



Clinical efficacy of robot-assisted thoracoscopic surgery for posterior mediastinal neurogenic tumors

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Background: Robot-assisted thoracic surgery (RATS) has an increasing usage throughout the world. This retrospective cohort study aimed to objectively compare the surgical results between video-assisted thoracic surgery (VATS) and RATS in posterior mediastinal neurogenic tumors (PMNT).

Methods: We retrospectively reviewed the clinical data of 130 patients diagnosed with posterior mediastinal neurogenic tumor between 2015 and 2018. Magnetic resonance imaging (MRI) or enhanced computed tomography scan (CT-scan) was used to locate the tumor and investigate the Adamkiewicz's artery preoperatively. The individual surgical approach was determined by both tumor size and patient's willings.

Results: The surgical time in RATS (43.2±12.6 min) was tended to be less than that in VATS (47.4±11.9 min) (P=0.054). Meanwhile, the estimated blood loss in RATS group (85.8±22.6 mL) was significantly less than that in VATS group (95.3±28.4 mL) (P=0.040). However, the duration of chest tube (days) and volume of drainage (mL) had no significant difference between two groups (P=0.12 and P=0.68, respectively). The postoperative hospital stay (days) of patients in RATS group (2.2±0.4 days) was significantly shorter than that in VATS group (2.4±0.6 days) (P=0.031). There were no significant differences between two groups in the incidence of the postoperative complications and adverse reactions.

Conclusions: RATS has the superiorities in terms of surgical blood loss and postoperative hospital stay over VATS for posterior mediastinal neurogenic tumor. In conclusion, RATS could be a feasible and safe way for resecting posterior mediastinal neurogenic tumor.

Keywords: Robot-assisted thoracic surgery (RATS); video-assisted thoracic surgery (VATS); posterior mediastinal neurogenic tumors (PMNT)

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Introduction

Tumors of the posterior mediastinum are usually diagnosed in young patients, but they can develop at any age and form any tissue that exists in or passes through the chest cavity (1,2). The diagnosis and the accurate assessment of the posterior mediastinum masses represent a challenge, given their clinical variability from asymptomatic to producing symptoms of cough, chest pain, and dyspnea. Posterior Mediastinal tumors are often neurogenic tumors and esophageal cysts. The neurogenic tumors are mainly composed of schwannoma, neurofibroma and ganglioneuroma (2-4). The traditional open transthoracic procedure is the standard surgery for posterior mediastinal neurogenic tumor (PMNT) (5,6). However, the video-assisted thoracoscopic surgery (VATS), with less surgical trauma, blood loss, postoperative complications, and shorter hospital stay, has been gradually recognized as a more feasible surgical procedure for posterior mediastinal neurogenic tumor (6-8). Also, the clinical outcomes of video-assisted thoracoscopic surgery were found to be more effective and safe than standard open surgery (9,10). However, the VATS is limited by a two-dimensional view and the reduced freedom of movements, which may disable delicate dissections of the posterior mediastinal neurogenic tumor, especially when the tumor was at a superior intrathoracic position. With the recent developments in surgical instruments, robot-assisted thoracic surgery (RATS) performing with the Da Vinci Si robotic system has an increasing usage throughout the world (11-13). Comparing with VATS, RATS offers superiorities, in terms of tremor filtration, three-dimensional visualization, ten-times-enlarged image and seven-degree freedom of its dexterity endowments, which enable the surgeon to operate in a stable and comfortable environment. RATS has already widely used in esophagectomy, lobectomy and other minimally invasive thoracic surgeries in recent years (14-17). Nonetheless, whether the RATS is suitable for resection of posterior mediastinal neurogenic tumor is still unclear. Only a few case reports were recorded to show the advantage of RATS in PMNT. Therefore, we performed a retrospective study to objectively compare the surgical results between VATS and RATS.

Methods

We retrospectively reviewed the clinical data of 130 patients diagnosed with posterior mediastinal neurogenic tumor

between 2015 and 2018 at the Department of Thoracic Surgery in Nanjing Jinling Hospital. The diagnoses and clinical information were collected by consulting medical records of the patients. Magnetic resonance imaging (MRI) or enhanced computed tomography scan (CT-scan) was used to locate the tumor and investigate the Adamkiewicz's artery preoperatively. Patient inclusion criteria were as follows: (I) diagnosis with resectable PMNT with tumor sizes less than 8 cm and (II) willingness to undergo a robot-assisted operation or video-assisted operation. And the excluded criteria were as follows: patients with cardiomegaly, poor cardiac function or severe arrhythmia. The clinical characteristics were composed of sex, age, body mass index (BMI), smoking and comorbidity (including chronic obstructive pulmonary disease (COPD), hypertension and diabetes. Tumor associated data, in terms of tumor size and tumor types, were also collected. The operative and postoperative data included surgical time, blood loss, conversion rate, duration of chest tube insertion, median volume of drainage, postoperative hospital stay, postoperative complications and adverse reactions. All patients involved in this study gave their informed consent. Institutional review board approval of our hospital was obtained for this study (2015NZKY-030-01). If data were missing, an imputation method was used to integrate the data.

Surgical method

The individual surgical approach was determined by both tumor size and patient's willings. Before surgeries, the patients were put into a feet-down tilt lateral decubitus position. In RATS, Three-arm technique is used in operation. If the PMNT located at the superior mediastinum, the camera trocar was first inserted at the fifth intercostal space (ICS), along the middle axillary line. Another trocar for dissecting arm was inserted at the seventh ICS, along the posterior axillary line. Then, the third trocar for grasping arm was inserted at the third ICS, along the anterior axillary line. Otherwise, the camera trocar was inserted at the sixth intercostal space (ICS), along the middle axillary line. The second trocar for dissecting arm was inserted at the eighth ICS, along the posterior axillary line and the third trocar for grasping arm was inserted at the fourth ICS, along the anterior axillary line. An assisted incision was applied alternatively according to the difficulty of operation and blood loss during RATS (*Figure 1*). The

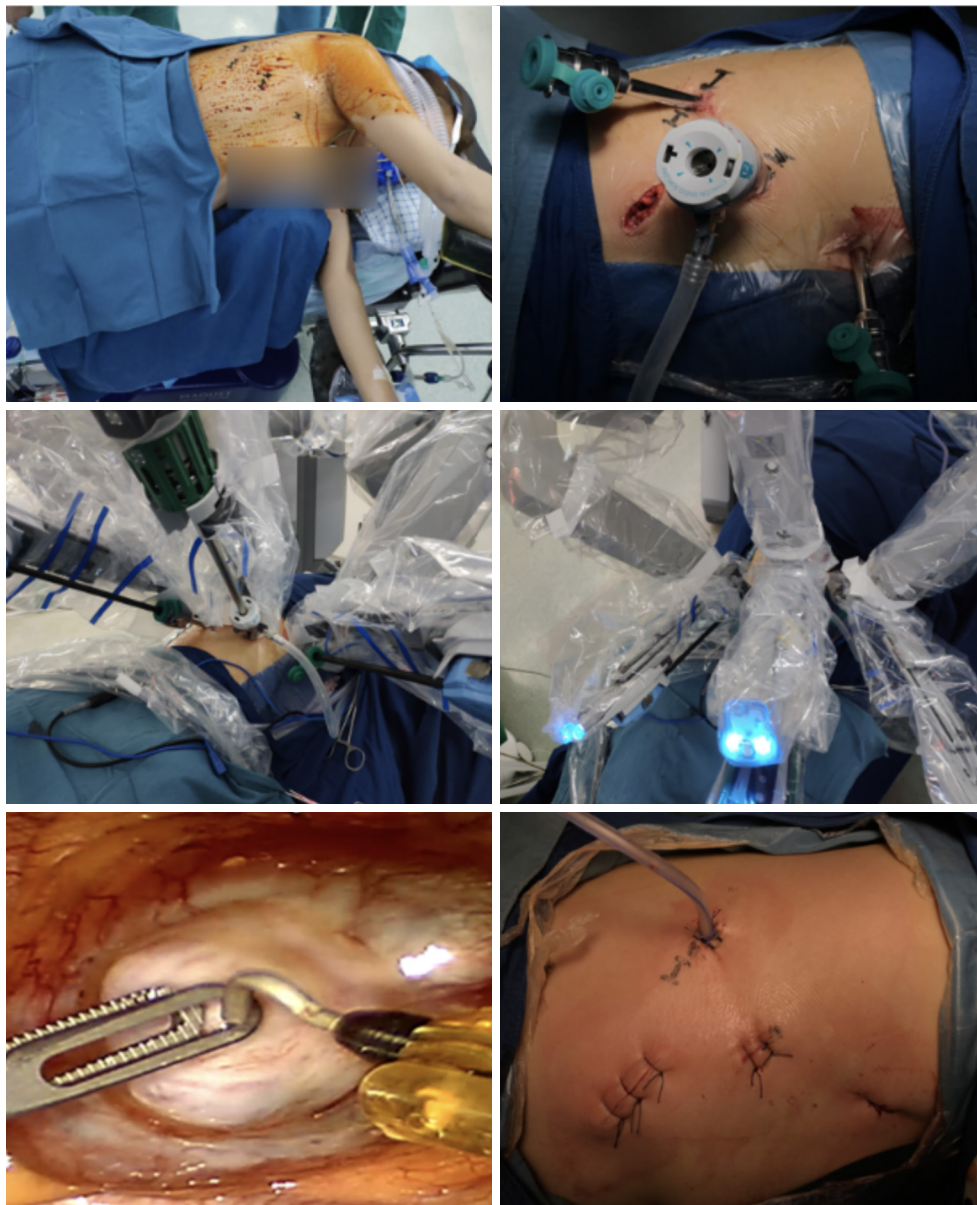


Figure 1 A 25-year-old woman with posterior mediastinal neurogenic tumor underwent robot-assisted thoracoscopic surgery. An assisted incision was used additionally to suction blood during surgery.

selection of incision which was designed as an equilateral triangle was according to the position of tumor (*Figure 2*). In VATS, the camera trocar was inserted at the sixth ICS, along the posterior axillary line. The second trocar was inserted at the seventh ICS, along the middle axillary line while the third trocar was inserted at the fourth ICS, along the anterior axillary line. Two surgeons who were familiar with both surgical techniques were involved in this study.

Statistical analyses

Continuous variables were expressed as the mean \pm standard deviation. The Mann-Whitney U test or *t*-test was used to assess differences between the two groups. Categorical variables were compared using Pearson's χ^2 or Fisher's exact tests. Results were considered statistically significant at a $P < 0.05$. Data were analyzed using statistical program SPSS 21.0 software (SPSS, Chicago, IL, USA).

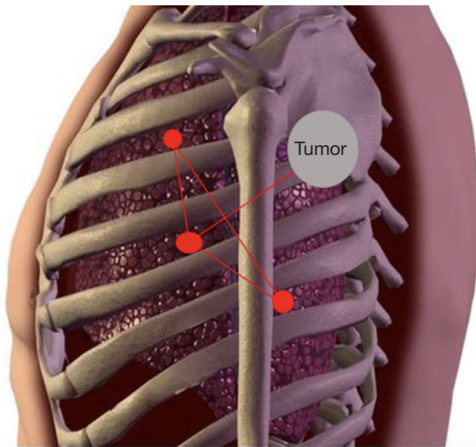


Figure 2 The selection of incision which was designed as an equilateral triangle was according to the position of tumor.

Results

There were 58 patients combined with 27 men and 31 women (mean age 38.5 ± 5.7 years) in RATS group, while VATS group included 72 patients with 35 men and 37 women (mean age 47.4 ± 1.9 years). There were no significant differences in basic characteristics between two groups. The pathological type of posterior mediastinal neurogenic tumor in our study included schwannoma, neurofibroma and ganglioneuroma. The tumor size and pathological type between two groups had no significant difference ($P=0.40$ and $P=0.89$, respectively) (Table 1). For surgical data, the surgical time in RATS (43.2 ± 12.6 min) was tended to be less than that in VATS (47.4 ± 11.9 min) ($P=0.054$). Meanwhile, the estimated blood loss in RATS group (85.8 ± 22.6 mL) was significantly less than that in VATS group (95.3 ± 28.4 mL) ($P=0.040$). However, the duration of chest tube (days) and volume of drainage (mL) had no significant difference between two groups ($P=0.12$ and $P=0.68$, respectively). The postoperative hospital stays (days) of patients in RATS group (2.2 ± 0.4 days) was significantly shorter than that in VATS group (2.4 ± 0.6 days) ($P=0.031$). There were 7 patients whose tumor size was larger than 6 cm in RATS group and 5 in VATS group. The operation could successfully be accomplished by stretching the incision. However, the operative procedures of 2 patients in RATS group and 3 patients in VATS group were converted to open thoracotomy because of the hemorrhage. There was only one patient in VATS group who was re-operated at postoperative day 3 on account of postoperative hemorrhage (Table 2). The CT

Table 1 Basic characteristics

Characteristics	RATS (n=58)	VATS (n=72)	P value
Age	38.5 ± 5.7	36.9 ± 5.4	0.22
Sex			0.82
Man	27 (46.6%)	35 (48.6%)	
Woman	31 (53.4%)	37 (51.4%)	
BMI	23.4 ± 3.1	22.9 ± 4.3	0.46
Smoking	9 (15.5%)	13 (18.1%)	0.70
COPD	2 (3.4%)	3 (4.2%)	0.83
Hypertension	5 (8.6%)	5 (6.9%)	0.72
Diabetes	2 (3.4%)	3 (4.2%)	0.83
Tumor size (cm)	4.6 ± 2.4	4.4 ± 2.9	0.40
Tumor type			0.89
Schwannoma	28 (48.3%)	33 (45.8%)	
Neurofibroma	21 (36.2%)	29 (40.3%)	
Ganglioneuroma	9 (15.5%)	10 (13.9%)	

BMI, body mass index; COPD, chronic obstructive pulmonary disease.

findings of a 28-year-old patient are presented in Figure 3. Complications, including pneumonia and surgical site infection, were recorded postoperatively. Postoperative complications occurred in 3 patients in RATS group and 7 in VATS group and there was no significant difference between two groups. Meanwhile, no significant difference was found between RATS group and VATS group in the incidence of the pneumonia and the surgical site infection ($P=0.83$ and $P=0.26$, respectively). Adverse reactions, consisting of blood pressure decrease, heart rate increase, chest pain and other reactions, were also collected. The adverse reactions occurred in 19 patients in RATS and 23 in VATS and no significant difference was found between two groups. There were no significant differences between two groups in terms of blood pressure decrease and heart rate increase ($P=0.44$ and $P=0.44$, respectively). Eight patients in RATS group and 7 in VATS group raise other adverse reactions and no significant difference was seen between two groups (Table 3).

Discussion

Posterior mediastinum neurogenic tumors are often schwannoma, neurofibroma and ganglioneuroma (3).

Table 2 Surgical data

Variables	RATS (n=58)	VATS (n=72)	P value
Surgical time (min)	43.2±12.6	47.4±11.9	0.054
Estimated blood loss (mL)	85.8±22.6	95.3±28.4	0.040
Duration of chest tube (days)	1.5±0.3	1.6±0.4	0.120
Volume of drainage (mL)	62.2±22.9	60.3±28.4	0.680
Postoperative hospital stays (days)	2.2±0.4	2.4±0.6	0.031
Conversion	2 (3.4%)	3 (4.2%)	1.000
Re-operation	0 (0%)	1 (1.4%)	1.000

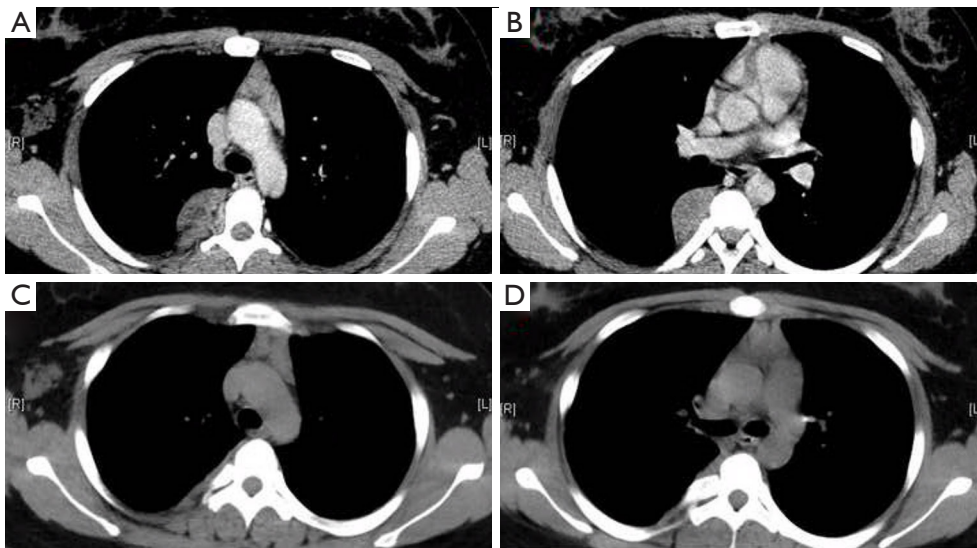


Figure 3 The computed tomographic of a patient with posterior mediastinal neurogenic tumor. (A,B) A 31-year-old man underwent robot-assisted thoracoscopic surgery on February 1, 2015. (C,D) Recurrence has not occurred until September 15, 2019.

Table 3 Postoperative complication and adverse reactions

Variables	RATS (n=58)	VATS (n=72)	P value
Postoperative complication	3 (5.2%)	7 (9.7%)	0.33
Pneumonia	2 (3.4%)	3 (4.2%)	0.83
Surgical site infection	1 (1.7%)	4 (5.6%)	0.26
Adverse reactions	19 (32.8%)	23 (31.9%)	0.92
Blood pressure decrease	2 (3.4%)	1 (1.4%)	0.44
Heart rate decrease	2 (3.4%)	1 (1.4%)	0.44
Chest pain	9 (15.5%)	16 (22.2%)	0.33
Others	8 (13.8%)	7 (9.7%)	0.47

Schwannoma is a rare tumor originating in the Schwann cells that surround peripheral nerve fibers (18-22). Less than 9% of schwannomas occur in the mediastinum, and this tumor is a relatively common mediastinal neurogenic tumor. Schwannomas are typically benign, slow growing, and well encapsulated. Neurofibroma is a benign neurogenic soft tissue tumor that may exist as a solitary tumor or as part of Neurofibromatosis (4,23,24). Ganglioneuromas, consisting of intermingled microscopic foci of neuroblastic elements in an expanding Schwannian stroma, are rare tumors that most often start in autonomic nerve cells and comprise more than 50% of the tumor volume (24-26). These three neurogenic tumors are usually noncancerous (benign). The video-assisted thoracoscopic surgery has been the most common method to resect posterior mediastinal neurogenic tumors recently. With the development of robot-assisted thoracoscopic surgery, several studies were reported to demonstrate the feasibility and safety of RATS. Ruurda *et al.* (27) reported the first case of robot-assisted thoracoscopic removal of a benign neurogenic tumor in the thorax. A 46-year-old woman presented with a history of paravertebral pain. A magnetic resonance imaging scan revealed a well-encapsulated mass that was suspected to be a neuroma at the level of T8-T9, separate from vascular structures, without extension in the foramina, and without a spinal canal component. A left robot-assisted thoracoscopic resection of the tumor was performed. Six trocars were placed during surgery, and then the tumor was carefully dissected and removed through one of the trocar openings. The histopathological findings revealed an ancient schwannoma. This case report demonstrates the feasibility and safety of robot-assisted thoracoscopic extirpation of a thoracic neurogenic tumor. A systemic review performed by Straughan *et al.* (28) manifesting robotic-assisted mediastinal surgery appears to be superior to open approaches of the mediastinum including PMGT and is comparable with video-thoracoscopic surgery when patient outcomes are considered. However, none original article was performed to explore the efficacy, feasibility and safety of RATS in PMGT. In this study, total 130 patients were enrolled and 58 patients underwent RATS. The individual surgical approach was determined by tumor size and patients' willing. If the patient's tumor size was less than 8 cm, the video-assisted or robot-assisted technique was used; otherwise, open operation was performed. The ultimate surgical approach was determined by patient's willing when the tumor size was less than 8 cm. The

results showed that the surgical time in RATS was tended to be less than in VATS while the estimated blood loss in RATS group was significantly less than that in VATS group. The potential reasons why RATS has superiority in operative blood loss over VATS could be explained as follows: first, VATS provides three-dimensional visualizations with ten-times-enlarged images and superior imaging quality, facilitating the identification of various structures during operations; second, RATS provides freely articulated movement of the robotic arms and seven degrees of freedom in dexterity with its EndoWrists, allowing surgeons to operate in a stable and comfortable environment, enabling more precise dissection and avoiding nerve and Adamkiewicz's artery injury. Only three trocars were used during RATS, and an additional assisted incision was performed alternatively according to the situation of bleeding. There were 7 patients whose tumor sizes were larger than 6 cm in RATS group and 5 in VATS group. Nevertheless, the tumor sizes of these patients were all less than 8 cm thus the operation could successfully be accomplished by stretching the incision. In clinical practice, tumor size which is larger than 8 cm could be considered a potential contraindication to RATS or VATS for PMNT. The postoperative hospital stay was found to be shorter in RATS group than that in VATS group which may be due to the less blood loss and more satisfaction of patients in RATS group compared with VATS group. The operative procedures of 2 patients in RATS group and 3 patients in VATS group were converted to open thoracotomy because of the hemorrhage. There was no significant difference in postoperative complications and adverse reactions between two groups. Only one patient with a 7 cm schwannoma underwent reoperation at postoperative day 3 because of the bleeding after surgery. Therefore, robot-assisted thoracoscopic surgery has the superiorities in terms of surgical blood loss and postoperative hospital stay over video-assisted thoracoscopic surgery for posterior mediastinal neurogenic tumor. In conclusion, robot-assisted thoracoscopic surgery could be a feasible and safe way for resecting posterior mediastinal neurogenic tumor.

Limitation

There are some limitations in our study. First, this is a single-center retrospective study, which could have suffered from the retrospective nature of our study. Second, the small sample size in our study could result in selection bias.

Conclusions

This study demonstrates the feasibility and safety of robot-assisted thoracoscopic surgery for posterior mediastinal neurogenic tumor. The robot-assisted surgery may prove to be of additional value in challenging the video-assisted thoracoscopic surgery since it has the advantages in terms of manipulation and visualization over the video-assisted thoracoscopic surgery. Therefore, robot-assisted thoracoscopic surgery could be considered as a standard treatment for posterior mediastinal neurogenic tumor.

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Footnote

Data Sharing Statement: Available at <http://dx.doi.org/10.21037/jtd-20-286>

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/jtd-20-286>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The Institutional Review Board of the Jingling Hospital approved the study. The ID of ethics approval is (2015NZKY-030-01). The study outcomes will not affect the future patient management. This study is based on data retrieved from a hospital medical record system. All personal data have been protected and secured according to current national and international laws.

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