Case Report

Combined minimally invasive surgery for a dumbbell tumor using spinal endoscopy and robot-assisted intrathoracic surgery: a case report

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Background: The resection of dumbbell tumors requires careful planning that combines neurosurgical and thoracic procedures, as intra-thoracic manipulation alone may result in uncontrolled bleeding in the spinal cord owing to tumor traction and spinal cord injury. In recent years, many studies have reported intra-thoracic manipulation using robot-assisted surgery for improved safety and minimal invasiveness. However, several neurosurgical procedures of hybrid surgery have been performed using laminectomy. Herein, we describe a less invasive approach that combines robot-assisted surgery with spinal endoscopy to successfully resect a dumbbell tumor.

Case Description: A 77-year-old man presented with a tumor in the posterior mediastinum. Computed tomography showed a well-demarcated, 3-cm sized dumbbell-shaped mass adjacent to the left side of the T3 vertebra. Magnetic resonance imaging showed a mass extending to the intervertebral foramen at the T3–T4 level and suggested a dumbbell-shaped schwannoma categorized as type 4, according to Eden's classification. A hybrid spinal endoscopic and robot-assisted surgery was planned for tumor resection. Resection of the tumor within the foramen was first performed using a spinal endoscope in the prone position. Subsequently, the tumor in the thoracic cavity was completely resected by robot-assisted surgery in the right lateral decubitus position. The tumor was removed while preserving the thoracic and intercostal nerves. The excised specimens were pathologically diagnosed as cavernous hemangioma. The patient was discharged after postoperative seven days without any complications or neurological symptoms.

Conclusions: Spinal endoscopy is a minimally invasive procedure with limited muscle and bone destruction. For dumbbell-shaped tumors, a hybrid of spinal endoscopy and robot-assisted thoracoscopic surgery may be less invasive and safer option.

Keywords: Dumbbell tumor; spinal endoscopy; robot-assisted thoracic surgery; case report

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Introduction

Surgery for dumbbell tumors requires careful planning because intrathoracic or spine manipulation alone may result in uncontrolled bleeding and spinal cord and intrathoracic organ injuries. The resection of dumbbell tumors has traditionally been performed using a combination of prone laminectomy and lateral video-assisted thoracic surgery for safety and minimal invasiveness. In recent years, many

studies have reported improved intrathoracic manipulation using robot-assisted surgery; however, limited reports have been published regarding spinal manipulation using endoscopy. In this case report, we describe a less invasive approach that combines robot-assisted surgery with spinal endoscopy to successfully resect a dumbbell tumor. We present this case in accordance with the CARE reporting checklist (available at https://vats.amegroups.org/article/view/10.21037/vats-22-61/rc).

Case presentation

A 77-year-old man with a history of diabetes and coronary artery stenosis was referred to our hospital because of a tumor in the posterior mediastinum; the tumor was detected on chest computed tomography (CT) performed at another hospital where he was treated for herpes zoster. The patient showed no abnormal physical or neurological findings. Chest CT showed a well-demarcated 3-cm-long dumbbell-shaped mass adjacent to the left side of the Th3 vertebra and a 1-cm nodule on the same side of the Th2 vertebra. Magnetic resonance imaging showed a mass with low signal intensity on T1-weighted images and high signal intensity on T2-weighted images extending to the intervertebral foramen (*Figure 1A*), and gadolinium-enhanced imaging showed a uniformly well-enhanced mass (*Figure 1B*). These imaging findings suggested a dumbbell-shaped schwannoma categorized as type 4, according to Eden's classification.

After general anesthesia, the patient was positioned prone, and a 1.8-cm skin incision was made over the left T3 laminae under C-arm radiological guidance to perform spinal endoscopic surgery first (*Figure 2A*). Using miniature ball-end diamond wheels, the lateral one-third of the T3 left vertebral arch, inferior margin of the T3 left transverse process, inferior margin of the pedicle, and superior margin of the left fourth rib head were removed, and a dark red, soft, encapsulated tumor was found in the T3–T4 left intervertebral foramen. A normal fourth thoracic nerve root was identified on the surface of the tumor (*Figure 2B*) and could be loosely separated from it. The tumor was exposed from the outer edge of the dural tube to the exit of the intervertebral foramen and resected in pieces, while preserving the nerve bundle.

Subsequently, the patient was moved to the right lower lateral decubitus position for intrathoracic manipulation. An 8-mm da Vinci port was placed on the 3rd intercostal anterior axillary line, 6th intercostal anterior axillary line (for the camera), and 8th intercostal middle axillary line (*Figure 3A*). A 20-mm assist port was placed on the 4th intercostal anterior axillary line for manipulation by the assistant and removal of the specimen. To avoid pneumoencephalopathy due to potential dural damage, the intrathoracic maneuvers were performed without CO_2 insufflation. The pleura was incised, and the third intercostal nerve was identified and taped outside the tumor (*Figure 3B*). The tumor bled easily; however, by following the third intercostal nerve centrally and proceeding with detachment, we were able to resect the tumor while preserving the nerve. A brief video is provided on a series of surgical operations of spinal endoscopy and robotic approach (*Video 1*). A 2-cm tumor near the T2 vertebra was removed via intrathoracic manipulation alone. The operation lasted 4 h and 54 min, with blood loss of 30 mL and console time of 1 h and 18 min.

The postoperative course was uneventful, with no neurological symptoms. The excised specimens were pathologically diagnosed as cavernous hemangioma. The patient was discharged 7 days postoperatively without any complications or neurological symptoms.

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written

Highlight box

Key findings

- A hybrid operation of spinal endoscopy and robot-assisted intra-thoracic surgery was performed for dumbbell-shaped tumors, providing a less invasive and safer procedure.

What is known and what is new?

- The resection of dumbbell tumors requires careful planning that combines neurosurgical and thoracic procedures as intra-thoracic manipulation. Although some studies have reported intra-thoracic manipulation using robot-assisted surgery for improved safety and minimal invasiveness, neurosurgical procedures of hybrid surgery have been mainly performed using laminectomy. In the present case, we present the surgical procedure and precautions for hybrid surgery of spinal endoscopy and robot-assisted intra-thoracic surgery.

What is the implication, and what should change now?

- Hybrid spinal endoscopy and robot-assisted thoracoscopic surgery for dumbbell tumors is a procedure that is likely to become more prevalent with the advantage of localized destruction of dorsal bone structures and the flexibility of the robotic arm.

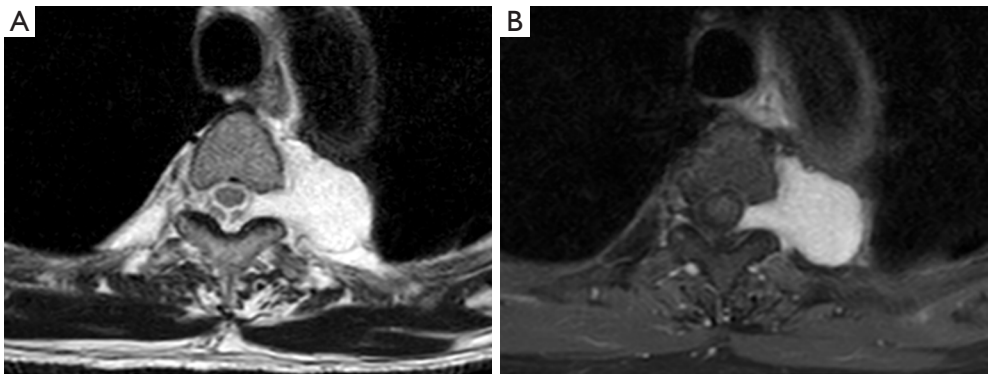


Figure 1 Magnetic resonance imaging shows a posterior mediastinal tumor extending into the intervertebral foramen. (A) T2-weighted image; (B) Gadolinium-enhanced T1-weighted image.

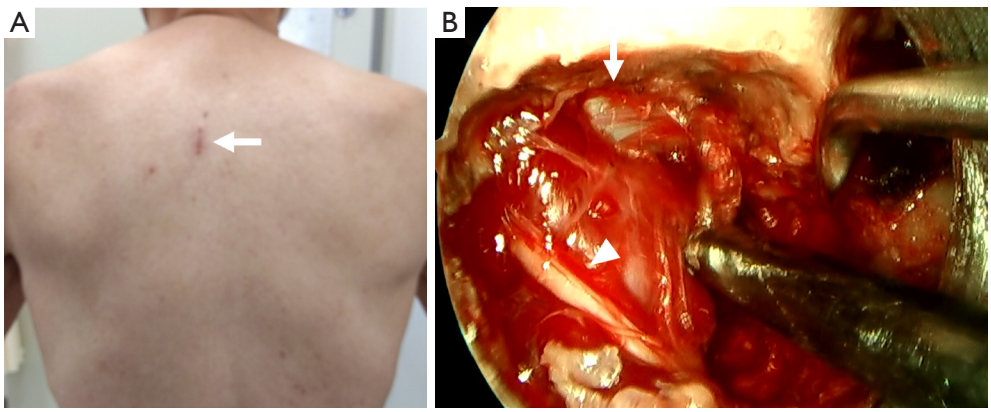


Figure 2 Skin incision (arrow) for spinal endoscopic surgery (A) and operative findings in T3/4 the left intervertebral foramen using a spinal endoscope (B). A dark reddish tumor is seen between the normal fourth thoracic nerve (arrowhead) and the dural tube (arrow).

consent is available for review by the editorial office of this journal.

Discussion

Dumbbell tumors are shaped like an hourglass or dumbbell and are classified into four categories according to Eden's classification. They can be found in two or more different compartments—intradural, epidural, intervertebral, and paravertebral (1). Dumbbell tumors extend through the intervertebral foramen; therefore, their resection requires careful planning that combines neurosurgical and thoracic procedures as intrathoracic manipulation alone may result in uncontrolled bleeding in the spinal cord owing to tumor traction and spinal cord injury. Since Eric Valleres reported a minimally invasive combination of microneurosurgery and video-assisted thoracic surgery in 1995, various approaches have been reported for improved safety and minimal invasiveness (2). In recent years, the introduction of robotic surgery has enabled safer and less invasive surgery that takes advantage of the flexible manipulability of robotic arms and clear image quality (3). However, many neurosurgical procedures of hybrid surgery have been performed using laminectomy, and to our knowledge, only Yang *et al.* have reported performing the posterior approach under spinal endoscopy (4).

Spinal endoscopy is a procedure in which a cylindrical tubular retractor is inserted into the surgical site, and an endoscope or surgical instruments are inserted inside the retractor (*Figure 4*). While conventional procedures exfoliate the back muscles or remove the vertebrae, the 16-mm tubular retractor minimizes muscle and bone damage. Compared with conventional laminectomy, spinal endoscopy reportedly results in reduced blood loss,

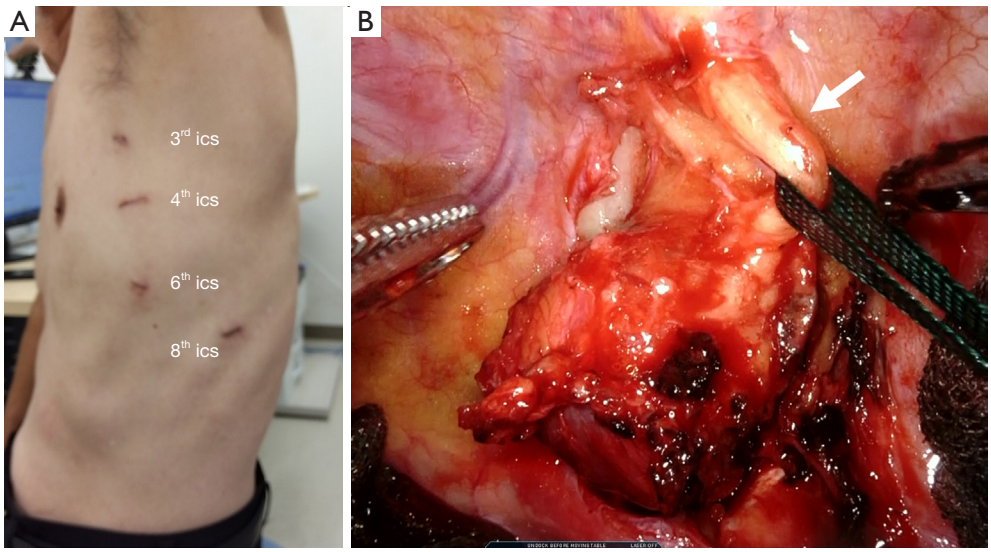
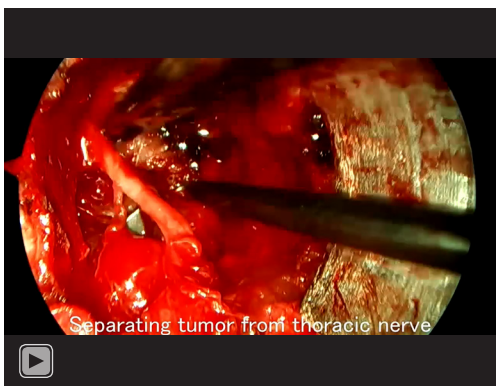


Figure 3 Port placement for robotic approach (A) and operative findings of the tumor in the thoracic cavity (B). An 8-mm da Vinci port was placed on the 3rd (left arm), 6th (for the camera), 8th (right arm) intercostal spaces and a 20-mm assist port was placed on the 4th intercostal space. The third intercostal nerve is reserved with polyester tape to identify the tumor. ics, intercostal space; arrow, intercostal nerve.



Video 1 Intraoperative video of combined spinal endoscopy and robot-assisted resection for dumbbell tumors.

Figure 4 Surgical scene for spinal endoscopy. A cylindrical tubular retractor is inserted into the surgical site, and an endoscope or surgical instruments are inserted inside the retractor.

inflammatory response owing to surgical invasion, and hospital stay, as well as no significant difference in the incidence of complications; it may also enable a minimally invasive surgery for dumbbell tumors (5,6). As regards the disadvantages of spinal endoscopic surgery for spinal tumors, Caballero *et al.* mention the technical difficulties of dural closure and the size of the tumor (7). Thus, Eden's type 1 and 2 dumbbell tumors, in which two tumors form across the dura, require combined resection of the dura and dural closure, making it difficult for spinal endoscopic surgery to be indicated for types 3 and 4.

CO_2 insufflation may be performed during intrathoracic manipulation to widen the field of view of the thoracic cavity during robotic surgery. It may cause pneumocephalus in the case of dumbbell tumors, if the dural injury is due to surgical manipulation close to the dura. Therefore, we performed intrathoracic manipulation without CO_2 insufflation. The thoracic maneuver was performed in the

lateral position, although the position change from the back maneuver was time-consuming. Okazaki *et al.* reported that using the flexibility of the robotic surgery arm and performing the procedure with the patient in the prone position has the advantage of shortening the operation time and allowing the patient to be operated at any time from the dorsal side (8). However, some cases of cavernous hemangioma, such as the present case, have been reported to have difficulty with hemostasis and excessive bleeding. Intrathoracic maneuvers for dumbbell tumors may be safer in the lateral position because of the ease of thoracotomy in preparation for bleeding and the difficulty in adjusting the double-lumen tube in the prone position.

Conclusions

We reported a novel approach for a dumbbell tumor using combined spinal endoscopy and robot-assisted intrathoracic surgery. This technique may provide a less invasive and safer option because of the minimal destruction of dorsal bone structures and the flexibility of the robotic arm.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://vats.amegroups.org/article/view/10.21037/vats-22-61/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://vats.amegroups.org/article/view/10.21037/vats-22-61/coif). 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. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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