Intra and extra pelvic multidisciplinary surgical approach of retroperitoneal sarcoma: Case series report

Heekyoung Song, Jung Hwan Ahn, Yuyeon Jung, Jae Yeon Woo, Jimin Cha, Yang-Guk Chung, Keun Ho Lee

Abstract

BACKGROUND
Retroperitoneal sarcoma (RPS) is a rare malignancy arising from mesenchymal cells that most commonly presents as an abdominal mass and is associated with poor prognosis. Although several studies have assessed the survival benefits of wide excision, few have reported detailed methods for achieving wide excision in patients with RPS.

AIM
To describe our experience with multidisciplinary surgical resection of RPS using intra- and extra-pelvic approaches.

METHODS
Multidisciplinary surgery is an anatomical approach that combines intra- and extra-peritoneal access within the same surgery to achieve complete RPS removal. This retrospective review of the records of patients who underwent multidisciplinary surgery for RPS analyzed surgical and survival outcomes.

RESULTS
Eight patients underwent 10 intra- and extra-pelvic surgical resections, and their median mass size was 12.75 cm (range, 6-45.5 cm). Using an intrapelvic approach, laparoscopy-assisted surgery was performed in four cases and laparotomy surgery in six. Using an extrapelvic approach, ilioinguinal and posterior approaches were used in four cases each, and the prone position and midline skin

Specialty type: Oncology
Provenance and peer review: Unsolicited article; Externally peer reviewed.
Peer-review model: Single blind
Peer-review report’s scientific quality classification
Grade A (Excellent): 0
Grade B (Very good): 0
Grade C (Good): C, C
Grade D (Fair): 0
Grade E (Poor): 0
P-Reviewer: D’Orazi V, Italy; Lu H, China
Received: June 2, 2022
Peer-review started: June 2, 2022
First decision: July 14, 2022
Revised: July 18, 2022
Accepted: August 15, 2022
Article in press: August 15, 2022
Published online: September 26, 2022
incision were shared in one. All patients’ RPS masses were removed completely, and four achieved R0 resection through intra- and extra-pelvic surgery. The median estimated blood loss was 2000 mL (range, 300-20000 mL) and the median hospitalization was 12.6 d (range, 9-69 d). Reoperation was needed in two patients (one for wound necrosis and the other for bowel perforation and wound necrosis). The median overall survival rate and median progression-free survival were 64.6 and 13.7 mo, respectively.

**CONCLUSION**

RPS is therapeutically challenging because of its location and high risk of recurrence. Therefore, intra- and extra-pelvic surgical approaches can improve the macroscopic security of the surgical margin.

**Key Words:** Margins of excision; Retroperitoneal neoplasms; Sarcoma

©The Author(s) 2022. Published by Baishideng Publishing Group Inc. All rights reserved.

**Core Tip:** Retroperitoneal sarcomas (RPS) are therapeutically challenging because of their location and high risk of recurrence. Multidisciplinary surgery is an anatomical approach that combines intra- and extra-peritoneal access within the same surgery to achieve complete RPS removal. This retrospective review of the records of eight patients who underwent multidisciplinary surgery for RPS analyzed surgical and survival outcomes. All patients’ RPS masses were removed completely, and four achieved R0 resection through intra- and extra-pelvic surgery. Therefore, intra- and extra-pelvic surgical approaches can improve the macroscopic security of the surgical margin.

**Citation:** Song H, Ahn JH, Jung Y, Woo JY, Cha J, ChungYG, Lee KH. Intra and extra pelvic multidisciplinary surgical approach of retroperitoneal sarcoma: Case series report. *World J Clin Cases* 2022; 10(27): 9693-9702

**URL:** https://www.wjgnet.com/2307-8960/full/v10/i27/9693.htm

**DOI:** https://dx.doi.org/10.12998/wjcc.v10.i27.9693

**INTRODUCTION**

Retroperitoneal sarcoma (RPS) is a rare malignancy arising from mesenchymal cells that most commonly presents as an abdominal mass and is associated with poor prognosis[1]. Liposarcoma, either well-differentiated or dedifferentiated (WDLPS or DDLPS), is the most frequent histological subtype (50%-63%), followed by leiomyosarcoma (LMS) (19-23%) [2,3]. Other less frequent soft tissue sarcoma subtypes in the retroperitoneum include solitary fibrous tumor, malignant peripheral nerve sheath tumor (MPNST), synovial sarcoma, and undifferentiated pleomorphic sarcoma (UPS) [2,3]. The incidence is approximately 0.5-1 case per 100000, and these tumors are almost always sporadic[4]. Surgery is the mainstay of curative therapy, and local control is critical for an outcome[5]. In addition, the Korean obstetric gynecology group also noted that absent residual disease was an important prognostic factor in patients with leiomyosarcoma (hazard ratio 5.07, P < 0.001)[6]. Conversely, the role of chemotherapy in the management of localized RPS remains unclear; moreover, the potential benefit of radiotherapy (RT) remains controversial and is currently under evaluation[7]. Nevertheless, anatomical constraints in the retroperitoneum limit the ability to achieve a wide resection margin[1]. Considering this anatomical challenge, hospital volume may be a surrogate for the infrastructure and support necessary for the optimal management of these complex malignancies[8].

Although several studies have assessed the survival benefits of wide excision, few have reported detailed methods for achieving wide excision in patients with RPS. Therefore, the present study aimed to describe our experience with multidisciplinary surgical resection in patients with RPS, including intra- and extra-pelvic approaches. Our multidisciplinary surgical approach used an anatomical approach for tumor removal, combining intra- and extra-peritoneal RPS access (Figures 1 and 2). Although this two-step approach is more invasive than the conventional approach, it is a potential solution to overcome the surgical limitations of the anatomic location in the retroperitoneal space.

**MATERIALS AND METHODS**

Eligible patients seen at Seoul St. Mary’s Hospital, College of Medicine at The Catholic University of Korea, were identified based on their surgical history of RPS. Only patients who underwent surgical
Figure 1 Intra and extra pelvic multidisciplinary surgical approach. A: Incision of intra and extra pelvic approach (midline incision + ilioinguinal approach); B: Intra pelvic approach; C: Extrapelvic approach. *: Medial part of the sarcoma mass, soft tissue of the obturator internus; †: Lateral part of the sarcoma mass, from the ilium and ischium; EIA: External iliac artery.

Figure 2 Magnetic resonance image of retroperitoneal sarcoma involved Lt. pelvis (Lt. iliac bone, Lt. obturator internus muscles, Lt. common and internal iliac lymph node). A: Coronal T2 weighted image; B: Coronal T1 weighted fat suppression image.

RESULTS

Ten intra- and extra-pelvic surgical treatments were administered to eight patients in September 2014. The patients’ mean age and BMI were 42.75 years (range, 14-78 years) and 22.4 (range, 17.6-24), respectively. The median mass size was 12.75 cm (range: 6-45.5 cm). The masses extended from the
intra- to the retroperitoneal areas. Palpable mass or pain at specific sites was reported as the initial symptom in four patients. Three patients underwent multidisciplinary surgery as the primary surgical resection, whereas the others underwent a secondary or greater surgical resection (Table 1). Before surgery, all cases were discussed regarding resectability, necessary pre-operative procedures, and predicted complications in a multidisciplinary cooperative center at the Department of Oncology, Seoul St. Mary’s Hospital. In routine systems, contact with specialized doctors is available at every surgical time, owing to hospital policy. Another surgical team could be requested to join our surgery at any time during the operation.

For the intrapelvic approach, laparoscopy-assisted surgery was performed on four patients, and laparotomy surgery with midline incision was performed on six. For the extrapelvic approach, ilioinguinal and posterior approaches were used in four patients, while the prone position and midline skin incision were shared in one. In all 10 procedures, wide or marginal mass excision was performed, with resection of suspicious tumor invasion structures. The pelvic organs (sigmoid colon and external or internal iliac vessels) were dissected and mobilized by several specialized doctors. Pelvic lymph node dissections, prophylactic fixation, or revision of the structures were performed. In all 10 cases, a median of three surgical teams (range, 2-5 teams) cooperated to remove the RPS. The colorectal or vascular team of general surgery, gynecologic oncology team, bone tumor or spine part of orthopedic surgery, and urology doctors participated in multidisciplinary surgery (Table 2).

Prior to surgery, six patients underwent arterial embolization to reduce blood loss; nevertheless, their estimated median blood loss was 2000 mL (range, 300-20000 mL). Furthermore, nine patients received transfused blood intraoperatively. Ligation of the internal iliac vessel in one patient and dissection with mobilization of the iliac vessel in three were performed by a vascular surgical team. In addition, the vascular surgical team performed an internal iliac artery-deep femoral artery allograft bypass on one patient. The gynecologic oncology team performed another dissection and primary closure of the iliac vessel. These procedures are necessary to achieve surgical margins and reduce blood loss.

The median hospitalization duration was 12.6 d (range: 9-69 d). Reoperation was needed in two patients, one for wound necrosis and the other for bowel perforation and wound necrosis. No postoperative deaths occurred.

All the patients had the total tumor mass removed macroscopically, and four (40%) achieved R0 resection through intra- and extra-pelvic surgical treatment. The most common histology of RPS (two patients) was the myxoid type of well-differentiated liposarcoma. LMS, MPNST, osteosarcoma, chondrosarcoma, low-grade fibromyxoid sarcoma (LGFMS), and malignant spindle cell tumor were also noted. Neoadjuvant chemotherapy was administered to two patients, and all patients received adjuvant treatment (RT and/or chemotherapy).

Five patients are currently alive. Two patients died due to RPS progression, and one was lost to follow-up. Among the five living patients, disease progression was reported in three, while two showed no progression. The median OS was 64.6 mo (range, 11.4-206.8 mo), and the median PFS following treatment was 13.7 mo (range, 4.3-50.6 mo).

## Discussion

RPS consists of a heterogeneous group of malignant tumors with very low incidence. Very little is known about their biological behavior, and no specific causative compounds have been identified[9]. Macroscopically clear margins are an important prognostic factor for patients[9]. However, securing a clear margin is challenging because of the tumor location. Malinka et al[10] reported a macroscopically clear margin in 84% (51, total 61). Hogg et al[11] in a separate study, reported it in 88.9% (80, total 90). Our finding that all patients had a macroscopically clear margin is superior to that of conventional studies.

Patients used all treatment methods currently available, including surgical approaches, chemotherapy or target therapy, and RT. RT was the treatment option used to treat these patients. RT is usually used to control local recurrence or improve surgical margins; however, it does not affect distant metastasis or OS[12]. Haas et al[12] reported that pre-operative RT was associated with better local control in an unadjusted univariate analysis among the three cohorts, but not after accounting for imbalances in prognostic variables. According to Turner et al[13] compared with resection alone, additional neoadjuvant RT was associated with multi-visceral resection (87.5% vs 66.1%, P = 0.02) and negative margins (72.5% vs 30.6%, P < 0.001). Roeder et al[14] also reported that the combination of neoadjuvant intensity-modulated RT, surgery, and intraoperative RT is feasible with acceptable toxicity and yields good results in terms of local control and OS in patients with high-risk retroperitoneal sarcomas (estimated 3- and 5-year local control rates of 72% and estimated 3- and 5-year OS rates of 74%). This method showed superior effectiveness in achieving a surgical margin compared with neoadjuvant RT alone [R0 in six patients (22%) and R1 in 22 (74%)]. The combination method showed a rate with a macroscopically clear margin similar to ours (100%) but included several side effects and limitations. First, the combination method has more reported postoperative side effects. Nine patients (30%) had more than grade 3 postoperative side effects, four (15%) needed reoperations, and two died...
Table 1 Characteristics of patients with retroperitoneal sarcoma (n = 8)

| Characteristics                                      | Value                  |
|------------------------------------------------------|------------------------|
| Mean age (yr)                                        | 42.75 ± 18.4           |
| Mean BMI                                             | 22.4 ± 2.4             |
| Initial symptoms, n (%)                              |                        |
| Palpable mass                                        | 4 (50)                 |
| Pain on the specific site                            | 4 (50)                 |
| Median mass size (long axis, cm)                     | 12.75 ± 11.7           |
| Order of surgery, n (%)                              |                        |
| Primary                                              | 3 (30)                 |
| Secondary                                            | 2 (20)                 |
| Tertiary                                             | 2 (20)                 |
| More than tertiary                                   | 3 (30)                 |
| History of neoadjuvant or adjuvant treatment, n (%)   |                        |
| Neoadjuvant treatment                                | 2 (25)                 |
| Adjuvant treatment                                   | 8 (100)                |
| Surgical outcome                                     |                        |
| Median overall survival (mo, median)                 | 64.6                   |
| Progression-free survival (mo, median)               | 13.7                   |
| Died patients due to disease, n (%)                  | 2 (25)                 |
| Pathology, n (%)                                     |                        |
| Liposarcoma                                          | 2 (25)                 |
| Leiomyosarcoma                                        | 1 (12.5)               |
| Malignant peripheral nerve sheath tumor               | 1 (12.5)               |
| Osteosarcoma                                         | 2 (25)                 |
| Chondrosarcoma                                        | 1 (12.5)               |
| Low-grade fibromyxoid sarcoma                        | 1 (12.5)               |

during the prolonged postoperative period. These rates are higher than ours: two patients (20%) underwent reoperation, and none died postoperatively. Another limitation of the combination method is that it should only be administered to inpatients in hospitals with appropriate facilities for intensity-modulated and intraoperative RT. Thus, a multidisciplinary surgical approach is a good option for treating patients with RPS to achieve a clear margin.

However, the efficacy of chemotherapy and immunotherapy for RPS is limited. The role of adjuvant/neo-adjuvant systemic therapy is not well-defined because of the rarity of the disease and the paucity of randomized controlled data. The role of palliative systemic therapy is better established, mostly through extrapolation of data from sarcomas at other locations[15]. Currently, anthracycline-based therapy is the standard first-line treatment[16]. However, it induces a response in only 15%-35% of patients, irrespective of the histological subtype[17]. Thus, complete surgical resection is considered a milestone in RPS treatment. Several agents have recently emerged as second-line treatment options, including gemcitabine/docetaxel, high-dose ifosfamide monotherapy, trabectedin, pazopanib, and eribulin. According to the PALETTE study, pazopanib significantly increased PFS compared with placebo in metastatic soft tissue sarcoma, progressing despite previous standard chemotherapy[18]. According to Dickson et al[19] the selective CDK4 and CDK6 inhibitor palbociclib inhibits growth and induces senescence in liposarcoma cell lines, favoring progression free; however, there was no significant difference in PFS between patients who had or had not received prior systemic therapy ($P = 0.70$). Depending on the histological type, there are several randomized controlled trials on neoadjuvant or systemic chemotherapy. The EORTC-1809-STBSG- STRASS 2 study was intended to be an international randomized multicenter, open-label phase 3 trial, with stratification by specific tumor histology, including only high-grade dedifferentiated liposarcoma and LMS[20]. This study aimed to evaluate whether neoadjuvant chemotherapy reduces the development of distant metastases in these well-
Table 2 Surgical approach and outcomes (total 10 cases)

| PN   | Number of surgery | Intra pelvic surgery | Extra pelvic surgery | Pathology                  | Resection margin | EBL (mL) | HD (d) | OS (mo) | PFS (mo) |
|------|-------------------|----------------------|----------------------|----------------------------|------------------|----------|--------|---------|---------|
|      |                   | Approach method      | Approach method      | Intra pelvic surgery       | Extra pelvic surgery |         |        |         |         |
|      |                   | and operation title  | and operation title  | R0                         | R0               |          |        |         |         |
| 1    | Primary surgery   | Laparoscopy          | Posterior approach   | WDLPS                      |                  | 300      | 15     | 65.3    | 13.7    |
|      |                   | Mass excision        | of hip               | Wide excision              |                  |          |        |         |         |
| 1    | Secondary surgery | Laparotomy           | Laparotomy           | WDLPS                      |                  | R1       | R1     | 2000    | 17      |
|      |                   | Mass excision        | Marginal excision-    | neurolysis                 |                  |          |        |         |         |
|      |                   | Dissection and       | Lt. iliac vessel     |                            |                  |          |        |         |         |
|      |                   | mobilization of Lt.  | Lt. iliac artery     |                            |                  |          |        |         |         |
| 2    | 5th surgery       | Laparotomy           | Ilioinguinal approach| LMS                        |                  | R1       | R0     | 1250    | 19      |
|      |                   | Mass excision        | Wide excision        |                            |                  |          |        |         |         |
| 3    | Secondary surgery | Laparoscopy          | Ilioinguinal approach| MPNST                      |                  | R0       | R1     | 10000   | 42      |
|      |                   | Rt. RSO and PLND     | Wide excision        |                            |                  |          |        |         |         |
|      |                   | Sigmoid colon        | Dissection of Rt.    |                            |                  |          |        |         |         |
|      |                   | mobilization         | external and internal|                            |                  |          |        |         |         |
|      |                   | Lt. iliac vessel     | iliac vessel         |                            |                  |          |        |         |         |
| 4    | Primary surgery   | Laparotomy           | Posterior approach   | Myxoid liposarcoma         |                  | R0       | R1     | 2000    | 16      |
|      |                   | Mass excision        | of hip               | Wide excision neurolysis   |                  |          |        |         |         |
|      |                   | Dissection of Lt.    | Lt. iliac artery     |                            |                  |          |        |         |         |
|      |                   | common and external  | iliac vessel         |                            |                  |          |        |         |         |
|      |                   |Lt. iliac artery      | Dissection of Lt.    |                            |                  |          |        |         |         |
|      |                   |                   | internal iliac artery|                            |                  |          |        |         |         |
| 5    | Tertiary surgery  | Laparotomy           | Posterior approach   | Osteosarcoma               |                  | R0       | R0     | 20000   | 52      |
|      |                   | Mass excision        | of hip               | Wide excision, neurotomy   |                  |          |        |         |         |
|      |                   | Rectum mobilization  | L5-S1                |                            |                  |          |        |         |         |
| 6    | Tertiary surgery  | Laparotomy           | Ilioinguinal approach| LGFMS                      |                  | R1       | R0     | 12000   | 67      |
|      |                   | Mass excision        | Marginal excision skin flap and graft | |                  |          |        |         |         |
|      |                   | Int. iliac-deep femoral artery, | | |                  |          |        |         |         |
|      |                   | allograft bypass     | Lt. D-J catheter     | insertion with primary bladder repair | |          |        |         |         |
| 6    | Quaternary surgery| Laparotomy           | Prone position       | Osteosarcoma               |                  | R1       | R0     | 700     | 12      |
|      |                   | Mass excision        | Wide excision        |                            |                  |          |        |         |         |
| 7    | Primary surgery   | Laparoscopy          | Posterior approach   | Malignant spindle cell tumor| R0               | R0       | 10000   | 69      |
|      |                   | Mass excision        | Malignant spindle cell tumor | |                  |          |        |         |         |
|      |                   | Dissection and       | Wide excision        |                            |                  |          |        |         |         |
Defined histologic entities[20]. Thus, we are awaiting this result to determine the efficacy of neoadjuvant chemotherapy.

Complete surgical resection and securing clear surgical margins are the most effective therapeutic methods. However, as described above, surgical treatment is challenging for most surgeons because of the RPS location. To overcome this obstacle, neoadjuvant and/or adjuvant therapy was developed, and the Trans-Atlantic RPS Working Group was established in 2013. This group insisted on the importance of presurgical imaging studies and multidisciplinary discussions for patients with RPS. They also noted that complete resection should be accomplished despite large resections of adjacent organs[1]. Thus, an interdisciplinary collaboration among teams of surgeons, anesthesiologists, and nurses is necessary to achieve a complete RPS resection.

Several side effects have been noted following a multidisciplinary approach for RPS resection. Although there were no deaths in our sample, reoperation was needed in two patients. One patient underwent wound revision and local flap coverage for wound necrosis 17 d after surgery. The other patient’s complications were more severe (i.e., bowel perforation and wound necrosis), requiring exploratory laparotomy with ileostomy and wound debridement with flap coverage almost one month postoperatively. Compared to pelvic exenteration for recurrent or advanced cervical cancer, which is one of the most challenging surgeries in gynecological cancer, our multidisciplinary two-step approach resulted in higher wound complications than pelvic exenteration (20% vs 4.3%)[21]. The Dana-Farber/Brigham and Women’s Cancer Centre, which reviewed conventional surgical resection for RPS, reported a smaller median size of resected mass than this study [15.5cm (range, 1.8-60.0 cm) vs 12.75 cm (range, 6-45.5 cm)][22]. Long hospitalizations (range, 9-69 d) and large estimated blood loss volumes (range, 300-20000 mL) were also found, despite 60% of the patients receiving pre-operative arterial embolization. All 10 patients also required transfused packed red blood cells, fresh frozen plasma, and/or platelets. Moreover, almost 70% of all the patients had this surgery for recurrent diseases. Considering a few treatment options for recurrent RPS, a multidisciplinary approach is an essential option, though the surgical side effects are severe and the size that can be resected is rather small. This approach achieved a clear margin rate of 100%. Thus, it is a superior method to the conventional single-incision approach.

According to Bizzarri et al.[23] minimal invasive surgery could be applied to challenging surgery, keeping the same survival outcomes compared to conventional surgery. This two-step approach can also be changed to minimally invasive surgery using a robotic system or other advanced surgical methods. This could decrease the complication rates in patients with RPS using a two-step approach. Furthermore, this complication rate was lower than that found in a combination of RT and surgery, which achieved a similar clear surgical margin rate. In addition, pre-operative vascular assessment (Tinelli’s Score) could be a new option to achieve surgical margins and reduce blood loss[20,24]. We discussed several factors influencing the surgical status before surgery and performed arterial embolization if the cancerous mass was located or invaded the major vessel. However, we did not use this evaluation system pre-operatively. Therefore, we retrospectively analyzed our data using Tinelli’s Score. Among the 10 cases, six (60%) were grade 1 or 2, and two were grade 3. One case each was grade 4 and 5, and a major vessel allograft was performed in the case of grade 5 vessel invasion. Among the four cases with upper grade 3, arterial embolization was performed in 3. However, for these cases that showed a large amount of bleeding even after embolization, if a large amount of bleeding during surgery is suspected, even with a low score, embolization should be considered before surgery. Therefore, checking the vessel invasion grade, performing arterial embolization before surgery, and cooperation with the vascular surgical team could achieve complete tumor resection and reduce blood loss and surgical complications in the next surgery. Finally, applying enhanced recovery after surgery (ERAS) or a modified ERAS method may reduce hospitalization and postoperative complications.

These findings support the need for a multicenter or randomized controlled study to test the effectiveness of the multidisciplinary approach, despite the Trans-Atlantic RPS Working Group’s current guideline that the multidisciplinary approach is superior for complete tumor resection.

| 8 (5th surgery) | Laparoscopy | Ilioinguinal approach | Chondrosarcoma | R0 | R0 | 300 | 9 | 115 | 13.7 |
|----------------|-------------|----------------------|----------------|----|----|-----|---|-----|------|
| Mobilization of Lt. | Mass excision, Rt. | Marginal excision | Primary closure of Rt. | external and internal iliac vessel | PLND | |

EBL: Estimated blood loss; HD: Hospitalization days; LGFMS: Low-grade fibromyxoid sarcoma; LMS: Leiomyosarcoma; MPNST: Malignant peripheral nerve sheath tumor; OS: Overall survival; PFS: Progression-free survival; PN: Patient number; RSO: Right salpingo-oophorectomy; WDLPS: Well-differentiated liposarcoma; PLND: Pelvic lymph node dissection.
CONCLUSION

Therapeutic challenges associated with RPS are based on their location and high risk of recurrence. Therefore, a multidisciplinary approach is necessary to improve patient outcomes. The location of RPS and the benefits of using intra- and extra-pelvic treatments make this a good candidate for a multidisciplinary approach. This approach may improve the securing of the macroscopic surgical margins.

ARTICLE HIGHLIGHTS

Research background
Retroperitoneal sarcoma (RPS) is a rare malignancy and is associated with poor prognosis. Although several studies have assessed the survival benefits of wide excision, few have reported detailed methods for achieving wide excision in patients with RPS.

Research motivation
Considering poor prognosis of RPS, we'd like to find effective surgical approach to complete resection for RPS. This Multidisciplinary surgery is an anatomical approach that combines intra- and extra-peritoneal access within the same surgery to achieve complete RPS removal.

Research objectives
We described our experience with multidisciplinary surgical resection of RPS using intra- and extra-pelvic approaches.

Research methods
This study reviewed of the records of patients who underwent multidisciplinary surgery for RPS analyzed surgical and survival outcomes retrospectively.

Research results
All patients’ RPS masses were removed completely, and four achieved R0 resection through intra- and extra-pelvic surgery.

Research conclusions
RPS is therapeutically challenging because of its location and high risk of recurrence. Therefore, intra- and extra-pelvic surgical approaches can improve the macroscopic security of the surgical margin.

Research perspectives
These findings support the need for a multicenter or randomized controlled study to test the effectiveness of the multidisciplinary approach, despite the Trans-Atlantic RPS Working Group’s current guideline that the multidisciplinary approach is superior for complete tumor resection.

FOOTNOTES

Author contributions: Lee KH, Chung YG, and Song H designed this study; all other authors contributed to data collection; Song H, Ahn JH, Jung Y, Woo JY, and Cha J analyzed and interpreted the data, and Song H wrote the draft of the manuscript; Lee KH and Chung YG supervised and revised the manuscript for intellectual content.

Institutional review board statement: This study was approved by the institutional review board of Seoul St. Mary’s Hospital (approval number: KC20RISI0350).

Informed consent statement: The institutional review board waived the need for informed consent.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

Data sharing statement: No additional data are available.

STROBE statement: The authors have read the STROBE Statement—checklist of items, and the manuscript was prepared and revised according to the STROBE Statement—checklist of items.

Open-Access: This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-
REFERENCES

1. Trans-Atlantic RPS Working Group. Management of primary retroperitoneal sarcoma (RPS) in the adult: a consensus approach from the Trans-Atlantic RPS Working Group. *Ann Surg Oncol* 2015; 22: 256-263 [PMID: 25316486 DOI: 10.1245/s10434-014-3965-2]

2. Tan MC, Breman MF, Kul D, Agaram NP, Antonescu CR, Qin LX, Moraco N, Crago AM, Singer S. Histology-based Classification Predicts Pattern of Recurrence and Improves Risk Stratification in Primary Retroperitoneal Sarcoma. *Ann Surg* 2016; 263: 593-600 [PMID: 25915910 DOI: 10.1097/SLA.0000000000001149]

3. Gronchi A, Strauss DC, Miceli R, Bonvalot S, Swallow CJ, Hohenberger P, Van Coevorden F, Rutkowski P, Callegaro D, Hayes AJ, Honoré C, Fairweather M, Cannell A, Jakob J, Haas RL, Szacht M, Fiore M, Casali PG, Pollock RE, Raut CP. 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: 1002-1009 [PMID: 26727100 DOI: 10.1097/SLA.0000000000001447]

4. Trans-Atlantic RPS Working Group. Management of current Retroperitoneal Sarcoma (RPS) in the Adult: A Consensus Approach from the Trans-Atlantic RPS Working Group. *Ann Surg Oncol* 2016; 23: 3531-3540 [PMID: 27480354 DOI: 10.1245/s10434-016-5336-7]

5. van Houdt WJ, Zaidi S, Messiou C, Thway K, Strauss DC, Jones RL. Treatment of retroperitoneal sarcoma: current standards and new developments. *Curr Opin Oncol* 2017; 29: 260-267 [PMID: 28590807 DOI: 10.1097/COC.0000000000001377]

6. Paik ES, Kang JH, Kim J, Lee YJ, Choi CH, Kim TJ, Kim BG, Bae DS, Lee JW. Prognostic factors for recurrence and survival in uterine leiomyosarcoma: Korean single center experience with 50 cases. *Obstet Gynecol Sci* 2019; 62: 103-111 [PMID: 30918878 DOI: 10.5468/ogs.2019.62.2.103]

7. Cananzi FCM, Ruspi L, Sicoli F, Minerva EM, Quangluo V. Did outcomes improve in retroperitoneal sarcoma surgery? *Surg Oncol* 2019; 28: 96-102 [PMID: 30859291 DOI: 10.1016/j.suronc.2018.11.004]

8. Adam MA, Moris D, Behrens S, Nussbaum DP, Jawitz O, Turner M, Lidsky M, Blazer D 3rd. Hospital Volume Threshold for the Treatment of Retroperitoneal Sarcoma. *Anticancer Res* 2019; 39: 2007-2014 [PMID: 30952744 DOI: 10.21873/anticancer.13311]

9. Mantas D, Garmnps N, Polychroni D, Garmnp A, Danusikos C, Liaka A, Syspa G, Kousks E. Retroperitoneal sarcomas: from diagnosis to treatment. Case series and review of the literature. *G Chir* 2020; 41: 18-33 [PMID: 32038009]

10. Malinka T, Nebrig M, Klinf P, Pratschke J, Bahr M, Andrea A. Analysis of outcomes and predictors of long-term survival following resection for retroperitoneal sarcoma. *BMC Surg* 2019; 19: 61 [PMID: 31182086 DOI: 10.1186/s12893-019-0521-9]

11. Hogg HD, Manas DM, Lee D, Dildey P, Scott J, Lunec J, French JJ. Surgical outcome and patterns of recurrence for retroperitoneal sarcoma at a single centre. *Ann R Coll Surg Engl* 2016; 98: 192-197 [PMID: 26876538 DOI: 10.1308/rcsann.2016.0057]

12. Haas RL,M, Bonvalot S, Miceli R, Strauss DC, Swallow CJ, Hohenberger P, van Coevorden F, Rutkowski P, Callegaro D, Hayes AJ, Honoré C, Fairweather M, Gladly R, Jakob J, Szacht M, Fiore M, Chung PW, van Houdt WJ, Raut CP, Gronchi A. Radiotherapy for retroperitoneal liposarcoma: A report from the Transatlantic Retropertoneal Sarcoma Working Group. *Cancer* 2019; 125: 1290-1300 [PMID: 30602055 DOI: 10.1002/cncr.31927]

13. Turner BT, Hampton L, Schiller D, Mack LA, Robertson-More C, Li H, Quan M., Bouchard-Fortier A. Neoadjuvant radiotherapy followed by surgery compared with surgery alone in the treatment of retroperitoneal sarcoma: a population-based comparison. *Curr Oncol* 2019; 26: e766-e772 [PMID: 31896947 DOI: 10.3747/co.26.5183]

14. Roeder F, Ulrich A, Habl G, Uhl M, Saleh-Ebrahimi L, Huber PE, Schulz-Errner D, Nikoghosyan AV, Alldinger I, Ulrich A, Habl G, Uhl M, Saleh-Ebrahimi L, Huber PE, Schulz-Errner D, Nikoghosyan AV, Alldinger I, Krempien R, Mechterisheger H, Hensley FW, Debis J, Bischof M. Clinical phase III/II trial to investigate preoperative dose-escalated intensity-modulated radiation therapy (IMRT) and intraoperative radiation therapy (IORT) in patients with retroperitoneal soft tissue sarcoma: interim analysis. *BMJ Cancer* 2014; 14: 617 [PMID: 25163595 DOI: 10.1186/1471-2407-14-617]

15. Constantinidou A, Jones RL. Systemic therapy in retroperitoneal sarcoma management. *Curr Oncol* 2018; 117: 87-92 [PMID: 29194633 DOI: 10.1002/isoa.24933]

16. van Houdt WJ, Raut CP, Bonvalot S, Swallow CJ, Haas R, Gronchi A. New research strategies in retroperitoneal sarcoma. The case of TARPSW, STRASS and RESAR: making progress through collaboration. *Curr Opin Oncol* 2019; 31: 310-316 [PMID: 30893150 DOI: 10.1097/CCO.0000000000000553]

17. Almond LM, Gronchi A, Strauss D, Jafri M, Ford S, Desai A. Neoadjuvant and adjuvant strategies in retroperitoneal sarcoma. *Eur J Surg Oncol* 2018; 44: 571-579 [PMID: 29472043 DOI: 10.1016/j.ejso.2018.02.001]

18. van der Graaf WT, Blay JY, Chawla SP, Kim DW, Bui-Nguyen B, Casali PG, Schlöflki P, Aglietta M, Staddon AP, Beppu Y, Le Cesne A, Gelderblom H, Judson IR, Araki N, Ouali M, Marreaud S, Hodge R, Dewi MR, Coens C, Demetri
GD, Fletcher CD, Dei Tos AP, Hohenberger P; EORTC Soft Tissue and Bone Sarcoma Group; PALETTE study group. Pazopanib for metastatic soft-tissue sarcoma (PALETTE): a randomised, double-blind, placebo-controlled phase 3 trial. Lancet 2012; 379: 1879-1886 [PMID: 22595799 DOI: 10.1016/S0140-6736(12)60851-5]

19 Dickson MA, Schwartz GK, Koochan ML, D'Angelo SP, Gounder MM, Chi P, Antonescu CR, Landa J, Qin LX, Crago AM, Singer S, Koff A, Tap WD. Progression-free survival among patients with well-differentiated or dedifferentiated liposarcoma treated with cdk4 inhibitor palbociclib: A phase 2 clinical trial. JAMA Oncol 2016; 2: 937-940 [PMID: 27124535 DOI: 10.1001/jamaoncol.2016.0264]

20 Trans-Atlantic Retroperitoneal Sarcoma Working Group (TARPSWG). Management of metastatic retroperitoneal sarcoma: a consensus approach from the Trans-Atlantic Retroperitoneal Sarcoma Working Group (TARPSWG). Ann Oncol 2018; 29: 857-871 [PMID: 29432564 DOI: 10.1093/annonc/mdy052]

21 Ter Glane L, Hegele A, Wagner U, Boekhoff J. Pelvic exenteration for recurrent or advanced gynecologic malignancies - Analysis of outcome and complications. Gynecol Oncol Rep 2021; 36: 100757 [PMID: 33898694 DOI: 10.1016/j.gore.2021.100757]

22 Fairweather M, Wang J, Jo VY, Baldini EH, Bertagnolli MM, Raut CP. Surgical Management of Primary Retroperitoneal Sarcomas: Rationale for Selective Organ Resection. Ann Surg Oncol 2018; 25: 98-106 [PMID: 29067605 DOI: 10.1245/s10434-017-6136-4]

23 Bizzarri N, Chiantera V, Ercoli A, Fagotti A, Tortorella L, Conte C, Cappuccio S, Di Donna MC, Gallotta V, Scambia G, Vizzielli G. Minimally Invasive Pelvic Exenteration for Gynecologic Malignancies: A Multi-Institutional Case Series and Review of the Literature. J Minim Invasive Gynecol 2019; 26: 1316-1326 [PMID: 30611973 DOI: 10.1016/j.jmig.2018.12.019]

24 Vizzielli G, Chiantera V, Tinelli G, Fagotti A, Gallotta V, Di Giorgio A, Gueli Alletti S, Scambia G. Out-of-the-box pelvic surgery including iliohypogastric resection for recurrent gynecological malignancies: Does that make sense? Eur J Surg Oncol 2017; 43: 710-716 [PMID: 27890348 DOI: 10.1016/j.ejso.2016.10.028]
