Analysis of the efficacy of the da Vinci robot in surgery for posterior mediastinal neurogenic tumors

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Abstract

Background: The present research is designed to evaluate the short-term outcome of robot-assisted thoracoscopic surgery (RATS) for the treatment of posterior mediastinal neurogenic tumours.

Methods: We retrospectively analyzed clinical data on 35 consecutive patients with mediastinal neurogenic tumors after RATS treatment completed by the same operator in the Department of Thoracic Surgery, Gansu Provincial People's Hospital from January 2016 to June 2022. There were 19 males and 16 females with a mean age of (34.9±7.1) years in this analysis report. The tumor of the patients were localized and evaluated preoperatively using magnetic resonance imaging (MRI) or enhanced CT.

Results: All 35 patients successfully underwent the resection of posterior mediastinal neurogenic tumors under RATS, and no conversion to thoracotomy occurred during the operations. The average operative time was (62.3±18.0) min, the average docking time was (10.3±2.6) min, the average intraoperative bleeding was (33.9±21.6) ml, the average 24-hour postoperative chest drainage was (69.0±28.9) ml, the average postoperative chest drainage time was (2.2±1.4) days and the average post-operative hospital stay was (3.2±1.3) days. Postoperative complications occurred in 3 patients, including 2 patients with transient Honor syndrome after surgery and 1 patient with transient anhidrosis of the affected upper limb after surgery. [1]

Conclusion: RATS for posterior mediastinal neurogenic tumours is safe, effective, feasible and bring the superiority of robotic surgical system into full play.

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Background

Neurogenic tumours of the posterior mediastinum are one of the most common mediastinal tumours in adults, accounting for over 75% of posterior mediastinal tumours and 10%-34% of all mediastinal tumours [1, 2]. The disease is mostly young and middle-aged patients, and 90% of patients are benign lesions [3]. At present, the specific causes of the diseased neurological tumors clinically have not completely studied thoroughly [3]. Traditional open thoracotomy for mediastinal tumours uses a posterior lateral chest incision to remove the ribs or enter the chest through the rib cage, which is a long and damaging incision [4]. In 1992, Landreneau et al. [5] reported a case of successful resection of a posterior mediastinal tumour by video-assisted thoracoscopic surgery (VATS), which laid the foundation for minimally invasive surgery in the resection of mediastinal tumours.

In recent years, the da Vinci robot has further demonstrated its advantages for complex movements in enclosed spaces thanks to features such as its 3D field of view and flexible robotic arms [6, 7]. Its progressive development and importance in the field of surgery. Since the application of the da Vinci robotic surgical system in clinical surgery, the first case of a mediastinal neurogenic tumour after RATS
resection was reported by Ruurda et al. [8] in 2003. However, there is still insufficient evidence of its effectiveness in the immediate postoperative period following resection of posterior mediastinal tumours. Since the introduction of the da Vinci robotic surgical system (da Vinci Si Surgical System) in our hospital in January 2016, 35 posterior superior mediastinal tumour operations have been performed, and we experience its significant advantages in the resection of neurogenic tumours in the posterior superior mediastinum, as reported below.

Materials And Methods

Eligible patients

In this single-centre retrospective study, we included and analysed 35 consecutive patients with posterior mediastinal neurogenic tumours treated with RATS completed by the same operator in the Department of Thoracic Surgery, Gansu Provincial People's Hospital from January 2016 to June 2022.

Inclusion criteria: (1) preoperative tumour localisation using MRI or enhanced CT, tumour size <8cm and resectable posterior mediastinal neurogenic tumour; (2) willingness to undergo robot-assisted surgery. Exclusion criteria: (1) anterior and middle mediastinal tumours; (2) patients with poor cardiopulmonary function or severe cardiac arrhythmias. For patients with intervertebral foraminal invasion, regular post-operative follow-up visits to the clinic are required to monitor for tumour recurrence.

TABLE 1 [General information of patients [n=35, mean±standard deviation/case (%)]
<table>
<thead>
<tr>
<th>Clinical Information</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>19±54.3</td>
</tr>
<tr>
<td>female</td>
<td>16±45.7</td>
</tr>
<tr>
<td>Age (years)</td>
<td>34.9±7.1</td>
</tr>
<tr>
<td>BMI kg/m²</td>
<td>23.4±4.1</td>
</tr>
<tr>
<td>Smoking history</td>
<td>8±22.9</td>
</tr>
<tr>
<td>COPD</td>
<td>2±5.7</td>
</tr>
<tr>
<td>Hypertension</td>
<td>2±5.7</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1±2.9</td>
</tr>
<tr>
<td>Tumour size (cm)</td>
<td>4.2±1.4</td>
</tr>
<tr>
<td>Tumour type</td>
<td></td>
</tr>
<tr>
<td>Schwannoma</td>
<td>20±57.1</td>
</tr>
<tr>
<td>Neurofibroma</td>
<td>12±34.3</td>
</tr>
<tr>
<td>Ganglioneuroma</td>
<td>3±8.6</td>
</tr>
<tr>
<td>Symptom</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>22±62.9</td>
</tr>
<tr>
<td>Chest pain</td>
<td>5±14.3</td>
</tr>
<tr>
<td>Chest tightness</td>
<td>4±11.4</td>
</tr>
<tr>
<td>Cough</td>
<td>4±11.4</td>
</tr>
</tbody>
</table>

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

**TABLE 2** Surgical data and postoperative complications of patients [n=35, mean±standard deviation/case (%)]
### Clinical Information

<table>
<thead>
<tr>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery time (min)</td>
</tr>
<tr>
<td>Docking time (min)</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
</tr>
<tr>
<td>Post-operative 24h chest drainage (ml)</td>
</tr>
<tr>
<td>Post-operative chest drainage time (d)</td>
</tr>
<tr>
<td>Post-operative length of stay (d)</td>
</tr>
</tbody>
</table>

#### Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honor Syndrome</td>
<td>38.6</td>
</tr>
<tr>
<td>No sweating on the affected upper limb</td>
<td>25.7</td>
</tr>
</tbody>
</table>

Note: The procedure time is from cutting to sewing and does not include docking time.

### Operative methods

A three-hole, three-arm, full-port, CO2 artificial pneumothorax is used. Position: Lateral position, slightly leaning forward. Perforation location: Based on the CT image, a projection is outlined on the body surface and the perforation is designed according to this projection as required by the robot operated arm. For posterior superior mediastinum tumours, the hole is set up in the “6-4-7” method ([Figure 1](#)) "6” is the observation hole, between the sixth intercostal space of the posterior axillary line on the affected side; "4” is the operation hole of the arm, between the fourth intercostal space of the anterior axillary line; "7” is the operation hole of the arm, between the seventh intercostal space of the posterior axillary line. For posterior inferior mediastinal tumours, the hole setting is the "5-3-8" method ([Figure 2](#)) "5” is the observation hole, between the sixth intercostal space of the posterior axillary line on the affected side; "3” is the operation hole of the arm, between the fourth intercostal space of the anterior axillary line; "8” is the operation hole of the arm, between the seventh intercostal space of the posterior axillary line. Guiding the bedside instrument arm system in the direction of the inlet and the extension of the swelling line, connecting the robot system lens and the manipulator arm. The left arm is connected to the bipolar coagulation forceps and the right arm is connected to the unipolar coagulation hook. The tumour is separated sharply with the electrocoagulation hook, and the tumour is excised completely without an auxiliary port, and if there is bleeding or poor visualisation, an auxiliary hole is made between the ribs in front of the entrance port and a suction device is used to assist. Some of the intraoperative procedures are shown in Figures 3, 4 and 5.

### Data collection

Pre-operative data included basic clinical information such as patient’s age, gender, body mass index (BMI), underlying disease, tumour size and type; intra-operative data included operative time, loading time.
and intra-operative bleeding; post-operative data included 24h post-operative chest drainage, post-operative chest drainage time, post-operative length of stay and post-operative complications.

**Statistical analysis**

SPSS 26.0 software was used for statistical analysis, and measurement data conforming to a normal distribution were described by mean ± standard deviation; measurement data not conforming to a normal distribution were described by median (upper and lower quartiles) [M(P25, P75)]; count data were described by frequency and percentage (%).

**Ethical review**

This study has been reviewed by the Ethics Committee of Gansu Provincial People's Hospital, approval number: 2022-304 . All patients signed the informed consent form for surgery before surgery.

**Results**

**Patient General Information**

A total of 35 patients with resected mediastinal neurogenic tumours after RATS were included in this study, of whom 19 (54.3%) were male and 16 (45.7%) were female. The mean age of the patients was 34.9 ± 7.1 years, BMI was 23.4 ± 4.1 kg/m2 and tumour size was 4.2 ± 1.4 cm. There were 22 patients (62.9%) with no symptoms, 5 patients (14.3%) with chest pain, 4 patients (11.4%) with chest tightness and 4 patients (11.4%) with coughing symptoms. Among the tumour types, there were 20 cases (57.1%) of nerve sheath tumours, 12 cases (34.3%) of neurofibromas and 3 cases (8.6%) of ganglieneuroma; see Table 1.

**Surgical results**

The patient’s surgical profile is detailed in Table 2. Surgery time: 62.3±18.0min; loading time: 10.3±2.6min; intraoperative bleeding: 33.9±21.6mL; postoperative 24h chest drainage: 69.0±28.9mL; postoperative chest drainage time: 2.2±1.4 days; postoperative hospital stay: 3.2±1.3 days.

There were no serious surgical complications during the operation, such as intermediate open heart and perioperative death, and all patients recovered and were discharged after the operation. In terms of postoperative complications, there were two cases of postoperative transient Honor syndrome and one case of transient absence of sweating on the affected upper limb; see Table 2.

**Discussion**
Most posterior mediastinal tumors are of neurogenic origin and arise from the thoracic of neurological origin from the peripheral, sympathetic and parasympathetic nerves within the The tumors are of neurogenic origin [9,10]. Histologically, mediastinal tumors of neurogenic origin can be divided into nerve sheath tumors, sympathetic tumors (ganglion cell tumors account for approximately 40%-60% of tumors) and neurofibromas. Currently, surgery is the main treatment main treatment modality.

In traditional open-heart surgery for posterior superior mediastinal neurogenic tumors, it is difficult to obtain a satisfactory view of the tumor due to its the high location of the tumor makes it difficult to obtain a more satisfactory surgical view. Although thoracoscopic surgery may to some extent meet the requirements for surgical field of view requirements, its 2D-only imaging system is sometimes difficult to obtain high quality surgical images. The da Vinci robot's naked-eye 3D imaging technology provides high-quality magnified images that can magnify the surgical field 10-15 times in three dimensions, allowing the operator to obtain a high-quality surgical image that facilitates the identification of the tumor's feeding vessels and its relationship to vital nerves [11]. The two ganglion cell tumors in this group were located at the entrance to the thorax at the top of the pleura The upper part of the tumor was located deep to the neck. The thoracoscopic surgery is difficult to perform because of the high level of stability and precision required for open-heart surgery, which is only possible with a "semi-clam incision" [12].

Due to the high tumor position and small operating space of the tumor of the rear neuronal nerve source, the surgical field of vision is poor during routine opening surgery, the tumor leakage is difficult, and the movement of surgical instruments during thoracoscopy is often limited [13]. The difficulty of dissection is caused by losing accuracy, and the accuracy of the robot surgery system is excellent. Some neurogenic tumors tend to adhere to the surrounding tissue, making it more difficult to separate and ligate the feeding vessels of the tumor. For tumors originating from important motor nerves or in close proximity to important nerves, there is a high risk of nerve collateral damage due to the small operating space and the difficulty of handling surgical instruments. The robotic arm of the Da Vinci Robot Surgery System has 7 free activity of wrist type, including advanced and retreating, wrist rotation, bending up, down, left and right directions, and the end-of-right grabbing movement [14]. The activity space in the limited surgery field and fixed angle can be extended to the areas where traditional equipment cannot reach. These features of the da Vinci robotic surgical system allow it to operate not only in tight spaces, but also to expose the surgical area more fully and provide a better view of difficult anatomical areas, thus allowing surgeons to precisely isolate and treat blood vessels and vital nerves, improving surgical safety [15]. In this group, 28 tumors were located in the posterior superior mediastinum and were closely related to the sympathetic chain. 9 ganglioneuroblastomas were located at the entrance to the thorax and originated from the sympathetic chain. After fine intraoperative dissection, 2 cases developed Honor's syndrome postoperatively, which was observed with oral vitamins, etc. the symptoms partially recovered and 1 case developed an absence of sweating in the affected upper limb, otherwise no significant neurological complications were observed. As proficiency in the operation increases, the number of accidental and unnecessary injuries unnecessary injuries are gradually reduced.
The da Vinci robotic system requires only one 1.2 cm incision for access and two 0.8 cm incisions for manipulation of the posterior mediastinal neurogenic tumour. The intraoperative use of an 8 mm Hg pneumothorax does not increase airway resistance, but significantly increases intraoperative exposure. Usually we do not use an auxiliary port, and when gauze is fed, or when haemostatic powder needs to be sprayed on the wound, simply withdraw the instrument temporarily and feed it through the instrument hole; when the tumour needs to be removed after excision, remove one arm trocar and use the endoscopic retriever to remove the specimen. We usually use an anterior chest wall incision to remove the specimen because of its wide rib space and thin muscle tissue. In the early stages, it takes longer to remove the specimen from the tiny single hole, and then it is easier to remove the specimen by extending the incision to the size of the tumour diameter.

For robotic surgery, the position of the body and incision determines the ease and even the success of the procedure. Usually we choose the 6th intercostal space in the posterior axillary line as the observation hole position. When the tumour is in a high position, we choose a lateral folding position to prevent the lens arm from compressing the hip, and the instrument arm holes are chosen at the 4th intercostal space in the anterior axillary line and the 7th intercostal space in the posterior axillary line. Unlike lumpectomy or open surgery, it is not the case that the closer the incision is to the swelling, the closer the incision is to the swelling, the greater the movement of the large arm when the tip of the instrument is moved laterally the same distance, causing more opportunities for collision and thus limiting the movement of the instrument, so choosing a more distant incision is more beneficial to the operation.

In the operation, we operate the bipolar electrocoagulation grasper with the left hand and the electrocoagulation hook with the right hand to complete all the operations. The electrocoagulation hook is separated by layered electrocoagulation and the bipolar grasper deals with the trophoblastic vessels and assists in the exposure, but because the tumour is usually brittle and does not have a hard and tough outer membrane, and the grasper does not have force feedback, it cannot complete the "clamping" action during the freehand operation.

**Conclusion**

In summary, the da Vinci robotic posterior superior mediastinal neurogenic tumour resection is safe and feasible, with good surgical results. For the resection of neurogenic tumours in particularly narrow spaces such as the pleural apex, the da Vinci robotic surgical system has clear advantages, especially in preserving nerve function.

**Abbreviations**

BMI: body mass index; COPD: chronic obstructive pulmonary disease; MRI: magnetic resonance imaging; RATS: robot-assisted thoracoscopic surgery; VATS: video-assisted thoracoscopic surgery

**Declarations**
Acknowledgements

No.

Author contributions


Funding

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Availability of data and materials

The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was performed in accordance with the ethical guidelines of the World Medical Association Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. This study was approved by the Ethics Committee of Gansu Provincial People's Hospital, approval number: 2022-304. Written informed consent for inclusion in the study was obtained from all patients.

Consent for publication

Written informed consent was obtained from both the patients and parents/guardians for the publication of potentially identifying information and/or images.

Competing interests

The authors declare that they have no competing interests.

References


Figure 1

The "6-4-7" orifice approach for posterior superior mediastinal tumour
Figure 2

The "5-3-8" orifice approach for posterior inferior mediastinal tumour
Figure 3

Opening the envelope
Figure 4

Anatomical tumour
Figure 5
Removal of tumour

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