated that renal resection during the primary surgery for retroperitoneal sarcoma provides improved disease-free survival (DFS) [14,15]. Also, a previously published study that included more than four years of follow-up data showed that patients who underwent renal resection did not require treatment for renal insufficiency, even though they received postoperative chemotherapy [16]. Therefore, if left nephrectomy is necessary, it may be performed when retroperitoneal sarcoma is adjacent to the left kidney. A further previous study showed that the resection of the retroperitoneal tumor and renal capsule preserved the renal parenchyma when the hilum was not involved, even if the kidney was encased by the tumor [17]. In the present study, 44% of the patients who underwent nephrectomy had infiltration of the renal parenchyma. Therefore, during kidney-preserving surgery, exploration is necessary to identify whether the tumor has invaded the renal parenchyma, which may lead to rupture of the retroperitoneal sarcoma and increase the probability of recurrence and peritoneal metastasis [18]. Also, retroperitoneal sarcoma infiltration cannot be evaluated accurately before or during the operation and should be confirmed by histopathology. For these reasons, nephrectomy is recommended for retroperitoneal sarcoma that occurs adjacent to the kidney.

All patients in the present study had tumors that were adjacent to the pancreas, and approximately 60% of the patients had infiltration of the pancreatic parenchyma and/or surrounding fat. Also, although 36% of patients who underwent pancreatectomy only had surrounding fat infiltration. Currently, there is no technique that can accurately assess parenchymal infiltration before or during surgery. Therefore, organ preservation will only be possible if intra-operative techniques are developed to assess accurately adjacent organ involvement, distal pancreatectomy is currently necessary to achieve negative surgical margins. However, when retroperitoneal sarcoma in the lower left retroperitoneum is not directly adjacent

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to the pancreas, distal pancreatectomy remains controversial in this setting. Therefore, additional research is needed to determine the optimal surgical approach in this scenario.

Splenectomy was performed in this study for two primary reasons. First, most left-sided retroperitoneal sarcomas are bulky and are closely related to the spleen and its associated blood vessels, which may cause compression of the spleen and inadequate exposure of the spleen during surgery. Splenic injury and bleeding are possible if the spleen is retained. Second, intraoperative assessment of splenic infiltration cannot be reliably performed if the tumor is close to the spleen. Several previous studies have indicated that splenectomy is safe for adult patients [19–21]. Therefore, removal of the spleen is still recommended, despite the small proportion of cases of left retroperitoneal tumors with splenic infiltration. In the cases evaluated in this study, the splenic artery was ligated near its origin to avoid any bleeding caused by accidental injury to the distal end of the splenic artery or the spleen.

The boundary between normal fat and retroperitoneal sarcoma is often difficult to discern, especially for well-differentiated liposarcoma [12]. Therefore, in this study, all retroperitoneal adipose tissue was removed to minimize the risk of incomplete resection. However, some soft-tissue sarcomas in the left retroperitoneum can be close to the diaphragm, which leaves only a small space for surgical access and can make it difficult to examine the relationship between the tumor and the diaphragm. In this scenario, the tumor should be freed from the distal end to the superior end, which should be followed by an examination of the relationship between the tumor and the diaphragm. If the tumor has infiltrated the diaphragm, resection and repair of the diaphragm should be performed. For patients requiring larger diaphragm resections and more complicated repair, a synthetic patch can be used. In the present study, no complications were detected that were related to resection of the diaphragm, and organ involvement was observed in 42.9% of these cases. Therefore, the findings of the present study support that resection and repair of the diaphragm is necessary in cases with tumor invasion, which is consistent with the previously published findings of Nicholas et al. [22].

It is often difficult to reach an early diagnosis of retroperitoneal sarcoma, as symptoms only appear when the tumor is relatively large. Therefore, given the size of symptomatic retroperitoneal sarcoma, a lateral surgical approach (via the left paracolic gutter) has several limitations. First, the left paracolic gutter cannot be adequately exposed, which may impair the view of the operative field. Second, it is difficult to examine the anatomical relationship between the tumor and the abdominal aorta using a lateral approach, which increases the likelihood of accidental aortic injury or incomplete resection. Third, if the use of the lateral approach leads to aortic injury and excessive bleeding, the poor exposure of the operative field may cause hemostatic challenges and possibly uncontrolled bleeding. Therefore, the medial approach was used for the patients in the present study, which facilitated a safer anterior approach to *en bloc* resection in left-sided retroperitoneal sarcoma with adjacent organ involvement.

Grade III and IV postoperative complications occurred in three patients (12%), with surgical re-intervention being necessary for one patient (4%). This result was slightly better than in previous studies of extended resection for retroperitoneal sarcoma, which showed severe postoperative complication rates of between 16.4–30% and surgical re-intervention rates of between 12–14% [5,13,23]. Although postoperative pancreatic fistulas accounted for 67% of all Grade III and IV complications in the present study, drainage was effective in those cases. For distal pancreatectomy, there is less risk associated with surgical treatment of left-sided retroperitoneal sarcoma, although the number of resected organs is a risk factor for postoperative complications, there appears to be no association between surgical morbidity and long-term outcome [5,23]. Therefore, extended surgery should be recommended for retroperitoneal sarcoma, and the anterior approach to *en bloc* resection appears to be a safe choice for the management of left-sided retroperitoneal sarcoma with adjacent organ involvement.

There are various subtypes of retroperitoneal sarcoma with a broad histological spectrum and variable biological behavior, responses to therapy, and clinical outcomes [24–27]. Gronchi et al. have reported that patients with Grade 1 and 2 retroperitoneal sarcoma benefitted from extended surgery, although no benefit was observed in Grade 3 sarcoma cases, which may be related to the high rate of distant metastasis in high-grade sarcomas [7]. Gronchi et al. have also reported that the recurrence patterns for retroperitoneal sarcoma varied between the different histological subtypes [27]. Also, Bonvalot et al. suggested that, for an retroperitoneal sarcoma entirely confined to the retroperitoneal muscles, there is no need to resect more than the affected muscle and that the femoral nerve must be preserved if it is not directly involved, but resection and reconstruction are needed for retroperitoneal sarcoma originating from the inferior vena cava [28]. Therefore, individualized treatment should be given for retroperitoneal sarcoma, which should be based on the specific histological subtype and anatomical position.

The present study had several limitations, including a relatively short follow-up time, and further large controlled long-term studies are needed to determine whether an anterior approach to *en bloc* resection in left-sided retroperitoneal sarcoma with adjacent organ involvement can improve patient clinical outcome. However, among the eight patients who underwent simple tumor resection before admission to our center, the median

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time from the primary surgery to recurrence was eight months (range, 2–34 months). In this context, some surgeons believe that left-side retroperitoneal sarcoma is a mass that only presses against, but does not infiltrate, the adjacent organs. Therefore, patients may undergo simple resection for the tumor itself but have an elevated risk of recurrence. Furthermore, *en bloc* resection of the tumor and adjacent organs is challenging and may be avoided by less experienced surgeons based on the risk of severe bleeding and postoperative complications. Nevertheless, among the 23 patients who underwent macroscopically complete resection (R0 or R1) in the present study, only one patient (4.3%) experienced local recurrence at 28 months after surgery. The findings of this study using an anterior approach to *en bloc* resection in left-sided retroperitoneal sarcoma with adjacent organ involvement appear to be encouraging and may be helpful for improving clinical decision making and treatment in similar settings.

Conclusions

An anterior approach to *en bloc* resection when there is adjacent organ involvement is an achievable surgical approach in patients with left-sided retroperitoneal sarcoma, and the rates of postoperative complications, re-operation, and 90-day mortality were within acceptable limits in this study of 25 patients at a single center.

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Conflicts of interest

None.

References:

1. Lewis JJ, Leung D, Woodruff JM, Brennan MF: Retroperitoneal soft-tissue sarcoma: Analysis of 500 patients treated and followed at a single institution. Ann Surg, 1998; 228: 355–65
2. Linehan DC, Lewis JJ, Leung D, Brennan MF: Influence of biologic factors and anatomic site in completely resected liposarcoma. J Clin Oncol, 2000; 18: 1637–43
3. Anaya DA, Lev DC, Pollock RE: The role of surgical margin status in retroperitoneal sarcoma. J Surg Oncol, 2008; 98: 607–10
4. Soft tissue and visceral sarcomas: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol, 2014; 25(S3): iii102–12
5. Bonvalot S, Miceli R, Berselli M et al: Aggressive surgery in retroperitoneal soft tissue sarcoma carried out at high-volume centers is safe and is associated with improved local control. Ann Surg Oncol, 2010; 17: 1507–14
6. Porter GA, Baxter NN, Pisters PW: Retroperitoneal sarcoma: A population-based analysis of epidemiology, surgery, and radiotherapy. Cancer, 2006; 106: 1610–16
7. Gronchi A, Miceli R, Colombo C et al: Frontline extended surgery is associated with improved survival in retroperitoneal low- to intermediate-grade soft tissue sarcomas. Ann Oncol, 2012; 23: 1067–73
8. Fletcher CDM, World Health Organization, International Agency for Research on Cancer. WHO classification of tumours of soft tissue and bone. 4th ed. Lyon: IARC Press, 2013
9. Trojani M, Contesso G, Coindre JM et al: Soft-tissue sarcomas of adults; study of pathological prognostic variables and definition of a histopathological grading system. Int J Cancer, 1984; 33: 37–42
10. Dindo D, Demartines N, Clavien PA: Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg, 2004; 240: 205–13
11. Bonvalot S, Rivoire M, Castaing M et al: Primary retroperitoneal sarcomas: A multivariate analysis of surgical factors associated with local control. J Clin Oncol, 2009; 27: 31–37
12. Mussi C, Colombo P, Bertuzzi A et al: Retroperitoneal sarcoma: Is it time to change the surgical policy? Ann Surg Oncol, 2011; 18: 2136–42
13. Pasquali S, Vohra R, Tsimopoulou I et al: Outcomes following extended surgery for retroperitoneal sarcomas: Results from a UK Referral Centre. Ann Surg Oncol, 2015; 22: 3550–56
14. Rhu J, Cho CW, Lee KW et al: Radical nephrectomy for primary retroperitoneal liposarcoma near the kidney has a beneficial effect on disease-free survival. World J Surg, 2017; 42(1): 254–62
15. Singer S, Antonescu CR, Riedel E, Brennan MF: Histologic subtype and margin of resection predict pattern of recurrence and survival for retroperitoneal liposarcoma. Ann Surg, 2003; 238: 358–70; discussion 370–71
16. Hull MA, Niemierko A, Haynes AB et al: Post-operative renal function following nephrectomy as part of *en bloc* resection of retroperitoneal sarcoma (RPS). J Surg Oncol, 2015; 112: 98–102
17. Crago AM, Singer S: Clinical and molecular approaches to well differentiated and dedifferentiated liposarcoma. Curr Opin Oncol, 2011; 23: 373–78
18. Rafat C, Zinzindohoue F, Hernigou A et al: Peritoneal implantation of pheochromocytoma following tumor capsule rupture during surgery. J Clin Endocrinol Metab, 2014; 99: E2681–85
19. Fan Y, Wu SD, Kong J et al: Feasibility and safety of single-incision laparoscopic splenectomy: A systematic review. J Surg Res, 2014; 186: 354–62
20. Stojcev Z, Bobowicz M, Jarzab M et al: Morbidity, mortality and survival after stomach resection with or without splenectomy – the single centre observations. Pol Przegl Chir, 2013; 85: 433–37
21. Cai YQ, Zhou J, Chen XD et al: Laparoscopic splenectomy is an effective and safe intervention for hypersplenism secondary to liver cirrhosis. Surg Endosc, 2011; 25: 3791–97
22. Harms NJ, Naderi S, Borys D et al: Complex diaphragm reconstruction using dermal collagen matrix after multivisceral resection of retroperitoneal sarcoma. J Thorac Cardiovasc Surg, 2010; 139: 1081–83
23. MacNeill AJ, Gronchi A, Miceli R et al: Postoperative morbidity after radical resection of primary retroperitoneal sarcoma: A report from the Transatlantic RPS Working Group. Ann Surg, 2017 [Epub ahead of print]
24. Trans-Atlantic Retroperitoneal Sarcoma Working Group (RPSWG): Management of primary retroperitoneal sarcoma (RPS) in the adult: A consensus approach from the Trans-Atlantic RPS Working Group. Ann Surg Oncol, 2015; 22: 256–63
25. Gronchi A, Miceli R, Shurell E et al: Outcome prediction in primary resected retroperitoneal soft tissue sarcoma: Histology-specific overall survival and disease-free survival nomograms built on major sarcoma center data sets. J Clin Oncol, 2013; 31: 1649–55
26. Toulmonde M, Bonvalot S, Meeus P et al: Retroperitoneal sarcomas: Patterns of care at diagnosis, prognostic factors and focus on main histological subtypes: A multicenter analysis of the French Sarcoma Group. Ann Oncol, 2014; 25: 735–42
27. Gronchi A, Strauss DC, Miceli R et al: Variability in patterns of recurrence after resection of primary retroperitoneal sarcoma (RPS): A report on 1007 patients from the multi-institutional collaborative RPS Working Group. Ann Surg, 2016; 263: 1002–9
28. Bonvalot S, Raut CP, Pollock RE et al: Technical considerations in surgery for retroperitoneal sarcomas: Position paper from E-Surge, a master class in sarcoma surgery, and EORTC-STBSG. Ann Surg Oncol, 2012; 19: 2981–91

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