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Knacks and pitfalls of retroperitoneal sarcoma surgery, part 2: practical tumor resection in Nagoya University

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ABSTRACT

This article provides a detailed account of the practical techniques and precautions regarding the surgical resection of retroperitoneal sarcoma (RPS). As there is no standardized procedure for RPS surgery, the operative approach must be flexible, depending on tumor location and extent. Stepwise dissection from multiple directions is emphasized, as well as decision-making regarding combined resection of adjacent organs, such as the intestine, pancreas, kidney, liver, and adrenal gland. Strategies for managing tumor-associated feeding arteries and drainage veins to minimize intraoperative bleeding are also discussed. Nephrectomy is recommended when the tumor invades the renal hilum or adjacent structures; however, kidney preservation is considered whenever possible. The paper also addresses the extent of resection required, noting that in retroperitoneal liposarcoma, compartmental fat tissue removal is often preferred over strict margin-based resection, considering the high rate of microscopic infiltration. Distinguishing well-differentiated from dedifferentiated components is partially achievable using imaging and intraoperative findings. Given the complexity of these procedures, multidisciplinary collaboration and the anesthesiologist's understanding of the surgical strategy are essential. This comprehensive overview highlights the technical depth and adaptability required for large RPS resections.

Keywords: practical tumor resection, nephrectomy, extent of resection

Abbreviations:
RPS: retroperitoneal sarcoma
CT: computed tomography

INTRODUCTION

Retroperitoneal sarcoma (RPS) represents a rare and heterogeneous group of malignant mesenchymal tumors arising in the retroperitoneal space, often characterized by their large size and complex anatomical involvement at diagnosis.[1] Surgical resection is the cornerstone of curative treatment, as other modalities such as chemotherapy or radiotherapy have limited efficacy in this

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setting.[2,3] However, RPS resection poses significant technical challenges due to the proximity of the tumor to vital structures, frequent infiltration or adherence to adjacent organs, and the absence of standardized surgical procedures.[4]

The primary goal of RPS surgery is complete macroscopic resection with negative margins; however, achieving an adequate oncologic margin is often challenging, especially for large tumors surrounded by critical vasculature and organs.[5,6] Moreover, intraoperative decision-making must balance oncologic radicality with organ preservation to minimize morbidity and maintain postoperative function.

In this context, practical surgical strategies, intraoperative judgment, and multidisciplinary collaboration are essential.[6] This article, as Part 2 of a series, focuses on the technical knacks and pitfalls encountered during practical tumor resection of RPS. It outlines key considerations, including dissection approaches, vascular control, organ involvement, and margin assessment, aiming to support surgeons in navigating the unique complexities of RPS surgery.

It should be noted that some aspects of the techniques described in this manuscript are not applicable to all types of RPS. Selecting techniques depending on RPS type and tumor status is recommended.

PRACTICAL TUMOR RESECTION

Dissection around the tumor

During laparotomy, surgeons should confirm whether there is unresectable peritoneal dissemination, unresectable multiple organ invasion, or unresectable large blood vessel invasion. If the case is deemed resectable, the tumor is exposed using total retroperitoneal exposing mobilization (TREM), as described in Part 1 of this series. TREM involves the mobilization of the right and left hemicolons, small intestine, pancreaticoduodenum, pancreatic body and tail, spleen, and right and left lobes of the liver, depending on the location of the tumor.

Once the retroperitoneal tumor is fully exposed by TREM, tumor resection can begin. Currently, there is no standard procedure for RPS resection. While observing the condition of the tumor, it should be gradually dissected from various directions, such as the lateral, medial, cranial, caudal, ventral, and dorsal sides. The tumor dissection should begin from an area that seems easy to approach. If the dissection at one location becomes difficult, it should be continued at another location that seems easier to dissect. This method should be repeated from multiple directions, which gradually increases tumor mobility and makes subsequent dissection easier. Continuous dissection from only one direction is not recommended.

Resection of the intestine

When any part of the intestine exhibits tumor involvement, partial intestinal resection should be performed. Even when the intestine is not directly involved by the tumor, intestinal resection is sometimes necessary because some parts of the mesenteric artery/vein are affected by the tumor. When an RPS is covered by the intestinal mesentery, resection of the intestine with its mesentery may enable an approach to the retroperitoneal space and ease further resection.

Dealing with tumor-feeding arteries and drainage veins

In tumors with abundant blood flow, it is necessary to determine the location of the feeding arteries and drainage veins using preoperative contrast computed tomography (CT). Radiologists may need to embolize the main feeding arteries before surgery to reduce intraoperative bleeding as much as possible (Fig. 1).

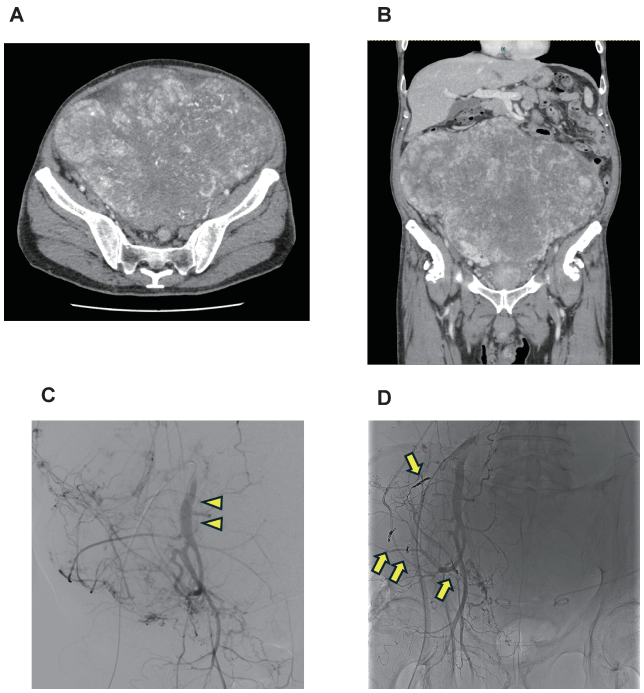

Fig. 1 A case of intrapelvic undifferentiated pleomorphic sarcoma
Axial (A) and coronal (B) computed tomography images indicate a large tumor originating from the pelvic floor. Several branches from the right internal iliac artery (arrowheads) fed the tumor, and these are embolized with multiple coils (arrows) one day before surgery (C, before embolization; D, after embolization).

It is also important to identify the main drainage vein of the tumor in advance. In many cases, the testicular/ovarian vein or venous plexus around the ureter is the major drainage vein of the RPS (Fig. 2A, B). In such cases, if the testicular/ovarian vein or ureter is cut too early in the resection process, tumor congestion may occur, making bleeding control difficult. If these veins are deemed important as drainage veins (as evidenced by their marked engorgement during surgery; Fig. 2C), surgeons should endeavor to cut them as much as possible at the final stage of tumor resection. However, this makes the resection process somewhat difficult because the tumor cannot be easily inverted from the retroperitoneum without cutting these veins.

On the dorsal side of the tumor, several feeding arteries and drainage veins are connected between the retroperitoneum and the tumor. If these are injured, heavy bleeding can occur. Torn blood vessels shrink and are buried in the retroperitoneum, complicating hemostasis. The feeding arteries and drainage veins of retroperitoneal tumors are often found beside the spine (vertebral body). Therefore, when the dissection layer approaches this area, it is necessary to pay close attention to hemostasis. When using a hemostatic energy device, attempts should be made to pinch the tissue as thinly as possible and ensure that a thick blood vessel is not pinched with the device.

It is occasionally difficult to ligate and dissect the feeding artery or drainage vein in the back of the tumor because of a large tumor hangover and insufficient working space to perform hemostatic maneuvers. In such cases, thin forceps should first be used to correctly grasp the bleeding point and achieve hemostasis (Fig. 3A). Thereafter, the forceps should be left, and dissection of other areas should proceed (with care not to inadvertently pull the forceps that grasp

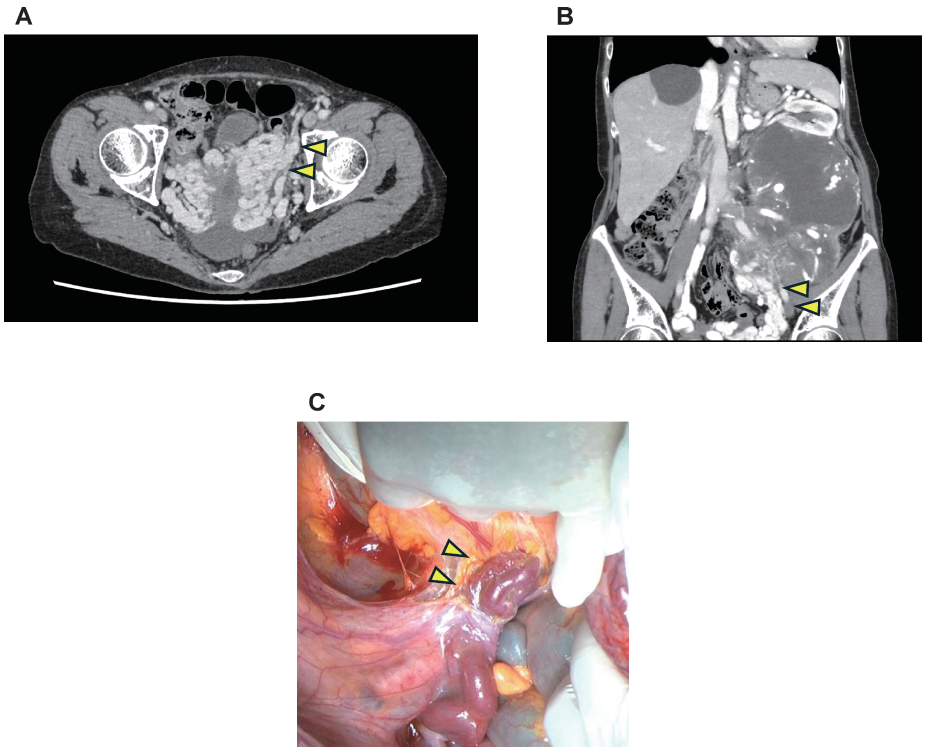

Fig. 2 A case of a large left-sided leiomyosarcoma
Axial (A) and coronal (B) computed tomography images indicate extensively engorged bilateral gonadal veins, suggesting that these vessels are major drainage veins of the tumor (arrowheads). Intraoperative photograph of a markedly engorged right gonadal vein (C). In this case, the left gonadal veins were dissected at the final stage of tumor resection.

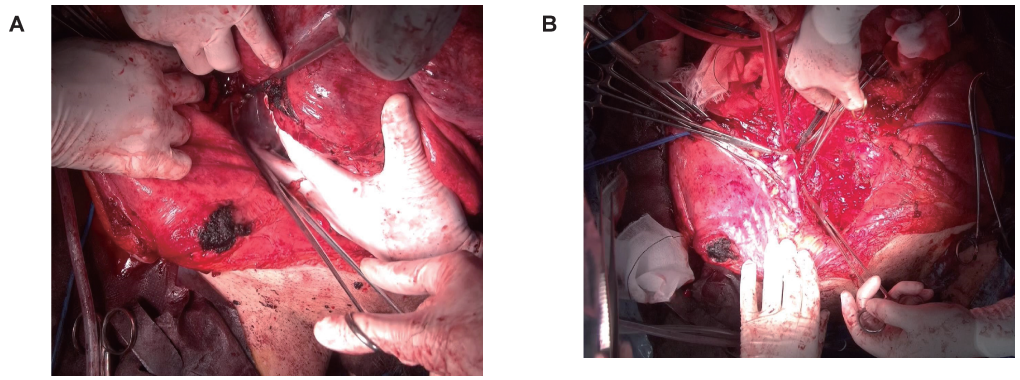

Fig. 3 A case of a large intrapelvic undifferentiated pleomorphic sarcoma
A large tumor received blood supply from numerous blood vessels in the pelvic floor. The bleeding point was grasped by forceps (A). At this point, it was notably difficult to perform a hemostatic maneuver because there was insufficient space due to the tumor hangover. After tumor removal, the bleeding points were processed individually (B).

the bleeding points). Once the surrounding area is dissected to a certain extent, the bleeding point should be revisited, at which point the working space should have expanded, allowing easier hemostatic maneuvers than before (Fig. 3B). This situation is very common in surgeries for large RPS. It is important not to panic even if bleeding occurs on the back of the tumor.

Tumor adhesion or infiltration to the diaphragm

Large tumors extending to the cranial side may be severely adherent to the diaphragm.

The diaphragm is dome-shaped; its ventral side comprises thick muscles and fascia, but the dorsal side (ie, the retroperitoneal side) is thin, becoming even thinner when it is severely compressed by a large tumor. Therefore, when a retroperitoneal tumor is dissected away from the diaphragm, the dorsal part of the diaphragm can tear easily, leading to an open chest. However, in general, only a small hole is made in an area where the lung does not exist, and repair can be easily performed after tumor removal. Even if the defect is large, the diaphragm can stretch; therefore, in most cases, it can be closed using a direct suture. Even if the diaphragm is missing in its half area, it can still be sutured directly. However, if the defect in the diaphragm is too large and cannot be closed directly, it can be patch-repaired using the fascia lata (Fig. 4).

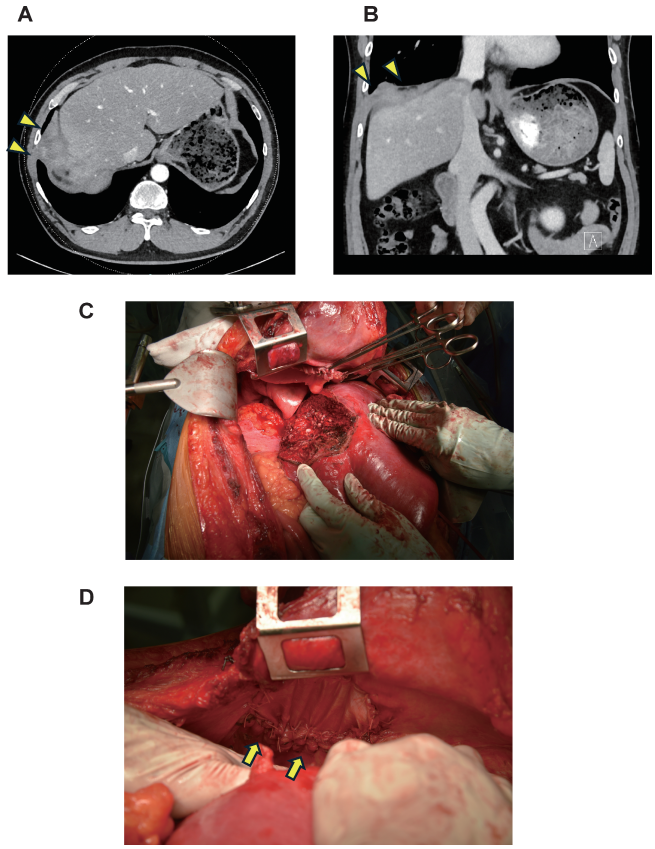

Fig. 4 A case of a right-sided diaphragmatic inflammatory tumor involving the liver dome
Axial (A) and coronal (B) computed tomography images indicate a tumor involving the liver dome (arrowheads). The tumor was resected with a wide portion of the diaphragm and the partial liver (C). The large defect of the diaphragm was patch-repaired using the fascia lata (arrows; D).

Tumor adhesion to the pancreatic head and the duodenum

In the case of a large right-sided RPS, it is not uncommon for the tumor to be in wide contact with the duodenum. Preoperative imaging may indicate the need for duodenectomy or pancreaticoduodenectomy (Fig. 5A, B). However, when surgery is performed, the tumor and pancreaticoduodenum can often be separated (Fig. 5C–E). In fact, in our surgical experiences in Nagoya University Rare Cancer Center (NURCC), there have been many cases in which pancreaticoduodenectomy was initially planned, but pancreaticoduodenectomy was rarely required. However, at the time of recurrence, pancreaticoduodenectomy may often be required due to the difficulty of separating the tumor from the duodenum or pancreatic head.

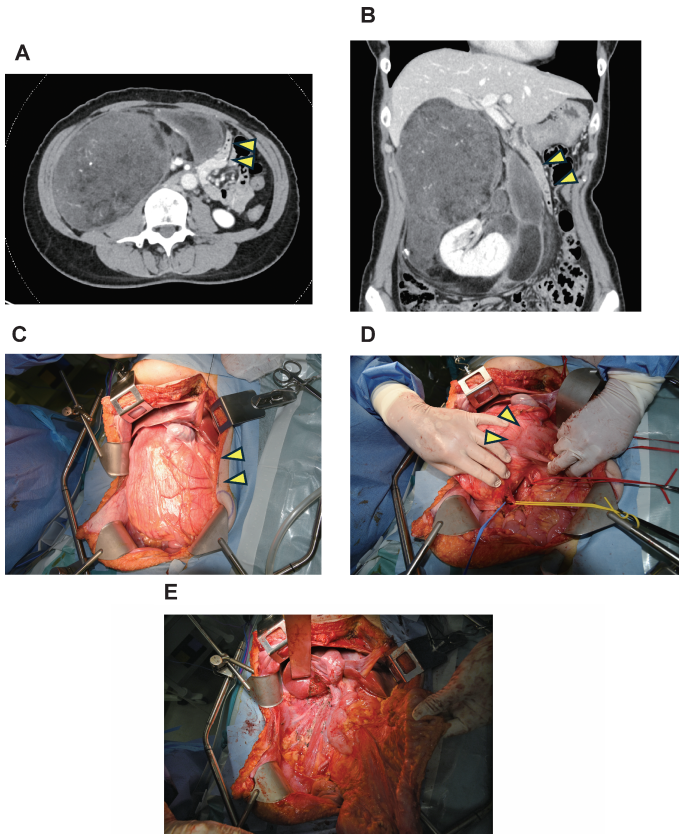

Fig. 5 A case of a large right-sided retroperitoneal liposarcoma
Axial (A) and coronal (B) computed tomography images indicate that the tumor was in wide contact with the duodenum (arrowheads). There was no invasion of the tumor into the duodenum, and it was separated from the tumor (C and D). After tumor removal (E).

Tumor adhesion to the pancreatic body and tail

In RPS of the left upper abdomen, the tumor may be widely adherent to the pancreatic body and tail. When the tumor is large, it is difficult to determine the presence or absence of invasion using preoperative imaging (Fig. 6A, B). Therefore, assessment during surgery is often employed. Even if the pancreatic body and tail appear to be severely adherent to the tumor, they often come off unexpectedly during dissection (Fig. 6C, D). This is similar to the case of duodenal or

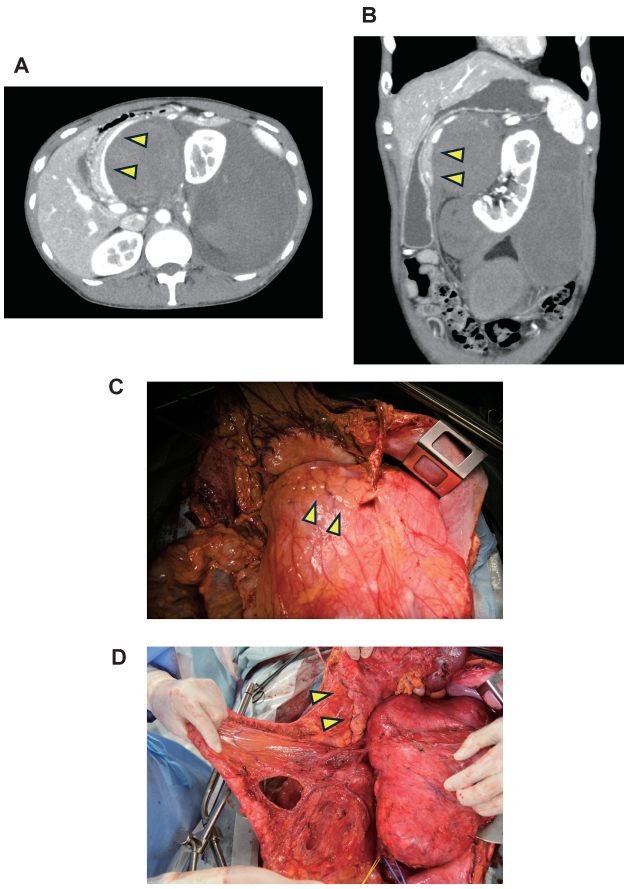

Fig. 6 A case of a large left-sided retroperitoneal liposarcoma
Axial (A) and coronal (B) computed tomography images indicate that the tumor was in wide contact with the pancreatic body and tail (arrowheads). There was no invasion of the tumor into the pancreas, and it was separated from the tumor (C and D).

pancreatic head dissection. If dissection is difficult, distal pancreatectomy and combined splenic resection should be performed.

When nephrectomy is required

When right-sided RPS requires combined resection of the right kidney, the right renal artery and vein are taped during the tumor dissection stage. The right renal vein is relatively easy to identify at the inferior edge of the liver and on the dorsal side of the duodenum. The right renal artery is usually located on the dorsal side of the right renal vein. After branching from the aorta, the right renal artery runs a relatively long distance behind the inferior vena cava (IVC). Sometimes, the right renal artery may branch into the upper and lower pole branches early on its course. Therefore, even if one right renal artery appears encircled at the renal hilum (on the right side of the IVC), another branch may exist. Identifying the renal artery is easier if the renal vein is cut off on the ventral side; however, this should never be performed before cutting the renal artery. At the renal hilum, all renal arterial blood flow should be cut off before processing the renal vein. Otherwise, blood will overflow from the ligated renal vein owing to

severe congestion.

If a left nephrectomy is required for left-sided RPS resection, the left renal vein behind the pancreatic body should first be taped. In this case, the left adrenal vein (the central vein) and the left testicular/ovarian vein should be taped separately to confirm the points where they join the left renal vein. During surgery, to preserve the left adrenal gland, the left renal vein should be processed on the upstream side of the left adrenal vein confluence. However, when a left nephrectomy is performed, the left testicular/ovarian vein should always be dissected simultaneously, so it may be processed in advance. However, as mentioned above, if the left testicular/ovarian vein serves as the main drainage vein of the tumor, it should be dissected at the late stage of tumor resection; otherwise, severe congestion of the tumor may occur, which may increase bleeding during the dissection.

The procedure for a left nephrectomy is similar to that of a right nephrectomy. First, the left renal artery should be ligated and dissected (Fig. 7A), and then the left renal vein should be processed (to avoid congestion) (Fig. 7B, C). The left renal artery is usually located immediately behind the left renal vein and may sometimes be difficult to identify from the ventral side. In this case, the tumor should be mobilized from the retroperitoneum and inverted to the right side to widen the view of the left posterior side of the tumor, and the left renal artery arising from the abdominal aorta should be taped and secured from the back side (Fig. 7A). In addition, similar

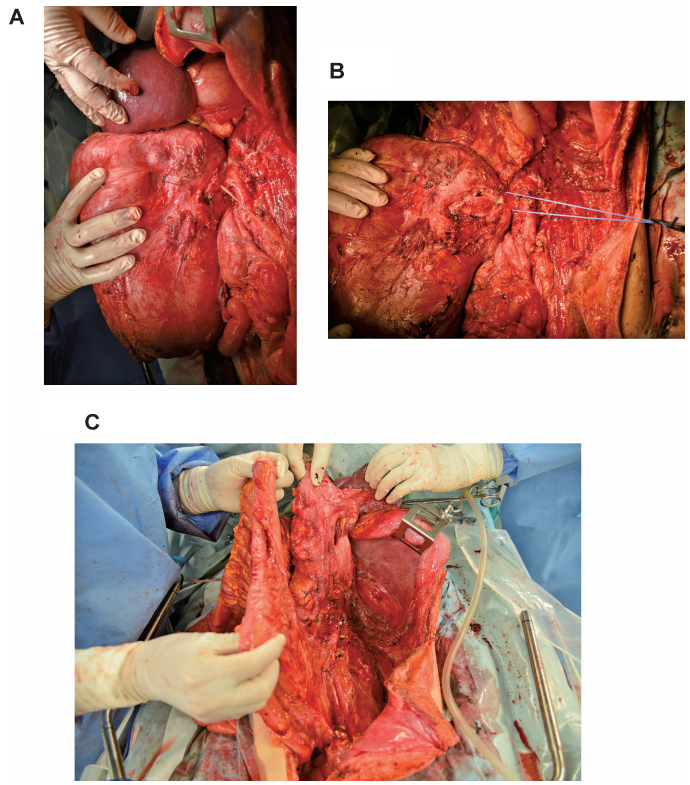

Fig. 7 A case of a large left-sided retroperitoneal liposarcoma
The left renal artery is encircled with red tape from the back of the tumor (A). The left renal artery was dissected to avoid congestion. Thereafter, the left renal vein was processed (B). After tumor resection (C). The left hemicolon, pancreatic body and tail, and spleen were preserved.

to the right renal artery, there are often multiple left renal arteries; therefore, it is important to accurately determine the number of left renal arteries and their branching points using CT scan images before surgery.

Preserving kidney

Retroperitoneal liposarcomas often develop in the pararenal fat space. In this case, the affected kidney is often surrounded by the tumor. However, even in the case of a large retroperitoneal liposarcoma, there are cases in which only well-differentiated components are clearly in contact with the kidney (Fig. 8A, B). In such cases, it is recommended that the kidneys be preserved as much as possible. Whether the kidney can be preserved is determined based on preoperative images; however, the most important judgment is made intraoperatively (Fig. 8C, D). It is important to ask urologists to insert a ureteral stent before surgery if surgeons intend to preserve the kidney. When preserving the kidney, the border between the renal parenchyma and the tumor

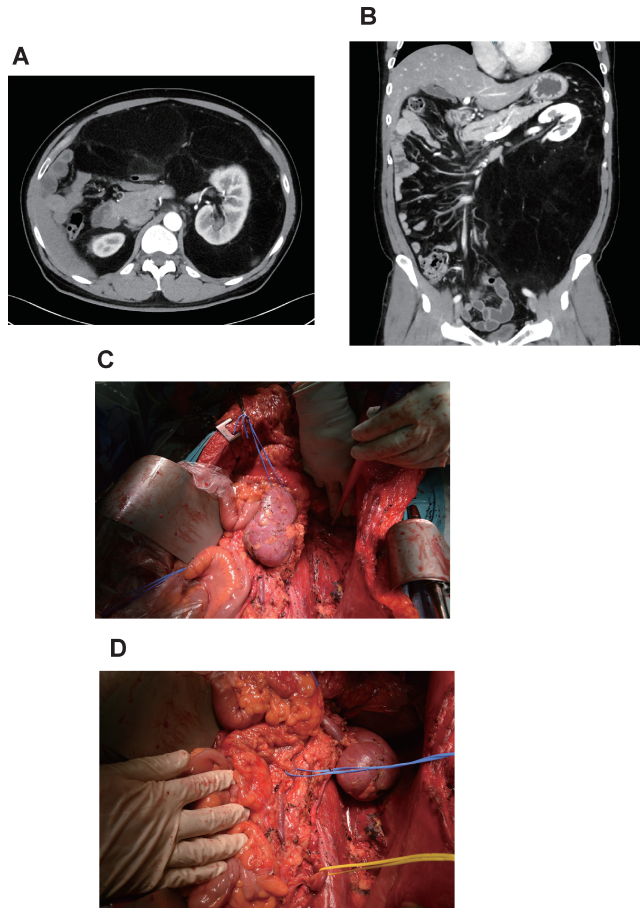

Fig. 8 A case of a large left-sided retroperitoneal well-differentiated liposarcoma
Axial (A) and coronal (B) computed tomography images indicate a large fat-dense tumor surrounding the left kidney. The tumor was resected while preserving the left kidney (C, left kidney is inverted; D, left kidney is in the normal position). The upper and lower poles of the kidney were fixed to the retroperitoneum to prevent torsion of the kidney.

must be carefully dissected. During dissection, surgeons may encounter areas where fat tissue is firmly adherent to the renal capsule. However, if these adhesions can be separated without compromising the renal parenchyma, dissection can be safely continued. However, it may be difficult to completely remove the fat tissue in the renal hilum. This area contains the renal artery and vein, ureter, renal pelvis, and hilar lymph nodes. It is difficult to skeletonize all of these structures. Therefore, if this area shows tumor involvement, nephrectomy is recommended.

When fat tissue around the kidney is completely removed, the kidney is connected only by the renal artery, renal vein, and ureter. Thus, after tumor resection, it is recommended that the upper and lower poles of the renal parenchyma be fixed to the retroperitoneal muscle or fascia to prevent torsion of the kidney.

In patients with retroperitoneal liposarcoma, combined nephrectomy is frequently performed (approximately 40% in our experience).[7] When the patient has only one kidney, the serum creatinine level may become higher than it was before surgery. However, it is rare for the creatinine level to exceed 2.0 mg/dL if the patient's creatinine level was within the normal range before surgery. In our experience at NURCC, no patient who developed a single kidney after surgery for RPS required hemodialysis unless the patient had renal failure before surgery. However, some patients who develop elevated creatinine levels are unable to undergo follow-up contrast-enhanced CT imaging. This should be explained to the patients before surgery.

Should the adrenal gland be routinely removed?

When performing combined resection of the affected kidney in patients with a large RPS, there is no consensus on whether to remove the adrenal gland simultaneously. Since the adrenal gland is in the same compartment as the kidney (in the pararenal fat space), it may be easy to remove it with the kidney in order to perform a wide margin resection. However, adrenal gland preservation may be a better choice if there is no clear tumor involvement. Thus, the pararenal fat space compartment around the adrenal gland should be deliberately accessed to preserve the adrenal gland. Sometimes, partial resection of the adrenal gland may be necessary.

The adrenal gland is a paired organ, similar to the kidney, so it can be removed as required. However, it is important in hormone secretion. When it is also necessary to remove the opposite adrenal gland, the patient will develop adrenal insufficiency and require oral steroid intake. Therefore, it is better to preserve the adrenal gland when possible.

How extensive is the resection?

For soft tissue sarcomas of the extremities, extensive resection is recommended over marginal resection. This is based on evidence that marginal resection is associated with a higher recurrence rate and a poorer prognosis.[8] So, what about RPS? Most large RPS can only be resected marginally. In soft tissue sarcomas of the extremities, a margin of at least 2 cm is recommended,[9] but it is almost infeasible for a "2 cm margin" to be achieved on the entire surface of a large RPS. Therefore, surgery for RPS must be considered separately from surgery for soft tissue sarcomas of the extremities, even if they are of the same histological type.

When performing surgery for retroperitoneal liposarcoma, which is the most common type of RPS, we repeatedly sample adipose tissue far from the tumor, where no tumor is observed on preoperative images. In these samples, well-differentiated liposarcoma components are frequently identified. This means that it is extremely difficult to determine the area of the tumor margin in cases of retroperitoneal liposarcoma. Therefore, in the initial surgery for this type of tumor, it is strongly recommended to remove as much retroperitoneal fat tissue on the affected side as possible (compartment resection). This is done to eliminate as much fat tissue as possible, which can be a risk factor for recurrence. Of course, various blood vessels and nerves run through the

retroperitoneal cavity, making it impossible to completely remove all fat tissue.

Some surgeons may think that if the kidney and adrenal gland are preserved too much, recurrence is more likely to occur. However, well-differentiated liposarcomas do not necessarily recur often, even if the resection margin is positive for well-differentiated components (note that this depends on the individual case). Therefore, the surgical approach for RPS should be considered separately from that for "carcinoma," which will almost definitely recur when the surgical margin is positive.

It is infeasible to perform pathological examinations of all the surgical margins of a large RPS.[10] Therefore, in surgical cases at the NURCC, pathological examination to evaluate the surgical margins is performed for areas with suspected tumor invasion. Nevertheless, in retroperitoneal liposarcomas, it is common for well-differentiated components to be positive in some areas; in other words, this is a pathological R1 resection (with a positive well-differentiated component). However, this does not mean that recurrence will occur at the positive surgical margin with the well-differentiated component. On the other hand, if the margin is positive for the dedifferentiated component, recurrence is almost certain. Therefore, it is crucial to make the margin negative for the dedifferentiated components.

How can we distinguish between well-differentiated and dedifferentiated components? Based on our experience at the NURCC, well-differentiated and dedifferentiated types can be distinguished to some extent by CT values and maximum standard uptake value (SUVmax) by positron emission tomography.[11] In the cited study, the cutoff values for differentiating dedifferentiated liposarcoma from well-differentiated liposarcoma were >24.4 HU (CT) and >2.90 (SUVmax). Additionally, during intraoperative judgment, tumors that are hard on palpation are more likely to be dedifferentiated. However, these indicators are not perfect, and the results are ultimately determined by pathological diagnosis.

DISCUSSION

Surgery for RPS requires a flexible arrangement depending on the tumor status. A wide range of surgical skills for the upper and lower gastrointestinal, hepato-pancreato-biliary, urinary tract, and reproductive organs is also necessary. It is also important for multidisciplinary surgeons to work together to perform surgery. In addition, anesthesiologists should also understand the surgical concepts for this rare and unusual tumor.

Surgery for RPS involving large retroperitoneal vessels is distinct from other surgeries. The knacks and pitfalls of surgery for this type of tumor will be discussed in Part 3.

CONFLICT OF INTEREST DISCLOSURE

None reported.

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