TECHNIQUES AND APPLICATIONS

MINIMALLY INVASIVE RESECTION OF INTRADURAL-EXTRAMEDULLARY SPINAL NEOPLASMS

Trent L. Tredway, M.D.
Department of Neurosurgery, University of Washington, Seattle, Washington

Paul Santiago, M.D.
Department of Neurosurgery, Washington University, St. Louis, Missouri

Melody R. Hrubes, B.A.
Section of Neurosurgery, Pritzker School of Medicine, University of Chicago, Chicago, Illinois

John K. Song, M.D.
Section of Neurosurgery, Pritzker School of Medicine, University of Chicago, Chicago, Illinois

Sean D. Christie, M.D.
Section of Neurosurgery, Pritzker School of Medicine, University of Chicago, Chicago, Illinois

Richard G. Fessler, M.D., Ph.D.
Section of Neurosurgery, Pritzker School of Medicine, University of Chicago, Chicago, Illinois

Reprint requests:
Richard G. Fessler, M.D., Ph.D., Professor and Chairman, Section of Neurosurgery, MC 3026, University of Chicago, 5841 South Maryland Avenue, Chicago, IL 60637. Email: rfessler@surgery.bsd.uchicago.edu

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OBJECTIVE: Spinal intradural-extramedullary neoplasms are uncommon lesions that usually cause pain or neurological deficit secondary to neural compression. Traditional treatment of these tumors includes open laminectomy with intradural resection. We describe an alternative minimally invasive surgical technique in a consecutive series of patients undergoing treatment for symptomatic lesions.

METHODS: Six patients (four men, two women) presented with symptoms including pain (five out of six) and/or neurological deficit (two out of six) with radiographic evidence of intradural pathology. All patients underwent surgical resection using a minimally invasive, unilateral approach. Pain relief was analyzed using the visual analog scale and magnetic resonance imaging to evaluate the extent of resection. Traditional laminectomy for tumor resection disrupts the muscular, ligamentous, and bony structures of the spine, which may contribute to pain and instability. Minimally invasive resection of intradural tumors offers the option of reducing approach morbidity when resecting these lesions. Using a tubular retractor system (X-Tube, Medtronic Sofamor-Danek, Memphis, TN) and microscopic surgical techniques, we were able to resect different intradural lesions successfully.

RESULTS: All patients underwent successful, complete resection of their intradural-extramedullary tumors. The average patient age was 47 years (range, 41–60 yr) with one cervical, one thoracic, and four lumbar lesions. The mean operative time was 247 minutes (range, 180–320 min), the estimated blood loss was 56 mLs (range, 40–75 mLs), and the hospital stay was 57 hours (range, 48–80 h). Histologically, five tumors were determined to be schwannomas and one was identified as a myxopapillary ependymoma. There were no complications associated with this surgical technique. Postoperative magnetic resonance imaging demonstrated complete resection in all cases.

CONCLUSION: Intradural-extramedullary neoplasms can be safely and effectively treated with minimally invasive techniques. Potential reduction in blood loss, hospitalization and disruption to local tissues suggest that, in the hands of an experienced surgeon, this technique may present an alternative to traditional open tumor resection.

KEY WORDS: Minimally invasive surgery, Myxopapillary ependymoma, Schwannoma, Spinal neoplasms

Intradural spinal cord tumors are uncommon with an incidence of 3 to 10 per 100,000 people (8, 15). The most common intradural-extramedullary tumors are the nerve sheath tumors comprised of schwannomas, neurofibromas, and malignant nerve sheath tumors. The second most common tumor in this category is meningiomas (10). It is estimated that approximately 50% of all intradural extramedullary tumors can be categorized as a nerve sheath tumor or a meningioma (10, 15). Patients harboring these lesions often present with radicular pain and, less commonly, with motor deficits when diagnosed later in the clinical course. Despite their location, complete surgical resection is often feasible with excellent clinical outcomes (1, 16).

Traditionally, an open surgical procedure consisting of laminectomy with intradural resection has been performed. These techniques have been used to achieve excellent outcomes.
as documented in a number of large series (9, 14). However, with recent advances in minimal access technology, many spinal procedures are being performed with an emphasis on minimizing surrounding tissue damage and blood loss. Our minimally invasive surgical technique and results with resection of intradural-extramedullary tumors are presented and discussed.

Illustrative Case 1

A 41-year-old man presented with a 1-year history of neck pain. There is no history of trauma or previous significant surgery or medical condition. He noted that his symptoms extended into his right neck, shoulder, arm, and the second and third fingers of his right hand. There was no history of gait disturbance or bowel/bladder dysfunction. On examination, he was found to have no overt sensory or motor deficits and there was no indication of myelopathy. Magnetic resonance imaging (MRI) scans revealed an enhancing intradural, extramedullary lesion on the right behind the C3 vertebral body (Fig. 1A). The patient underwent a minimally invasive resection of the tumor without incident and had postoperative resolution of his symptoms. Pathology was consistent with a schwannoma. Postoperative computed tomographic scans demonstrate the laminectomy defect (Fig. 1B).

Illustrative Case 2

A 40-year-old man presented with a 1-year history of limping and progressive left calf atrophy. In addition, he noted that urination had become increasingly more difficult. Further questioning revealed some sexual dysfunction. On examination, no overt signs of myelopathy were found, but significant weakness in the patient’s left foot plantar flexion was noted. MRI scans revealed an intradural, extramedullary lesion at the T12–L1 level (Fig. 2A). The patient underwent surgical resection, and postoperative imaging revealed complete resection (Fig. 2B). The tumor was revealed to be a myxopapillary ependymoma. The patient’s strength, urinary, and sexual dysfunctions resolved. Figure 2C demonstrates the extent of the skin incision.

METHODS

Six consecutive patients underwent surgical treatment of intradural-extramedullary tumors at two separate institutions between May 2003 and September 2004. Five of the six patients presented with a history of back or neck pain and two patients presented with neurological deficits. Preoperative evaluation consisted of physical examination and radiological imaging, including MRI scans with gadolinium and routine radiographs with dynamic imaging. All patients were determined to have imaging consistent with intradural-extramedullary lesions.

Pre- and postoperative outcome questionnaires, including visual analog scale (VAS), were obtained. Operative time, estimated blood loss, and length of stay were also recorded and analyzed. All patients were reviewed under guidelines set forth by the institutions’ Internal Review Boards in accordance with Health Insurance Portability & Accountability Act of 1996 regulations.

All patients gave consent and underwent a minimally invasive approach with resection of the intradural tumor. Briefly,
the X-Tube tubular retractor system (Medtronic, Memphis, TN) was used to gain access to the appropriate level of spinal pathology (Fig. 3). Residual soft tissue within the tube was resected using electrocautery. Hemilaminectomies were performed using standard Kerrison rongeurs and the ventral surface of the spinous process and contralateral lamina were removed using a shielded drill. Hemostasis of the epidural plexus was achieved using standard surgical compression.

In the cervical case (Patient 1), a paramedian incision, approximately 1.5 cm off the midline, was used to gain access to the posterior cervical spine. In the five thoracolumbar patients (Patients 2–6), a paramedian incision 3.5 cm off the midline was used. With the use of lateral fluoroscopy, the tubular retractor was localized over the lamino-facet junction of the respective level of spinal pathology. With the use of the operative microscope, a one- or two-level hemilaminectomy (based on the size of the lesion) with undercutting of the base of the spinous process and removal of the contralateral ligamentum flavum was performed. This surgical corridor allowed for excellent visualization and the ability to perform a midline durotomy. The edges of the dura were reflected with sutures (Fig. 4).

The tumors were resected using microscopic dissection techniques. The use of a nerve root stimulator provided the surgeon with immediate feedback during the procedure. Bayoneted instruments specifically designed for the minimally invasive approach facilitated the intradural surgery. After resection of the tumors, the dura was closed with a 4:0 suture in a running fashion. One patient requiring dural resection of a schwannoma and subsequent dural repair had a lumbar drain placed for 24 hours to decrease the risk of cerebrospinal fluid leak and pseudomeningocele formation.

**RESULTS**

The patients consisted of four men and two women with an average patient age of 47 years (range, 41–60 yr). Five of the six patients presented with pain as the chief complaint. Two of the six patients presented with weakness in dorsiflexion and extensor hallucis longus on examination. One patient had erectile dysfunction. The average length of onset of symptoms to diagnosis was 23.6 months (range, 4–60 mo) (Tables 1 and 2).

In respect to location, five of the six patients had tumors located between T12–L3. One patient had a cervical lesion at the C3–C4 level. Preoperative diagnosis based on radiographic imaging suggested five out of six lesions to be consistent with schwannoma, one seemed to be a myxopapillary ependymoma (Patient 3). Postoperative histological examination supported the preoperative diagnosis in all cases. Only one patient demonstrated evidence of dural involvement and required dural resection with reconstruction (Patient 4).

The mean operative time was 247 minutes (range, 180–320 min). The estimated blood loss was 56 mLs (range, 40–75 mLs), and the mean length of hospital stay was 57 hours (range, 48–80 h). Table 3 summarizes the operative statistics for each patient. The one patient requiring dural reconstruction underwent lumbar drainage for 24 hours. Patients presenting with pain demonstrated a significant reduction in their preoperative versus postoperative pain on VAS scoring administered at 1.5, 3, 6, 12, and 18 months postoperatively. Both patients presenting with lower extremity weakness improved with respect to motor strength on postoperative physical examination. The one patient with erectile dysfunction regained normal sexual function.
There were no complications encountered during the surgical procedures. One patient had a postoperative decrease in sensation in the left L3 distribution. This patient has extensive dural involvement and the tumor extended far out into the foramen. A gross total resection was achieved in all patients at the time of surgery and postoperative MRI scans confirmed complete resection of the tumors.

**DISCUSSION**

The first successful surgical removal of an intradural spinal tumor is credited to Victor Horsley in 1887 (5). The tumor was a fibromyxoma and removed via laminectomy. More than 100 years later, despite vast improvements in imaging, anesthetic care, and surgical instruments, the technique remains basically the same.

Intradural spinal cord tumors are relatively rare lesions and are thought to have an incidence of up to 10 per 100,000 people (8, 16). These lesions are broadly divided into two categories based on location: intramedullary and extramedullary. In adults, extramedullary tumors comprise approximately 70% of intradural spinal tumors. In the pediatric population, the distribution of intramedullary and extramedullary tumors is roughly even (2, 3). In the adult population, the most common intradural, extramedullary spinal tumors arise from the nerve sheath (approximately 30%) and from the meninges (approximately 25%) (16). Most of these lesions are benign and patients typically benefit from surgical decompression and resection.

Traditional surgical resection most often entails a posterior midline approach to the lesion with stripping of muscles and ligaments off of the underlying lamina and spinous processes. A bilateral laminectomy is usually performed from one level above the lesion to one level below the lesion to facilitate access and visualization. In the past century, surgeons have reported excellent results in resecting intradural-extramedullary spinal neoplasms. Sepalla et al. (14) reported a series of 187 patients that underwent surgical resection for spinal schwannomas.

### TABLE 1. Patients undergoing minimally invasive resection of tumors

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age (yr)/sex</th>
<th>Duration of symptoms (mo)</th>
<th>Level</th>
<th>Pathology</th>
<th>Follow-up period (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>41/M</td>
<td>12</td>
<td>C3</td>
<td>Schwannoma</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>50/F</td>
<td>4</td>
<td>L2</td>
<td>Schwannoma</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>42/M</td>
<td>12</td>
<td>T12–L1</td>
<td>Myxopapillary ependymoma</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>62/M</td>
<td>6</td>
<td>L2–L3</td>
<td>Schwannoma</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>45/F</td>
<td>36</td>
<td>L2</td>
<td>Schwannoma</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>44/M</td>
<td>6</td>
<td>L1–L2</td>
<td>Schwannoma</td>
<td>3</td>
</tr>
</tbody>
</table>

### TABLE 2. Pre- and postoperative neurological findings

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Preoperative symptoms</th>
<th>Preoperative signs</th>
<th>Postoperative symptoms</th>
<th>Postoperative signs</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Neck pain</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Back pain and bilateral leg pain</td>
<td>None</td>
<td>L3 numbness</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Urinary/sexual disturbance</td>
<td>Left calf weakness/atrophy</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Back pain, radiculopathy</td>
<td>None</td>
<td>None</td>
<td>Back pain</td>
</tr>
<tr>
<td>5</td>
<td>Back pain</td>
<td>None</td>
<td>None</td>
<td>Left foot drop</td>
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### TABLE 3. Operative statistics

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>No. of hemilamina removed</th>
<th>Blood loss (cc)</th>
<th>Time in operating room (min)</th>
<th>Length of hospital stay (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>60</td>
<td>180</td>
<td>56</td>
</tr>
<tr>
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<td>80*</td>
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<td>50</td>
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<td>48</td>
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<tr>
<td>6</td>
<td>1.5</td>
<td>75</td>
<td>320</td>
<td>56</td>
</tr>
</tbody>
</table>

* Lumbar drain placed for 24 hours.
large series, 90% were completely resected with a 10% surgical complication rate and 1.5% surgical mortality rate. Levy (9) also reported similar results on 66 patients with a 9% surgical complication rate and a 1.5% mortality rate. Potential complications (aside from neurological injury during resection) include pain, spinal instability, and cerebrospinal fluid leak.

With the advancement of minimally invasive techniques, a wider variety of spinal pathologies are being treated. Herniated discs, lumbar and cervical stenosis, synovial cysts, and lumbar instability have all been treated via minimally invasive techniques (4, 6, 7, 12, 13).

The current study describes our experience with resection of intradural-extradural lesions through a hemilaminectomy approach assisted with the use of a tubular retractor system. This approach provides adequate access to the intradural compartment with decreased disruption of spinal and paraspinal structures compared to traditional open techniques. Theoretically, this translates into decreased alteration of spinal biomechanics. Oktem et al. describe their experience with 20 patients undergoing open, unilateral hemilaminectomy for intradural tumor resection. Of these patients, for whom the contralateral lamina and ligamentous structures are unexposed, none exhibited spinal instability after 2 years of follow-up (11). As such, this technique represents the evolution of the use of a surgical tool. It is not a substitute for surgical judgement, experience, meticulous technique, or suboptimal resection or neurological outcome.

In addition, operative statistics from the current series demonstrated significant decreases in blood loss and length of postoperative hospitalization compared with historical cases in which open resection was performed. Operative times of about 4 hours for the discreet lesions investigated are similar to those if an open procedure were performed. Operative times of postoperative hospitalization compared with historical cases demonstrated significant decreases in blood loss and length of hospitalization. Most importantly, tumors were able to be completely resected without adverse neurological complications. With reductions in operative blood loss and postoperative pain and hospitalization. Most importantly, tumors were able to be completely resected without adverse neurological complications.

Although this is a small series of consecutive patients with a short follow-up, we have demonstrated that it is possible to completely resect intradural-extradural spinal tumors safely with reductions in operative blood loss and postoperative pain and hospitalization. Most importantly, tumors were able to be completely resected without adverse neurological complications. All patients with preoperative neurological deficits regained function after surgical resection. The results from this small series represent the extensive experience of the senior surgeon (RGF). It must be kept in mind that these results, although promising, may not be able to be easily reproduced by practitioners unfamiliar with minimally invasive techniques.

**FIGURE 5.** A, knot pusher. This device is specially useful for working down narrow corridors owing to its sliding action along the shaft and scissoring “trap” mechanism for pushing knots. B, close-up view of the tip.
CONCLUSION

Spinal intradural-extradural neoplasms can be safely and completely resected using minimally invasive techniques. The use of the X-Tube tubular retractor allows for excellent exposure while minimizing the trauma to the surrounding tissue. Furthermore, the contralateral ligamentous and bony structures are maintained and may decrease the incidence of postoperative instability and degenerative changes. Overall, we feel that in the hands of experienced surgeons, this technique can offer possible advantages to traditional open tumor resection for one or two level intradural, extramedullary spinal neoplasms.

REFERENCES


COMMENTS

This preliminary report establishes the feasibility and safety of minimally invasive resection of selected intradural tumors by a surgeon with extensive experience with these techniques. The senior author should be acknowledged for his leadership and innovation in the development and advancement of minimally invasive spinal techniques. Feasibility notwithstanding, however, the purported advantages of minimally invasive techniques over standard microsurgical resection of benign intradural tumors needs to more critically scrutinized for several reasons.

First, “pain and instability” due to disruption of the “muscular, ligamentous, and bony structures of the spine” rarely, if ever, complicates standard microsurgical resection of even large intradural tumors. Indeed, the results following microsurgical resection of benign intradural spinal tumors are among the most gratifying in all of neurosurgery. Secondly, the notion that minimally invasive spinal techniques reduce the risk of instability is dubious, at best, in my opinion. As the authors note, unilateral one or two level laminectomy is combined with resection of the base of the spinous process and bilateral removal of the ligamentum flavum. Since the dura is opened in the midline, I suspect that the interspinous ligaments are also disrupted with the described minimally invasive technique as is the medial aspect of the ipsilateral facet joint. Clearly, disruption of muscular, ligamentous, and bony structures of the spine also occurs during the performance of the minimally invasive procedure described in this paper.

There is no question that less muscle dissection and retraction is performed with minimally invasive exposures despite the fact that standard microsurgical resection for small laterally placed intradural tumors is now routinely performed via unilateral laminectomy. Depending on the surgeon, such ‘open’ microsurgery now takes no more than two or three hours with an average hospital stay of two to three days. Nevertheless, it is likely that early post-operative pain and analgesic intake, as opposed to long-term pain and instability, may be reduced with minimally invasive techniques due to the reduced muscle dissection. Curiously, however, the authors present no valid comparative data in this regard nor do they even quantify the level of pain or analgesic intake. Indeed, neither the VAS scores nor the “postoperative outcome questionnaire” results are reported. Finally, the major risks and morbidity associated with the removal of spinal intradural tumors are related to the intradural component of the surgery, not the extradural exposure or the inconsequential amount of blood loss.

Optimization of the intradural aspect of the surgery, therefore, represents a fundamental guiding principle. As the authors acknowledge, however, their minimally invasive “dural opening and working corridor is much smaller than in open (microsurgical) resections.” Such limitations could compromise safe or optimal achievement of the surgical objective or limit surgical options. Piecemeal resection of myxopapillary ependymomas, as necessitated during the minimally invasive procedure by the limited intradural exposure, for example, is associated with a substantially higher risk of recurrence and CSF dissemination than en bloc tumor removal. In the case of nerve sheath tumors, early identification of the afferent and efferent nerves at the tumor poles can facilitate safe tumor removal, often with preservation of at least some of the affected nerve. Perhaps ironically, precise internal debulking with “state of the art” ultrasonic aspiration (i.e., Cavitron) is currently not possible with the minimally invasive technique described in this paper. Instead, the authors are relegated to the dated technique of mechanical debulking with pituitary rongeurs.

Other than a temporary reduction in post-operative discomfort I am unconvinced that minimally invasive resection techniques are any safer, simpler, more efficient, or more effective than the current standard treatment of microsurgical resection of benign intradural spinal tumors. Nevertheless, I have full confidence that, if such meaningfully durable benefits exist, the senior author will appropriately identify and validly document them.

Paul C. McCormick
New York, New York
Tredway et al. have presented their early results with a minimally invasive approach to intradural lesions. This is truly a mini-open approach, and as such, is simply a variation of “normal” open surgery. This “simple” variation, however, requires significant commitment and effort. The advantages are obvious. So, however, are the disadvantages. The authors are to be congratulated for this pioneering work. I am certain that such approaches will become more and more accepted as time passes. The authors are clearly the leaders in this arena.

Edward C. Benzel
Cleveland, Ohio

The authors report the resection of intradural extramedullary tumors via a minimally invasive corridor. This appears to be a safe and efficacious technique when employed in selected patients by experienced surgeons. There is no question that minimally invasive techniques can provide adequate exposure to a number of spinal lesions with less manipulation of soft tissue than traditional open approaches. The hypothesis that this will result in decreased hospitalization and more rapid return to function is supported by a number of publications. One can expect the use of minimally invasive techniques for the management of spinal pathology to continue to increase over the years. Improvements in instrumentation and techniques will certainly be forthcoming and Tredway et al. address some of these in this communication. The use of a shielded drill decreases the risk of dural violation. Expanded tubular retractors and specially-designed bayonetted instruments improve visibility, and a specialized cardiac knot pusher facilitated the dural closure. Internal decompression of these small tumors was accomplished with rongeurs. I believe long, thin, tapered ultrasonic surgical aspirators will be developed in the future to assist in surgery of this nature.

Minimally invasive spinal surgery is an exciting and growing field. I anticipate that the number of surgical problems which can be addressed with this technique will continue to increase.

Vincent C. Traynelis
Iowa City, Iowa

Minimally invasive spinal surgery is continuing to push back frontiers, as highlighted by this article. The authors discuss six patients whose intradural-extramedullary lesions were removed using minimally invasive techniques facilitated by a tubular retractor system. They obtained good results, although the operative time and length of hospitalization does not appear to be significantly shortened compared to traditional techniques. Nevertheless, the small incision, minimal retraction, and possibility for resection through a minimal approach make this technique an excellent alternative for removing these lesions.

Volker K.H. Sonntag
Phoenix, Arizona

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