

Robot-Assisted Thoracoscopic Surgery of Neurogenic Tumours in the Apical Chest: A Case Series

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Research article

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Abstract

Background: Superior posterior mediastinal tumours may arise in the apical chest. However, the removal of such tumours via conventional minimally invasive approaches remains challenging. In this paper, we demonstrate our experience of robotic-assisted thoracoscopic surgery (RATS) for patients with neurogenic apical chest tumours (ACT).

Methods: We retrospectively included 15 consecutive patients who underwent the resection of posterior mediastinal neurogenic tumour wherein the upper extent of the tumour extended upwards to the sternoclavicular joint plane based on chest imaging findings. The clinical characteristics and perioperative outcomes of these patients were collected and analysed.

Results: Between April 2017 and June 2020, a total of 15 consecutive cases with ACT underwent radical surgical resection through RATS by our team. These patients showed encouraging short-term outcomes after surgery and there was no conversion to thoracotomy. The median tumour size was 4.0 (2.1-10.6) cm. Five large tumours (> 5.0 cm) were completely resected. The median overall time of surgery was 100 (range, 30–240) minutes. In only one case, a patient experienced massive bleeding (> 500 mL) with a left schwannoma (10.6*5.8*4.8 cm). This resulted in intraoperative haemorrhage because of significant adhesion around the lesion. However, this case was successfully managed by robotic manoeuvres. The median hospital stay was 3 (range, 4–7) days. The median duration of the chest tube was 2 (range, 1–3) days. One case suffered from a non-permanent Horner's syndrome and recovered within seven months. No patients developed brachial plexus-associated complications. No death occurred during the perioperative period.

Conclusions: RATS is a safe and effective alternative modality for the treatment of ACT. The technique extends conventional thoracoscopic indications for posterior mediastinal lesions including apical chest lesions.

Background

Although posterior mediastinal tumours are mainly comprised of various benign neoplasia, they may arise in extreme locations such as the apical or lower chest [1, 2]. Consequently, safe and complete surgical resection can be difficult via conventional minimally invasive surgery because of the confined space and vital structures around lesions. Large lesions are frequently found due to their benign nature, which further contribute to limited operating space. Additionally, many vital anatomical structures are contiguous to superior posterior mediastinal tumours, such as the oesophagus, airway, brachial plexus, sympathetic and recurrent laryngeal nerve, and neck-root vessels. This makes radical dissection of the lesions difficult and so open surgery remains the mainstream approach.

Video-assisted thoracoscopic surgery for ACT remains a major challenge with only very few studies having been published on minimally invasive surgery for ACT [1, 3]. Notably, robot-assisted thoracoscopic surgery (RATS) has been increasingly implemented in the past few years as it has many advantages over traditional thoracoscopic procedures including magnified three-dimensional imaging, a wristed instrument with seven degrees of freedom, and tremor filtration. These advantages may allow the application of minimally invasive surgery for ACT. The current study aimed to assess the efficacy of RATS for ACT by reviewing the short-term surgical outcomes of patients with neurogenic ACT treated by our team.

Methods

Approval for this retrospective study was obtained from the local research ethics committee. We consecutively reviewed patients with neurogenic ACT who underwent treatment using RATS (da Vinci surgical system, Intuitive Surgical, Inc., Sunnyvale, CA, USA) by one surgeon and their team between April 2017 and June 2020 in the Thoracic Surgery Department of West China Hospital. ACT refer to the lesions located at the thoracic inlet which are also called tumours of the cervicothoracic junction. Al-Mufarrej et al. defined these lesions as tumours located at the level of the third rib or higher [4]. To clarify our inclusion criteria, we defined the lesions as tumours located in the upper end above the sternoclavicular joint plane, as shown in Fig. 1. Neurogenic tumours were included based on diagnosis from chest imaging and pathology. Finally, a total of 15 cases with primary neurogenic ACT treated with RATS were consecutively included in the study. Patient data were collected which included basic clinical characteristics, details of the surgical operation, surgical time (defined as the duration between skin incision and skin closure), blood loss, intraoperative and postoperative morbidity, pleural drainage and hospitalization stay. Statistical analysis was conducted using SPSS 22.0 statistical software (SPSS Inc., Chicago, IL, USA).

Robotic surgical indications and case selection

Based on clinical manifestation and chest imaging, if ACT were relatively well encapsulated and showed clear boundaries of primary benign masses, RATS was considered as an alternative modality. For paravertebral tumours, there were no intraspinal components. Importantly, cases had no thoracic surgical history and image findings showed no evidence of infiltration of surrounding structures.

Perioperative management

A consistent treatment protocol for pre-operative preparation was implemented by the thoracic surgeon. The surgical modality and pre-operation scheme depended on the opinion of the surgeon and patient compliance. After surgery, in the absence of drainage (less than 200 mL/day), the chest tube was removed, and all patients were normally discharged on the following day after removal of the chest tube.

Surgical technique

Surgical resection was performed through a 3-arm robotic-assisted thoracoscopic procedure. The surgery was performed while anaesthesia was administered via single-lumen endotracheal tube following insufflation with CO₂.

Patients were placed in the lateral decubitus position with folding knife gesture. Generally, three small incisions were created for the camera and 2 working ports (Fig. 2). Of these ports, one 1 cm port was used for the camera located in the 6th intercostal space between the posterior axillary and scapular lines. One 0.8 cm port used for arm 1 was inserted in the 3rd intercostal space at the anterior axillary line, and the arm 2 port was created in the 6th intercostal space at the lateral border of the erector spinalis muscle. In most cases, an assistant port was not required. However, when necessary, it was inserted in the 7th intercostal space along the midaxillary line. The technical aspects of the operations varied slightly depending on the exact location of the lesions.

The ports were docked to the patient cart which came from the head of patient. The lesion was mobilized away from surrounding structures with electrocautery or using an ultrasonic scalpel through arm #1 under the help of fenestrated bipolar forceps or a Cadiere Forcep through arm #2 (Fig. 3). An assistant port was made to improve the exposure if necessary. Surrounding vital anatomical structures are protected from unexpected injury. When the resection was completed, the specimen was removed through the camera port. After haemostasis check, a chest tube was introduced through one of the instrument incisions.

Results

We consecutively reviewed a total of 15 patients with neurogenic tumours in the apical chest resected through RATS by our team. The basic clinicopathological features and perioperative data from the patients are summarized in Table 1. The median age was 49 years old (range, 18–62), and 7 men (46.7%) and 8 women (53.3%) were recruited to the study. Of these patients, nine cases presented with a left sided lesion (60.0%), including 4 ganglioneuromas (26.7%) and 11 schwannomas (73.3%). The tumour was found during a routine examination in eight patients (60.0%). Four cases (26.7%) were admitted because of cough and two cases (13.3%) were admitted because of pain in the neck, chest or upper extremities. One remaining patient (6.7%) was transferred to our team after treatment in the Department of Cardiology due to palpitations.

Table 1
Basic characteristic and perioperative data of the patients (n = 15).

Patient No.	Sex	Age (range,year)	BMI (kg/m ²)	Location	Histopathology	Tumor size(cm)	Tumor capsule	Intraoperative morbidity	Trocars + assistant-port	Operative time(min)	Blood loss(ml)
#1	male	61	25.6	right	schwannoma	4.6	complete	no	3 + 0	100	55
#2	female	59	24.0	left	schwannoma	2.3	complete	no	3 + 0	60	50
#3	male	50	26.0	left	schwannoma	4.0	complete	no	3 + 1	80	10
#4	male	62	25.4	right	schwannoma	4	complete	no	3 + 0	70	20
#5	female	30	20.3	left	schwannoma	10.6	noncomplete	bleeding	4 + 0	240	2400
#6	female	56	20.0	right	ganglioneuroma	2.3	complete	no	3 + 0	60	10
#7	female	49	22.0	right	schwannoma	4.3	complete	right ptosis	3 + 0	100	50
#8	male	18	18.0	right	ganglioneuroma	2.8	complete	no	3 + 0	70	20
#9	female	56	21.9	right	schwannoma	5.0	noncomplete	no	3 + 0	180	120
#10	female	23	18.0	left	ganglioneuroma	5.0	complete	no	3 + 0	105	5
#11	male	43	22.7	left	schwannoma	6.7	complete	no	3 + 0	115	100
#12	male	37	24.2	right	schwannoma	2.1	complete	no	3 + 0	30	10
#13	female	53	21.1	left	schwannoma	2.6	complete	no	3 + 0	120	40
#14	female	47	21.6	right	schwannoma	7.0	complete	no	3 + 0	85	20
#15	male	24	17.0	right	ganglioneuroma	3.5	complete	no	3 + 1	120	10

RATS: robot-assisted thoracoscopic surgery, BMI: body mass index.

In this cohort, a 3-trocar technique was used in 13 patients (86.7%), and 3-trocar plus one assistant port was used in 2 cases (13.3%). Radical excision was performed in all cases. A total of 5 large tumours (5 cm or larger in size) were completely resected. The median tumour size was 4.0 (range, 2.1–10.6) cm. The median blood loss was 20 (5-2400) ml. One intraoperative morbidity and one postoperative complication were observed including one massive bleed (> 500 mL) and one case of Horner's syndrome. Patient #5 developed massive bleeding with a blood loss volume of 2400 mL originating from one of the tumour feeding arteries. That was partly because of severe adhesion around the lesion and its excessive size (10.6*5.8*4.8 cm). This case was successfully managed by the surgeon without conversion and the patient was discharged with a smooth recovery after blood transfusion. Patient #7 suffered from a transient right ptosis and recovered within seven months during follow up. There was no conversion to thoracotomy. These procedures were performed with acceptable operation times as the median overall surgical time was 100 minutes (range, 30–240). The median hospital stay was 3 (range, 4–7) days. The median duration of the chest tube was 2 (range, 1–3) days. No other perioperative complications and mortality were observed in this cohort. All patients were successfully treated via RATS by encouraging short-term surgical outcomes.

Discussion

To the best of our knowledge, this is the first study to assess the efficacy of RATS for ACT. Currently, the removal of ACT by minimally invasive procedures remains challenging for thoracic surgeons due to distinctive locations and as a consequence, thoracotomy is still the mainstream surgical approach [5, 6]. Although minimally invasive surgery significantly enhances recovery after surgery as well and is strongly encouraged currently in the thoracic field, video-assisted thoracic surgery (VATS) is less commonly used for apical chest lesions owing to its distant view and inferior exposure in ACT [7]. RATS is an advanced modality for minimally invasive surgery that can address these associated problems. Several authors have reported their experiences using RATS for superior posterior mediastinal or paraspinal tumours [1, 3, 8–10]. However, no study has yet focussed on the efficacy of RATS on ACT. To enable radical resection and to simplify the manoeuvre, we selected well encapsulated or less invasive lesions in the apical chest, namely benign tumours according to putative diagnosis, at the start of RATS learning curve. In our small series of 15 neurogenic tumour cases, our results indicated that RATS showed promising efficacy and is an ideal alternative for ACT.

Neurogenic ACT is a subgroup pathology of superior posterior mediastinal tumours in term of its location. Previous experience in the superior posterior mediastinum can contribute to efficient removal of ACT. Massive bleeding (> 500 ml) was the most common intraoperative morbidity in superior posterior mediastinal tumours. Damage to the surrounding great vessels, such as subclavian vessels, is the most probable cause of uncontrollable haemorrhages. Also, injury to the main feeding artery of the tumour may lead to substantial bleeding, as has been reported in this case series. In cases with significant pleural adhesion, minimally invasive surgery procedures should be used with adequate assessment in ACT. Full preparation for thoracotomy must be undertaken during minimally invasive surgery [4]. However, open surgery also possibly leads to troublesome haemorrhages, especially during the transcervical approach [11]. In consideration of the safe and radical removal of ACT, all lesions in our case series were benign and the vast majority well encapsulated.

In addition, the prevention of nerve injury should be kept in mind during operations. Superior posterior schwannoma tumours are mostly derived from sympathetic nerves, the vagus nerve and the brachial plexus. Therefore, subcapsular enucleation or resection of the tumour may lead to nerve injury [12]. Also, large lesions in the superior mediastinum increase the risk of surgical injury to surrounding nervous structures. Injury to sympathetic nerves results in Horner's syndrome or palmar dryness. Recurrent laryngeal nerve injury leads to hoarseness or cough. Robotic da Vinci surgical systems help surgeons to more successfully avoid unwanted damage over VATS [13].

Postoperative complications are less common in neurogenic lesions posterior to the mediastinum. The rate of complication varies depending on tumour aggressiveness. Nerve-related complications were most common as described above. Also, general thoracic complications such as pulmonary infection or air leakage can commonly occur. Occasionally chylous fistula and arrhythmia may also develop [14]. Non-operative treatments are typically successful in managing these complications.

As depicted above, the prevention of intra-operative morbidity during en-bloc resection is the greatest challenge for surgeons. Robotic surgery can be successfully used in extreme thoracic locations. The stable and high-resolution three-dimensional view available to surgeons can allow accurate identification of the tumour target and adjacent structures. The working arm allows seven degrees of instrument motion and enables high dexterity in small working spaces. Tremor filtration also prevents unwanted injury to vital organs. These advantages plus better ergonomics for the surgeon and the assistant remarkably shorten the learning curve [15]. Bodner et al. and Podgaetz et al. believed the da Vinci robotic system could be used in broader indications in mediastinal operations compared to conventional VATS [15, 16]. Although there have been few investigations concerning the efficacy of RATS in high-seated lesions in the thoracic cavity, almost all authors show that robotic procedures are the perfect substitute for conventional thoracoscopy [1, 8, 15], closely agreeing with our results. According to our experience on mediastinal tumour resection via RATS [17, 18], we believe that RATS can be used in the treatment of superior posterior mediastinal tumours including apical chest masses.

Also, RATS can allow better exposure of the lesions in high-seated locations, especially for large tumour or adherent masses. In VATS, there are frequently extra retractions by the assistant to gain sufficient exposure to posterior mediastinal lesions [7]. In RATS, the surgeon is normally capable of retraction with a working arm without auxiliary incision [1, 19]. Excellent operative views contribute to minimizing tissue trauma. This has been previously reported in the case by Podgaetz et al. that underwent a robotic minimally invasive surgery in the thoracic component rather than thoracotomy [16]. In some instances, lesions extending to the neck could undergo extirpation via complete robotic procedure without accessory cervical incisions.

Since the introduction of robotic surgery into the thoracic field for superior posterior mediastinal masses, several approaches have been employed depending on the exact location of lesions. Mansour et al. used a three-arm robotic-assisted thoracoscopic technique plus an accessory port in two cases of an ectopic parathyroid gland [8]. Xu et al [3] detailed a three-port technique for neurogenic ACT. In a previous case series, both approaches were used in the posterior mediastinum [15]. Similarly, Podgaetz et al. employed a three-trocar technique for a huge thyroid goiter in the thorax [16]. Ruurda et al. used 6 trocars to dissect a posterior mediastinal neurogenic tumour during the early initial phase of robotic use [9]. As described in the methods section, we prefer red to utilize a 3-trocar robotic approach, normally without assistant incision. Notably, the 3-trocar technique and the 4-trocar plus one assistant port technique were also possibly used.

Satisfactory prognosis after complete resection has been previously reported in benign neurogenic tumour [1, 10]. Although we selected the most cases with clear tumour boundaries and with less possibility of infiltration, it appeared that robotic surgery can be used in more challenging indications. We treated several large lesions (> 5 cm) with significant adhesions without conversion to thoracotomy in this case series. However, we believe that a larger retrospective study is necessary to assess RATS for posterior mediastinal lesions. A prospective study, or perhaps even a randomised control trial would also be particularly informative and verify our findings.

Conclusion

Our preliminary study demonstrates RATS is a safe and effective alternative modality for the minimally invasive resection of ACT. The robotic system extends conventional thoracoscopic indications for posterior mediastinal lesions including apical chest lesions.

Abbreviations

ACT: apical chest tumours RATS: robotic-assisted thoracoscopic surgery VATS: video-assisted thoracic surgery.

Declarations

Ethics approval and consent to participate

The ethics committee of West China Hospital of Sichuan University Biomedical Research Ethics Committee approved this study, and the informed consent was not applicable because of the retrospective nature of the study

Consent for publication

Prior informed written consents of all participants were made at admission and obtained from the patients and their families for publication of this article and accompanying images.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YZ and HZ analyzed and interpreted the patient data and YZ wrote the first draft. FW and GQ collected the data of this study. YW and GC reviewed and edited the manuscript. All authors read and gave final approval of the version to be published, and agree to be accountable for all aspects of the work. YW is the Guarantor.

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Figures

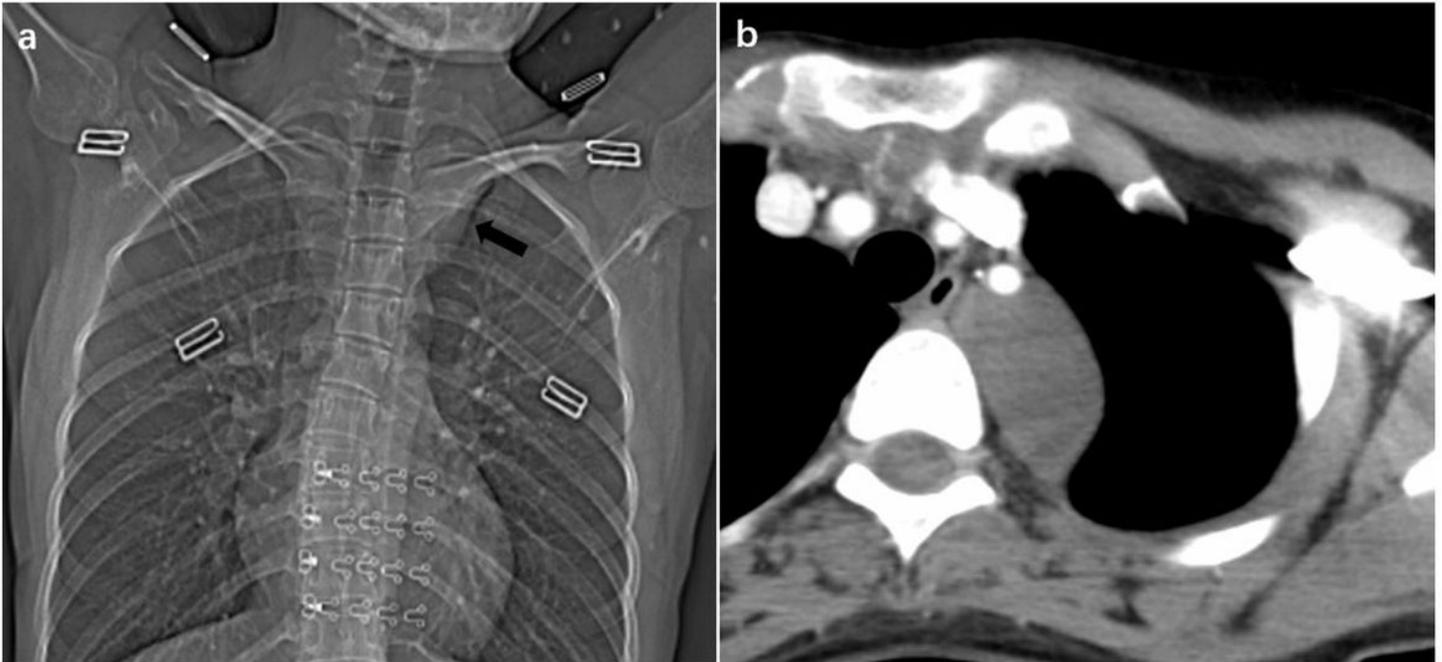


Figure 1
Chest computed tomography of a ganglioneuroma. (a) A large ganglioneuroma (5.0*3.5*3 cm) located at the left apical chest (the thin arrow indicating). (b) The lesion on the plane of the sternoclavicular joint.

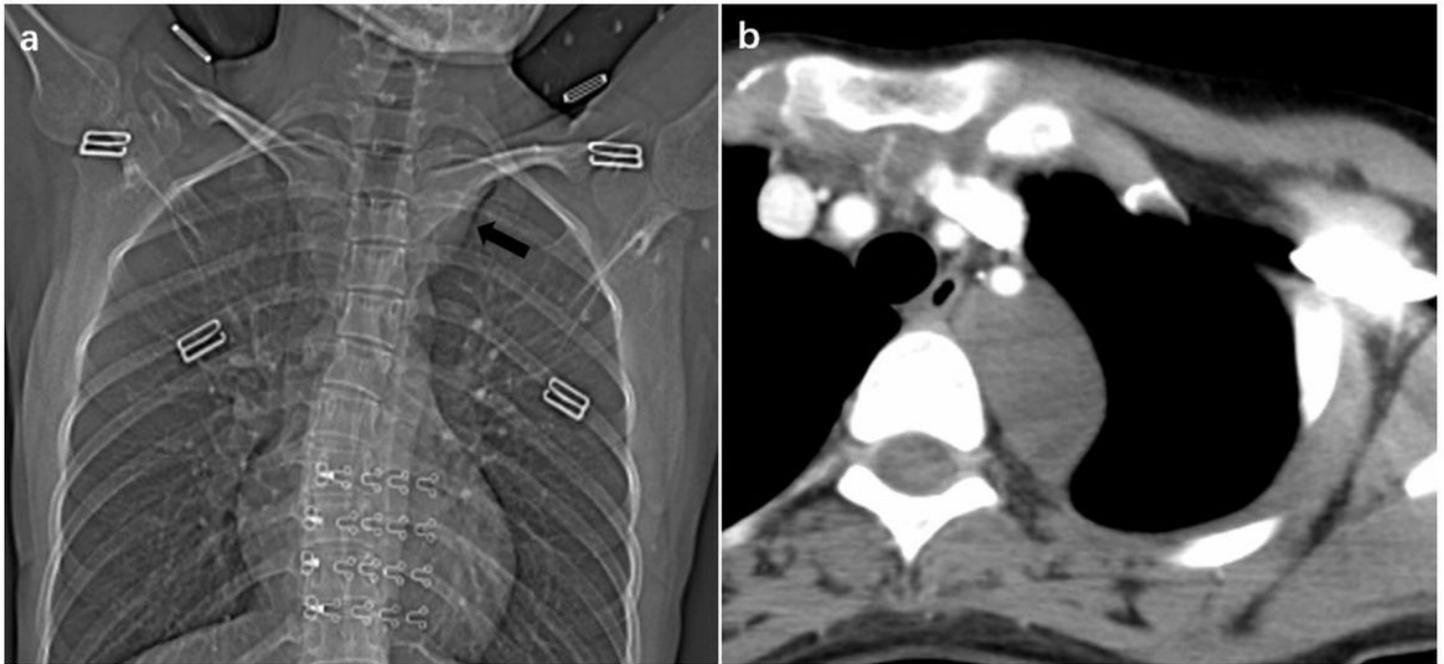


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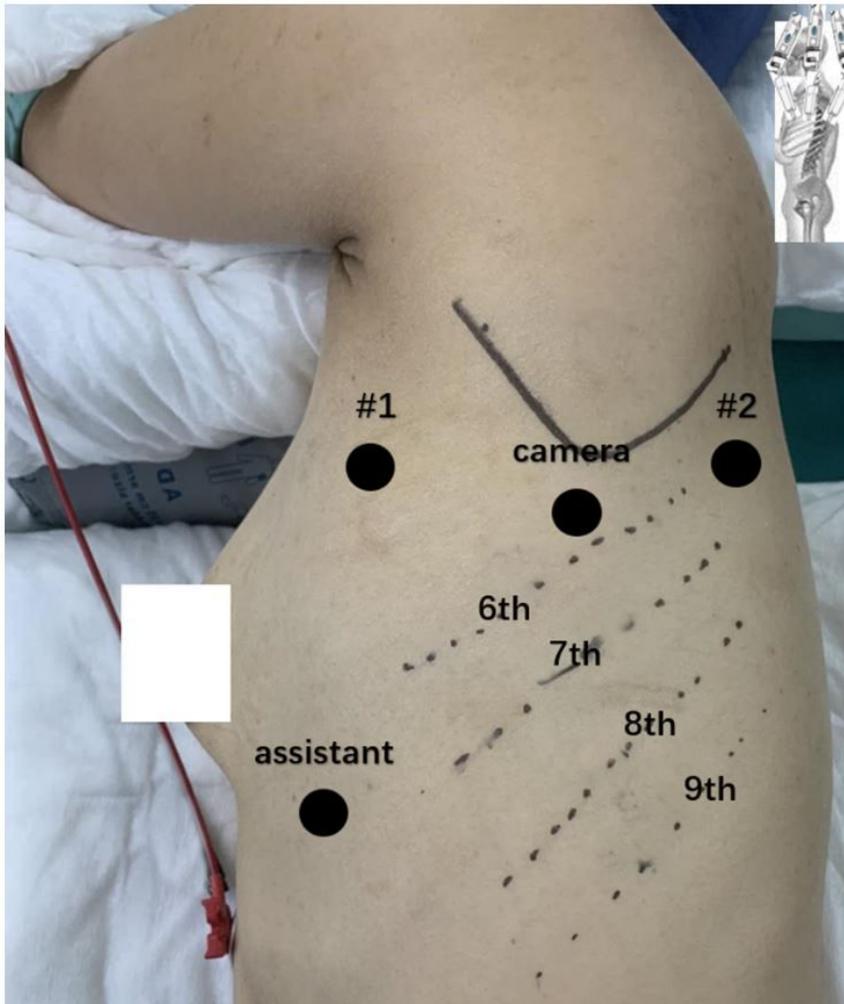


Figure 2

Placement of ports. The camera port was located in the 6th intercostal space between the posterior axillary line and the scapular line, arm 1 in the 3rd intercostal space at the anterior axillary line and the arm 2 port in the 6th intercostal space at the lateral border of the erector spinalis muscle. The assistant port was inserted in the 7th intercostal space along the midaxillary line when necessary.

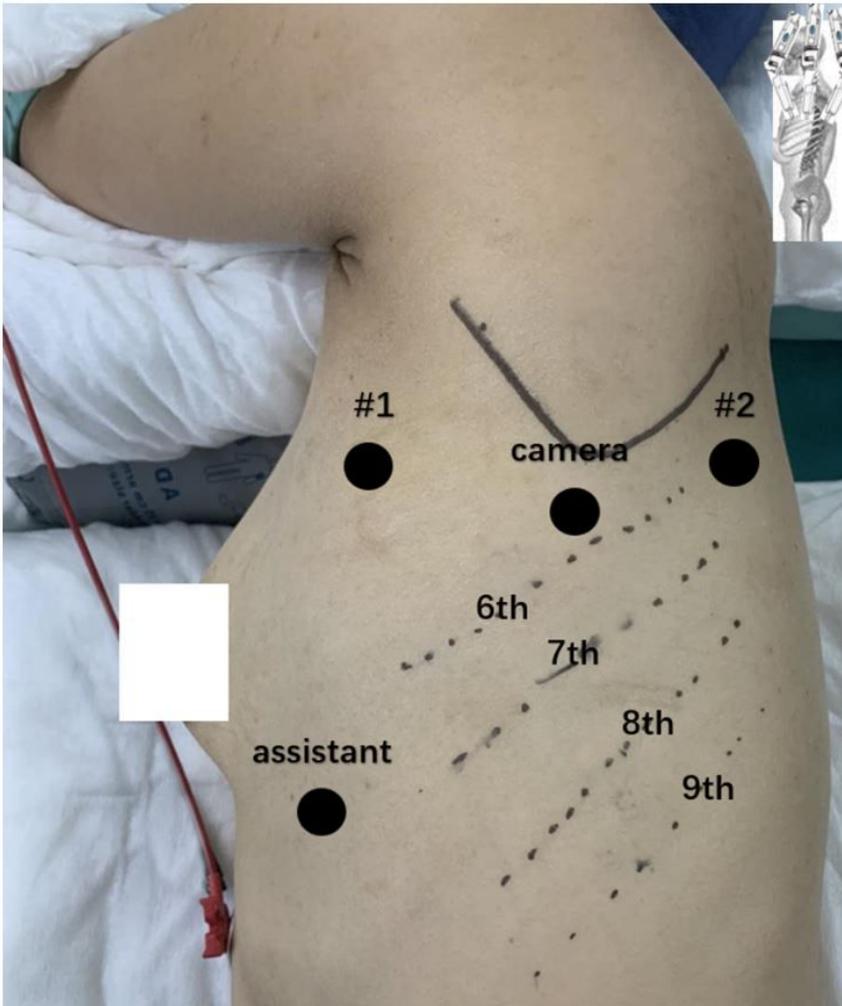


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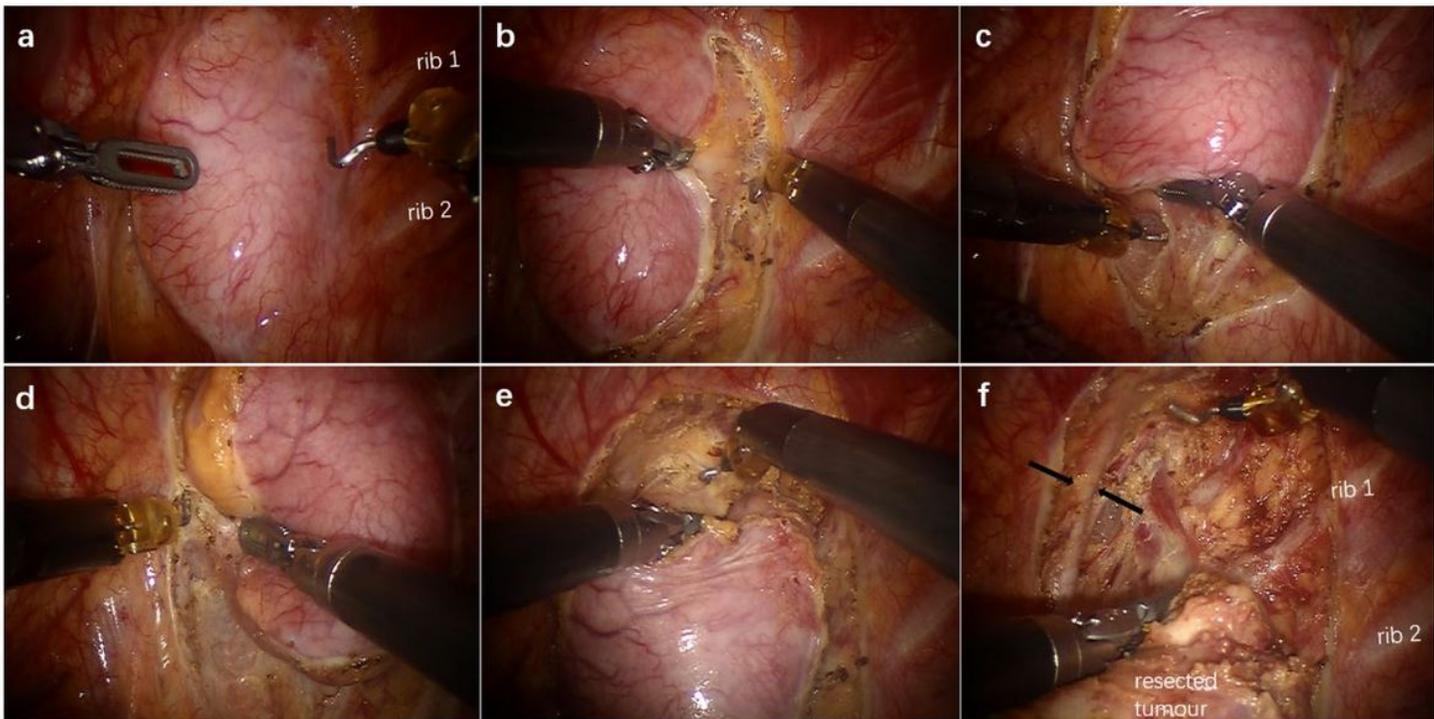


Figure 3
 The tumour was resected with RATS. (a) The ganglioneuroma was adjacent to the left subclavian artery. (b-e) The tumour was mobilized via an electrocautery and a Cadieere Forcep. (f) The tumour was successfully completely resected (the thick arrows indicating the left subclavian artery).

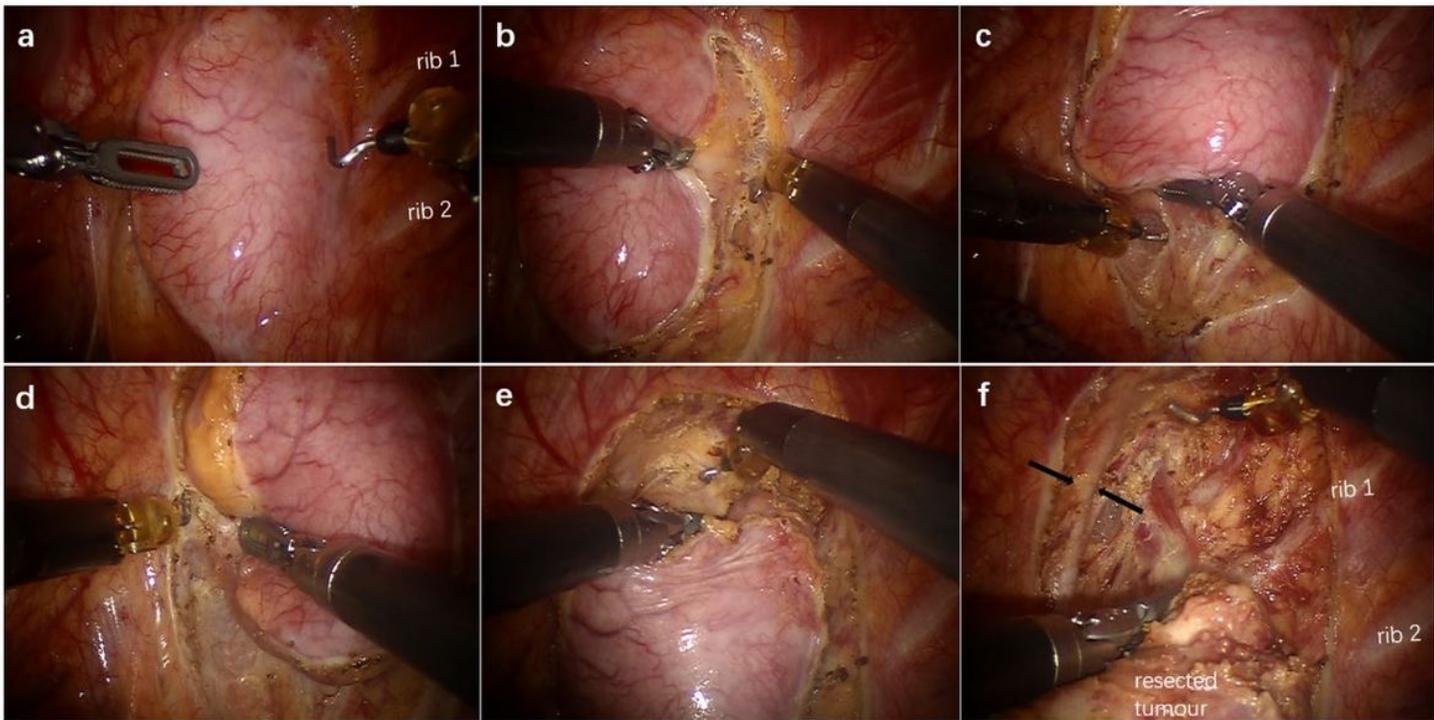


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