Use of the da Vinci Minimally Invasive Robotic System for Resection of a Complicated Paraspinal Schwannoma With Thoracic Extension: Case Report

BACKGROUND AND IMPORTANCE: Applications of robotics to minimally invasive spine surgery have produced several benefits while sparing patients the morbidity of traditional open surgery. Minimally invasive spine surgery offers the advantages of less pain and less blood loss, along with quicker recovery and shorter hospital stays. The da Vinci robotic surgical system has recently been adapted to neurosurgical applications. This article details a posterior approach using a tubular retraction system in conjunction with an anterior approach using the da Vinci robot to completely remove large spinal schwannomas with intrathoracic extension. This technique is an example of a novel application of existing technology initially developed for other applications.

CLINICAL PRESENTATION: Two patients with large thoracic schwannomas extending into the chest cavity are reviewed. We present images and video of the combined minimally invasive approach used to completely remove the lesions without complications.

CONCLUSION: This report describes a novel neurosurgical application of an existing minimally invasive robotic surgical system.

KEY WORDS: Da Vinci, Minimally Invasive, Schwannoma

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The robotic system lacks problem-solving ability and decision-making software. The operator fully controls the functionality of the robot. The multiarticulated design of the robotic system provides motions that exceed the natural range of motion of the human hand, including a tremor reduction and motion-scaling algorithm that further refines surgeon hand movements. Similar to other minimally invasive surgical approaches, the da Vinci procedure has the potential advantages of less pain, less blood loss, quicker recovery, and shorter hospital stays.

Recent developments in tubular retractors have led to a renaissance in minimally invasive approaches to the spine. Resection of large spinal tumors extending into the chest cavity, however, cannot be adequately resected using a posterior tubular retractor approach alone. This article describes 2 cases in which a posterior approach using a tubular retractor combined with an anterior approach using the da Vinci robotic system allowed complete resection of a large schwannoma.

CASE REPORT

Perioperative Evaluation and Treatment

Typical evaluation of complex thoracic spinal tumors includes preoperative spinal and thoracic magnetic resonance images (MRIs) with and without contrast. The extent of intradural extension of the lesion can be assessed. This allows preoperative preparation in the event that the tumor extends intradurally and requires dural closure to prevent postoperative cerebral spinal fluid leak into the chest. A sagittal scout MRI extending from the sacrum to the level of pathology is performed to accurately identify the level of the pathology for intraoperative localization. In addition, we routinely perform preoperative chest, anteroposterior and lateral thoracic, and lumbar plain x-rays. This helps to confirm the number of lumbar vertebrae, as well as thoracic ribs and vertebrae, for counting and lesion localization purposes.

The posterior minimally invasive approach can be performed with a variety of minimally invasive muscle-splitting dilators and tubular retractors. The anterior approach is performed with the da Vinci robotic system. The following ports are placed according to previously described thorascopic techniques: camera, Bovey cautery, dissector, and suction. An assistant applies suction as needed, and the Bovey and dissector ports are controlled with the da Vinci robotic system. A long thoracic forceps holding a sponge is kept on the Mayo table in the event of uncontrolled bleeding. Pressure applied with the sponge-forceps can help control bleeding until an emergency open thoracotomy incision can be performed. Patients are always informed preoperatively of the possibility of conversion from a thorascopic to an open thoracotomy approach if needed to ensure patient safety. Preoperative medical, cardiac, and pulmonary function tests are performed as needed. At the completion of the case, a chest tube is inserted, which can typically be removed the following day after confirmatory chest x-ray.

Patient 1

A 67-year-old man presented to our clinic with severe right-side shoulder pain. He had been previously diagnosed with a large right upper thoracic schwannoma, which was confirmed via computed tomography–guided biopsy. The patient had received radiation treatment to the tumor without tumor response. The patient’s medical history was significant for a left-side cerebral vascular event in the past. The patient underwent preoperative medical and cardiac clearance, including pulmonary function tests. The lesion had been followed up for several years with serial imaging. It extended from T2-3, expanding the neural foramina, with partial erosion of the T3 vertebrae. Physical examination revealed 5/5 strength in all muscle groups and no signs of hyperreflexia or pathological reflexes. Comparing the most recent MRI with previous films, we noted that the mass had enlarged. It extended from the T2-3 foramen into the spinal canal abutting the spinal cord, deforming the thecal sac. It also extended out into the chest at the apex of the lung on the right side (Figure 2).

The patient was initially positioned in the prone position on a radiolucent Jackson spinal table (Mizuho OSI, Union City, California). The level of the tumor was determined by counting vertebrae from the sacrum to the level of the lesion. An anteroposterior thoracic chest x-ray was also taken to count ribs to identify the level; thus, 2 methods were used to properly identify the level. An approximately 2-cm incision was made 3 cm lateral to the midline on the basis of preoperative axial MRIs at the level of the lesion to allow muscle dilator docking on the T2-3 facet complex. Serial muscle dilation was performed, and a minimally...
invasive retractor (Nuvasive, San Diego, California) was placed. A small amount of soft tissue was removed to expose the facet complex and ipsilateral lamina. A high-speed drill and cutting burr (Stryker TPS, Kalamazoo, Michigan) was used to carry out the laminectomy and facetectomy to expose the tumor, which was growing out of the neural foramen. All drilled bone graft material was collected with the BoneBac Press (Thompson MIS, Traverse City, Michigan). The sheath of the tumor was cut and the tumor was debulked (see Video 1, Supplemental Digital Content 1, http://links.lww.com/NEU/A472, which demonstrates the posterior debulking and piecemeal removal of the intraspinal portion of the tumor). Intraoperative specimens were sent for pathological evaluation. Duragen (Integra LifeSciences, Plainsboro, New Jersey) and Tisseel (Baxter, Deerfield, Illinois) were placed over the dura to prevent any occult cerebrospinal fluid leak into the thoracic cavity. The collected morselized autologous bone was used for a posterolateral arthrodesis between T2 and T3. The tubular retractor was removed, allowing the paraspinous muscles to return to their normal anatomic position. The patient was then placed in the supine position and underwent a minimally invasive thoracoscopy with the da Vinci system for resection of the intrathoracic portion of the lesion (see Videos 2 and 3, Supplemental Digital Contents 2 and 3, http://links.lww.com/NEU/A473 and http://links.lww.com/NEU/A474, which demonstrate dissection of the tumor from intrathoracic adhesions and en bloc removal from the thoracic cavity). A gross total resection was achieved (Figure 3). Intraoperative pathology revealed spindle-shaped tumor cells and Verocay bodies, consistent with schwannoma. Somatosensory evoked potential monitoring and motor evoked potential monitoring were used throughout the procedure. A chest tube was placed, and a chest x-ray was taken to confirm placement. The chest tube was removed on postoperative day 2. Combined estimated blood loss was approximately 250 cm$^3$. Postoperatively, the patient had full motor strength in the upper and lower extremities. Sensation was also intact and reflexes were symmetric. The MRI revealed no residual schwannoma. The patient was discharged on postoperative day 3. He was not treated with postoperative radiation or chemotherapy. At the 2-week follow-up, the patient had four 2-cm-long anterior chest wall incisions from the da Vinci portals and a 2-cm-long posterior incision (Figure 4). The patient returned to normal activities of daily living within weeks of surgery. This patient was seen in follow-up for 1 year with no evidence of tumor recurrence on serial MRI.

Patient 2

A 63-year-old woman with history of breast cancer and back pain presented with the finding of a large left T3-4 foraminal mass that extended into the thoracic cavity (Figure 5A). Neurological examination was normal. After evaluation by thoracic surgery, resection was recommended. In the first stage, after placement of a double-lumen endotracheal tube, the patient was placed prone on gel rolls. The operating table was radiolucent. Anterior-posterior and lateral views were used for localization. A 2.5-cm incision was made 2 cm off the midline to the left. After sequential dilation, an expandable tubular retractor was placed so that the lateral L3-4 lamina, L3-4 facet joint, and T4 transverse process were exposed. A left laminotomy and facetectomy were performed for resection of the foraminal component of the tumor (Figure 5B). She was then repositioned into the right lateral decubitus position, and selective ventilation via the double-lumen endotracheal tube was applied. A total of 4 incisions were then made. A 5-mm incision was made in the sixth and then eighth intercostal spaces. A 10-mm incision was made in the sixth intercostal space posterior to the initial incision. Finally, a 15-mm incision was made in the posterior interspace to free the lateral retractor. The morselized bone was used for a posterolateral arthrodesis between T2 and T3. The patient was then repositioned into the right lateral position, and a 2-cm-long posterior incision was made. The patient returned to normal activities of daily living within weeks of surgery. This patient was seen in follow-up for 1 year with no evidence of tumor recurrence on serial MRI.

FIGURE 2. Axial (A), sagittal (B), and coronal (C) preoperative T1 magnetic resonance imaging photographs show the mass extending from the T2-3 neural foramen into the chest at the right lung apex.
A chest tube was placed through the inferior incision, and the lung was re-expanded under thoracoscopic visualization. Combined estimated blood loss was 55 cm³.

On postoperative day 1, the patient had a normal neurological examination. The chest tube was removed. The patient was discharged on postoperative day 2. At the time of discharge, pain was controlled with Tylenol and ibuprofen. Postoperative MRI showed gross total resection of tumor, and pathology was consistent with schwannoma. At the 5-month follow-up, the patient remained neurologically intact with no pain other than occasional soreness along the scapula.

DISCUSSION

Minimally invasive access to complex surgical lesions has provided patients with better outcomes and fewer complications.³,⁴ Device development and newer instrumentation have provided us with tools that improve care to patients. As we continue to push the forefront to reduce approach-related morbidity, to shorten hospitals stays, and to provide quicker postoperative recovery, we must keep in mind the goal of surgery: to treat the patient by properly accessing the lesion and performing the full surgery. Minimally invasive surgery is not minimal surgery. It means performing the full surgery with all of its entailed benefits without exposing patients to the ancillary morbidity of large incisions, extensive muscle dissection, and compromise of vascular and neural supply and innervation.

There have been many new applications of robotic spinal surgery, encompassing both anterior and posterior approaches to the spine.⁵-¹⁰ The da Vinci robot has gained some popularity for transoral odontoidectiontomy because of its ability to tunnel down and operate down long corridors. Cadaveric and clinic reports show technical success with the procedure; however, long-term outcomes data are not available.¹¹-¹³ Intrauterine repair of myelomeningocele has received some publicity,¹⁴ but outcomes reports are still pending from a limited number of centers nationwide.

Spinal schwannomas can grow very large because of their relatively indolent course and benign behavior.⁵,¹⁵ When recognized, these lesions can present with considerable surgical challenges with marked spinal cord compression and extension into the thoracic cavity.⁵,¹⁵ Intradural extension can add to their surgical complexity because these cases can be associated with cerebrospinal fluid leakage into the thoracic cavity. Thus, preparation for tight dural closure is critical. Preoperative MRI and computed tomography/myelogram can help in the
assessment. Intrathoracic extension into the upper thoracic spine can be particularly challenging, and we believe that the use of the da Vinci robot in the first case made it much easier to remove this apical tumor.

There are relatively few examples of the robotic resection of intraspinal schwannomas in the literature. Yang et al describe a case of a 50-year-old man who presented with a paravertebral well-encapsulated mass originating from the prevertebral sympathetic plexus and abutting the abdominal aorta and left psoas muscle at the L4-L5 level. A robot-assisted retroperitoneal tumor resection was performed with the da Vinci system. There were no intraoperative complications.

Moskowitz et al describe a case of a 19-year-old male patient with a family history of neurofibromatosis who presented with back pain and was found to have a 3 × 4-cm neurofibroma in the T12-L1 left paraspinal area. After retroperitoneal laparoscopic access was obtained, the da Vinci robot was docked, and the mass was resected from its nerve origin, with pathology confirming neurofibroma. There were no complications, and the patient’s back pain resolved completely. The authors state that they opted for the minimally invasive approach over the open approach because of the risk to the patient with the open procedure and the faster recovery times and smaller incisions associated with the da Vinci surgery.

Johna et al describe the laparoscopic resection of a large retroperitoneal neurofibroma located inferior to the left kidney in a 37-year-old woman. The authors decided against an open resection to minimize surgical trauma and because of the proximity of the tumor to the parasympathetic plexus. The minimally invasive approach allowed them to minimize surgical manipulation and muscle cutting, both of which are known advantages of the minimally invasive approach.

As surgeons become more comfortable with these procedures and continue to collect data and contribute to the growing body of literature supporting the use of minimally invasive procedures, patients will continue to benefit. Several studies comparing minimally invasive and open surgery have reported that costs are reduced as a result of reduced hospital stays and recovery times. Approach-related morbidity is significantly reduced because normal anatomic structures are not disturbed. These procedures can be just as efficacious with respect to the pathology without the undue approached-related muscular and ligamentous dissection.

Using the da Vinci robotic surgical system requires specialized surgeon training. Moving at a console rather than in the patient can disorient the surgeon at times. The surgeon must be attuned to a different set of cues. The same touch and pressure feedback is not available. Therefore, proper training in courses and cadaver laboratories is of utmost importance. For surgeons wanting to learn, these resources are all currently available to help educate surgeons, thus improving patient outcomes and reducing complications.

Long-term outcomes and quality-of-life data for the minimally invasive techniques are lacking and therefore preclude a meaningful comparison with open approaches and cost-effectiveness analysis. This paucity of data may be used as an argument for not using minimally invasive techniques. Some insurance companies may further use it as a reason for nonreimbursement. However, as surgeons, we should train and familiarize ourselves with rapidly evolving technology and techniques. Indeed, the use of spine surgery thoracoscopic robotic techniques might help to reduce the morbidity associated with open thoracotomy techniques while reducing the steep learning curve associated with thoracoscopic techniques. More important, we should carefully collect clinical data on patient outcomes and report them in a timely fashion. In doing so, we can offer better treatment to our patients and improve outcomes.

Disclosures

De Perez-Cruet is CEO/President/Stockholder of MI4Spine LLC and is Chief Medical Director and owns stock in Thompson MIS LLC. Dr Park is a consultant for Depuy Spine and Globus Medical and has received honorarium from Medtronic. The other authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.
REFERENCES


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COMMENT

This case report describes surgical outcomes in 2 patients after combined posterior and anterior approach for intraspinal schwannomas with thoracic extension. The posterior approach involved microtubular piecemeal intracapsular debulking of the intraspinal component. The intrathoracic extension was approached anteriorly and resected en bloc with the da Vinci robotic system. The standalone microtubular approach is best suited for small to medium-sized intraspinal tumors. The authors, in collaboration with their colleagues in thoracic surgery, combined the microtubular approach with the multiport da Vinci system for resection of large schwannomas. The authors report remarkable results with gross total resection, minimal blood loss, and early discharge to home.

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