Surgical Removal of Spinal Cord Tumors

ARTICLE BY JAMES O. WILLEY, CST/CFA, AND MARK V. LARKINS, MD

In 1887, a British army captain became the first patient to undergo neurosurgical removal of a spinal cord tumor. This pioneering surgery, performed by doctor Sir Victor Horsley, was successful to the extent that the previously paraplegic captain regained his ability to walk.[1] Since then, the sophistication and safety with which spinal cord lesions are removed have evolved through the advent of new techniques such as microsurgery, neuroimaging, and intraoperative monitoring.

In this article, we will cover spinal cord anatomy and the surgical approach of choice for three types of intraspinal tumors: extradural, intradural-extramedullary, and intramedullary. The article concludes with three case reviews. But first, consider that as a surgical technologist or first assistant, a broad knowledge base enhances one's ability to facilitate the surgical procedure. For example, treating a patient with a spinal cord

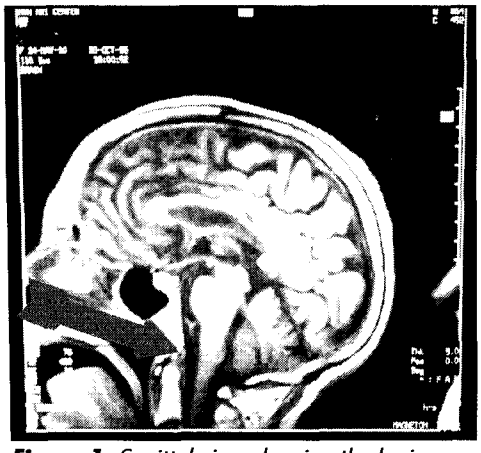

Figure 1. *Sagittal view showing the brain stem and the spinal cord as it exits the cranium through the foramen magnum. (The arrow points to the foramen magnum.)*

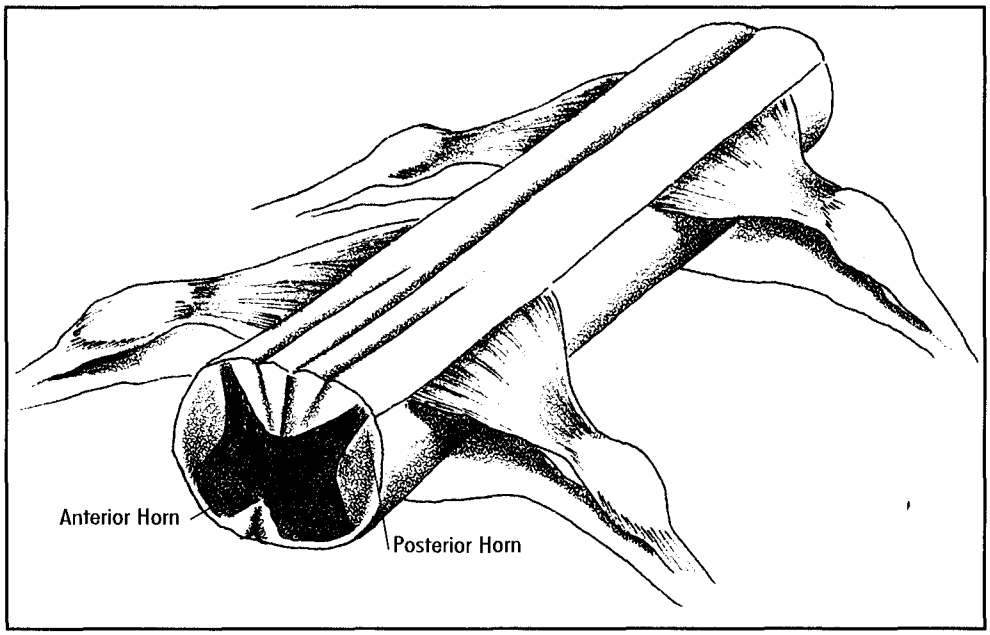

Figure 2. *The spinal cord is approximately 44-cm long.*

tumor differs greatly from treating a herniated lumbar disc patient because the fine microscopic dissection around the spinal cord represents a large risk. One slight error could have disastrous results. Tensions often run high during this procedure, and the ability of the CST or CST/CFA to react objectively to the surgeon's outward emotions will help both the operative team and the patient.

Anatomy

The spinal cord is an ovoid column of nervous tissue that extends from the medulla oblongata to the second lumbar vertebra (Figure 1). All nerves to the trunk and limbs arise from the spinal cord (Figure 2). The spinal cord and its roots are surrounded by a complex of bony structures that lend stability and protect the spinal canal's contents. A gray substance forms the shape of an "H" with an anterior and posterior horn in either half. The anterior horn consists of motor cells while the posterior horn provides a place for sensory neurons to enter. The afferent and efferent nerves connect the cord's white matter to the brain.[2] Intraspinal tumors, which are classified in one of three categories according to their relation to the dura and the spinal cord substance, can cause spinal cord compression, vascular compromise, or direct nerve-root compression. The three types of intraspinal tumors, in order of frequency of occurrence, are extradural, intradural-extramedullary, and intramedullary.[3] The surgical approach of choice must be based on the specific anatomic situation.

Extradural Tumors

Extradural tumors do not transgress the

dura (Figure 3). Most are metastatic and develop in patients after the age of 50.[4] They begin in the architecture of the spine and ultimately invade the intraspinal space. Thoracic spinal metastases are most commonly located around the fourth and eleventh thoracic vertebrae.[3] Nagging pain in the middle of the spine indicates onset. As the tumor increases in size, specific neurological impairments develop. A detailed neurological examination is required to determine the tumor's location.

Diagnostic Testing

Advanced neuroimaging helps determine the lesion's position relative to the neural elements. Plain films (x-rays), magnetic resonance imaging (MRI), myelograms, electromyography, computed tomography (CT), bone scan, and at times, angiography are all part of the radiological armamentarium.

A chest x-ray film may show some calcification of a tumor or erosion of the bony structures adjacent to the tumor (Figure 4). However, an MRI— with and without gadolium— is essential to defining the anatomic position of a lesion in relation to the spinal cord. If the primary cancer site is not known, a bone scan can show other affected areas (Figure 5). A myelogram may also be beneficial in determining the actual level of the lesion, ascertaining the extent of spinal cord compression, and obtaining cerebrospinal fluid (CSF) for protein analysis. While useful for diagnosis, the depletion of CSF that results from a myelogram may dangerously exacerbate the patient's symptoms. Occasionally, electromyography proves valuable in determining the level of a lesion. It recognizes fibrillation or denervation potentials in muscles innervated from a specific nerve root.[3] In extradural tumors with bone involvement, needle aspiration of the tumor under CT guidance may be helpful to obtain a tissue diagnosis.[4] Based on this diagnosis, a treatment plan is developed; this plan may include surgical resection or decompression of the tumor.

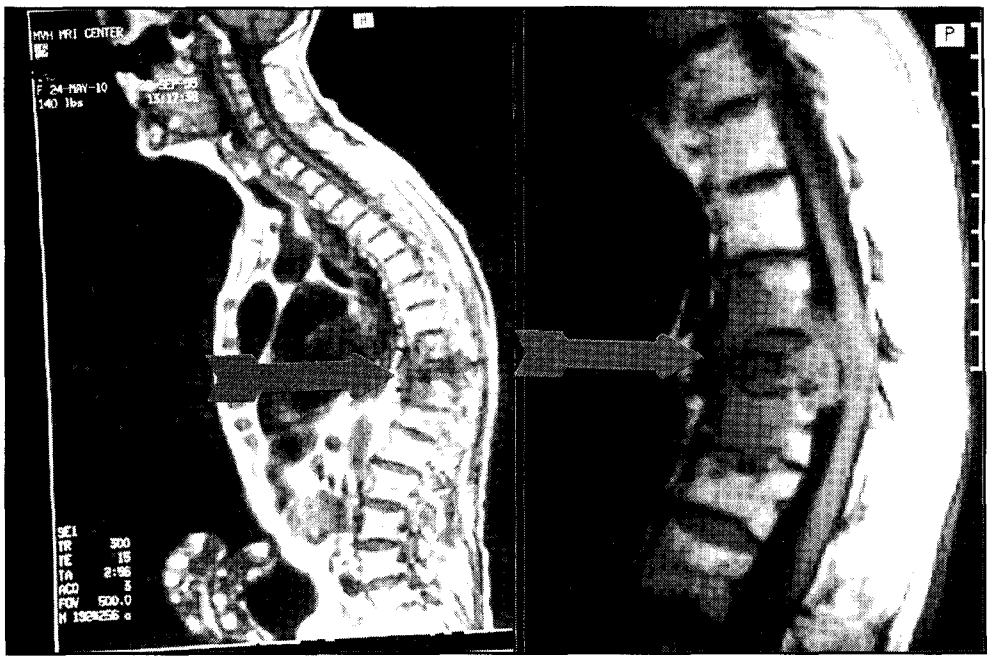

Figure 3. *Two views of an extradural tumor invading the spinal canal from the T-10 and T-11 vertebral bodies. (Arrows point to the tumor.)*

Presurgical Decisions

Prognosis for patient longevity, which can be determined by the patient's age at diagnosis and the extent of the disease, is the major factor in deciding which— if any—surgical approach would prove suitable. Elderly patients with widespread disease may elect pharmacological pain management rather than surgery. Presurgical medical clearance to assess surgical/anesthetic risk also helps determine if surgery is feasible. In instances of acute neurological decline, this cannot be evaluated in a timely fashion.

Surgery

The patient is usually placed on a spinal frame or chest rolls with all bony prominences amply padded. Throughout cervical and thoracic surgery, intraoperative evoked potential monitoring is useful to assess spinal cord function. A generous longitudinal midline incision is made over the spinous process one level above and carried to the level below the tumor. An intraoperative x-ray film may be used to confirm the proper levels. The spinous processes and laminae are removed with a double-action rongeur and 1-mm through 5-mm Kerrison rongeurs. Care is taken to avoid any downward pressure at this stage.

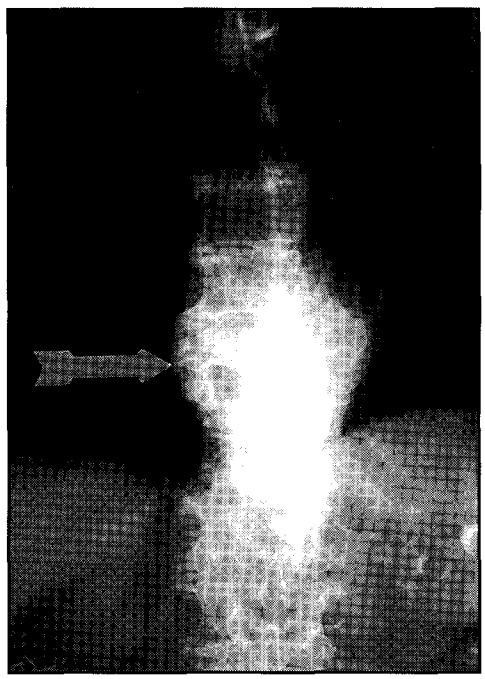

Figure 4. *Thoracolumbar x-ray film that shows a calcified vertebral body mass.*

Next, the microscope is employed for lateral bone removal, removal of the ligamentum flavum, and fine dissection of the tumor. A portion of the tumor is sent to pathology for a frozen section. If

the vertebral body is consumed by the tumor, an anterior approach or a combination of anterior and posterolateral approaches may be needed. Often, a partial vertebrectomy is performed in conjunction with these approaches. In these cases, spinal instrumentation may be required to stabilize the spine. Titanium spinal instrumentation is the preferred method of stabilization to accommodate postoperative MRIs. An example of this instrumentation would be facet or laminar hooks, and a 0.25-inch titanium rod construct.[5]

A large, crescent-shaped, curvilinear incision is often used on patients who will receive both an instrumentation construct and postoperative radiation therapy. Erosion of the instrumentation through the skin may be encountered in postoperative bed-confined patients. This complication might be avoided by making an incision that is not directly over the instrumentation construct. If the operation takes several hours to complete, the wound should be irrigated at least every hour with a triple-antibiotic solution applied with a pressure irrigation device.

Following tumor removal and achievement of hemostasis, the muscle layer is loosely approximated with 2-0 absorbable simple interrupted stitches. The facial layer is closed with a 2-0 absorbable running locking stitch. The subcutaneous layer is approximated with inverted interrupted 3-0 absorbable stitches. The skin edges may be approximated with a 4-0 monofilament running locking stitch. A sterile dressing is then applied with a piece of transparent breathable tape.

Blood loss can be significant. Postoperative draining of the wound is accomplished by using an externalized epidural and subcutaneous 10-Fr closed-suction draining device. The use of a cell saver is contraindicated because it would increase the risk of hematogenous spread of metastatic disease. However, donor blood or blood products represent an option in the event that blood replenishment is necessary.

Postoperatively, intraspinal tumor patients may require radiation and/or chemotherapy to further shrink the tumor. However, radiation therapy should not begin until the operative site is healed. Serial MRIs of the affected region may be needed every 6 to 12 months to assess the effectiveness of chemotherapy and/or radiation therapy on the tumor.[3] Postoperative patients with neurological deficits will require occupational and physical therapy. Many patients will need some type of ambulatory aid as well, such as a walker or a quad cane. For those patients with intraspinal metastasis in which the primary source is unknown, the long-term prognosis is poor.

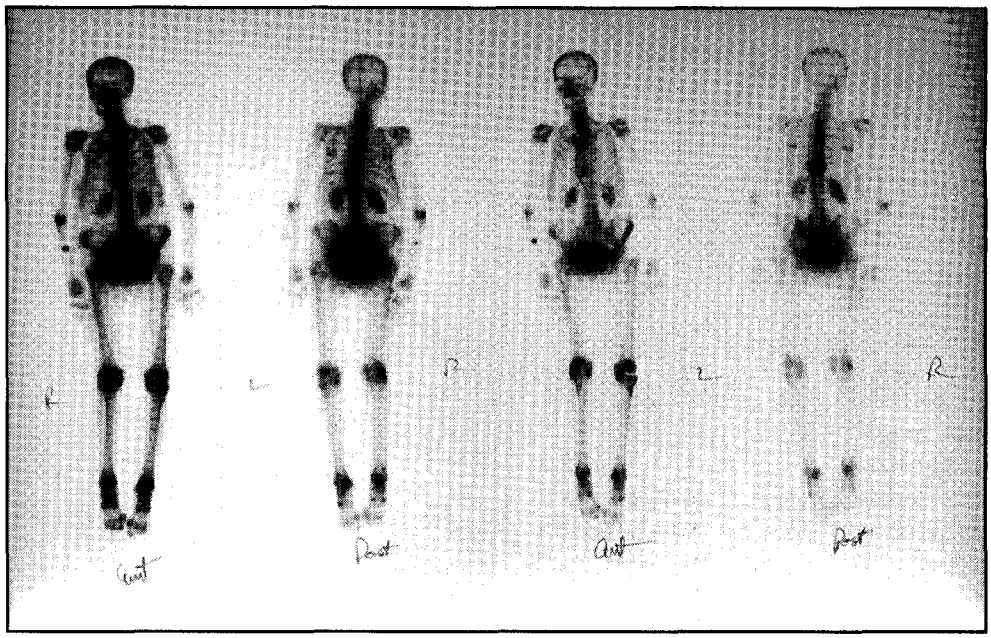

Figure 5. *A whole-body bone scan that shows a concentration of the radionuclitide material at the T-10 level of the spine.*

Intradural-Extramedullary Tumors

Intradural-extramedullary tumors (Figure 6, p. 14) are localized meningiomas or schwannomas.[3] Meningiomas generally grow at a very slow rate; thus, most patients who are symptomatic have reached their third decade of life.[6]

The symptoms—gait difficulty, urinary retention, and radiculopathy— vary in accordance with the tumor's location. Occasionally, patients may suffer from an odd symptom called "night radiculopathy," which is radiating leg pain experienced only at night. The cause of this spinal phenomenon is not known, but it may be a manifestation of funicular pain.[2] Spinal cord lesions near the foramen magnum may cause suboccipital headaches, neck pain, upper-extremity dysesthesia, and loss of dexterity. Cervical and thoracic lesions commonly cause nerve root compression, resulting in symptoms in a specific anatomical location. Women make up 80% of the patient population affected with intradural-extramedullary meningiomas.[3] These tumors are distributed as follows: 81% in the thoracic region, 16% in the cervical region, and 3% in the lumbar region. Sacral meningiomas are very rare. The vast majority of intradural-extramedullary tumors are benign.[6] No conservative therapy for this type of condition exists; expedient resection of these lesions is necessary.

Surgical resection of intradural-extramedullary tumors is similar initially to surgical resection of extradural tumors. The patient is positioned in standard fashion, and evoked potential monitoring is used to assess spinal cord function intraoperatively. A generous midline incision is made from one vertebral segment level above the tumor and carried to one level below the tumor. A laminectomy is performed over the

affected level to expose the dorsal aspect of the dura. Once the thecal sac is amply exposed, a durotomy is accomplished with a No. 11-blade knife and extended with fine Metzenbaum scissors. The edges of the dura are tacked up using 4-0 nonabsorbable stitches. The subarachnoid space is opened with a sharp, micro nerve hook for the release of CSF.

At this point, the surgeon performs a fine dissection of the tumor and nerve roots with the aid of the microscope. After a frozen section is used to identify the tumor type, the tumor is carefully removed—often by a piecemeal method. Every effort is made to resect the dura of origin or fulgurate unresected tumor. The wound is irrigated with antibiotic solution, and meticulous hemostasis is achieved. The dura is closed in a watertight fashion with a running locking 4-0 nonabsorbable suture on a small taper needle (Figure 7). Next, oxidized cellulose gauze is cut and placed over the dura, and the bony edges of the laminectomy defect are waxed to aid with hemostasis. Often, cryoprecipitate—a blood product—is mixed with thrombin, and this mixture is applied to the dural suture line to seal the dural closure; the cryoprecipitate resembles a gelatinous glue. Through the same incision, a moderate-sized fat graft or pad is harvested from the subcutaneous adipose layer and placed over the durotomy in the laminectomy defect. The remainder of the closure is carried out in standard fashion.

Postoperatively, patients may need physical therapy with lower- extremity strengthening exercises. Some patients experience a "spinal headache" immediately after surgery; this can be treated with bed rest, intravenous fluids, and intravenously administered caffeine bolus.[7] The headache may last from several hours to a couple of days. A diminished CSF volume is the primary cause of this condition.

Intramedullary Tumors

Intraspinal neoplasms that invade or arise from spinal cord substances and rarely metastasize are classified as intramedullary tumors. These tumors usually develop from one of the glial-type cells and are therefore broadly referred to as gliomas. Glial cells make up the supporting structure of the central nervous system (CNS).

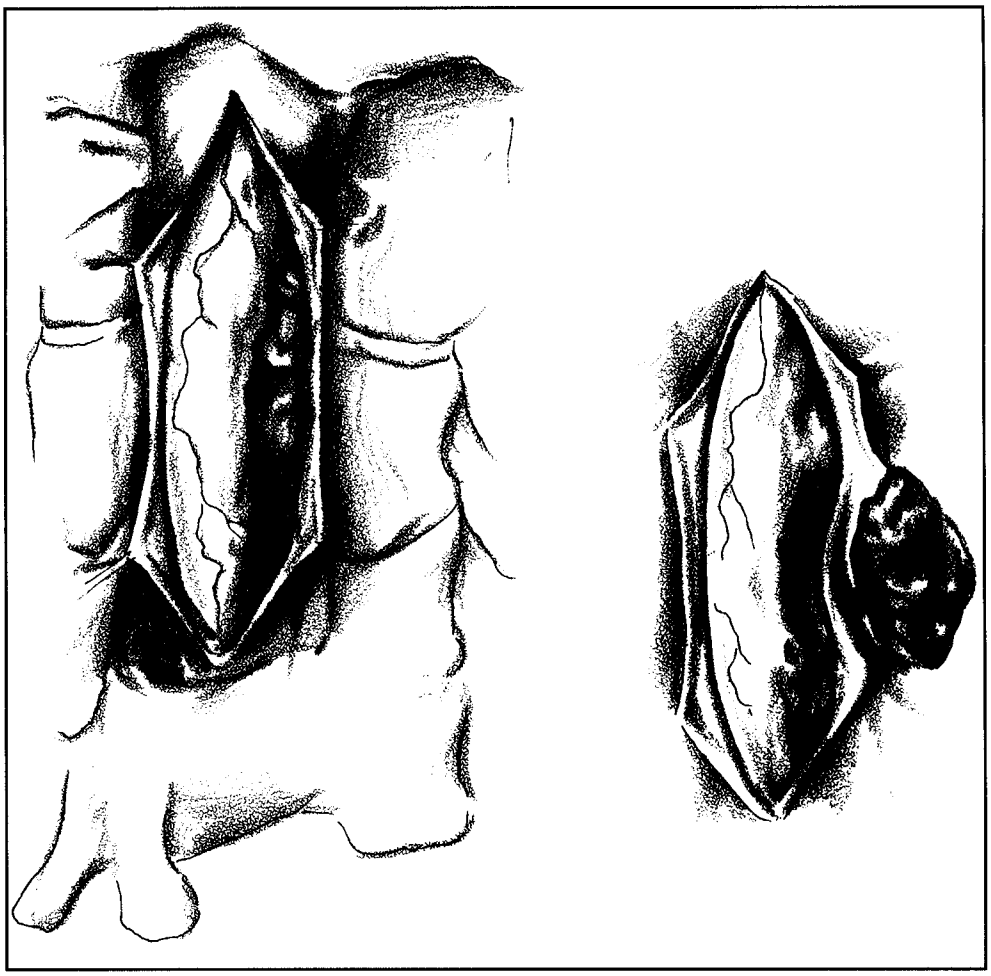

Figure 6. *Example of an intradural-extramedullary tumor showing the dura of origin. (Adapted from Tumors of the Cervical Segment of the Spinal Cord.* Archives of Neurosurgery. *1940;44:1-16. Printed with permission from the American Medical Association.)*

The specific types of intramedullary tumors are called ependymomas and astrocytomas. Ependymomas arise from the ependymal cells that line the ventricular system. Astrocytomas arise from the cells that seem important to biochemical support of the CNS. Ependymomas and astrocytomas are the most common types of intramedullary tumors and occur with nearly equal frequency.[6] Other types of intramedullary tumors are rare. The distribution of these tumors is 17.5% in the cervical region, 32.5% in the thoracic region, and 47.5% in the lumbar region.[3]

The most common type of intrinsic spinal cord tumor is the astrocytoma. Astrocytomas occur frequently in the third and fifth decades of life, and males are affected more often than females.[6] Surgical therapy for these lesions usually consists of a generous laminectomy to allow for a longitudinal, dorsal opening to encompass the rostral-caudal extent of the tumor. However, total removal of the tumor is rarely possible.[5] Follow-up radiation therapy may be an option. Chemotherapeutic protocols are available, but realistically may be of little benefit.

A specific type of glial tumor, the ependymoma, commonly arises from the filum terminale—a long, slender filament that extends from the end of the spinal cord to the end of the spinal canal. Ependymomas may be completely excised, but complete resection from the

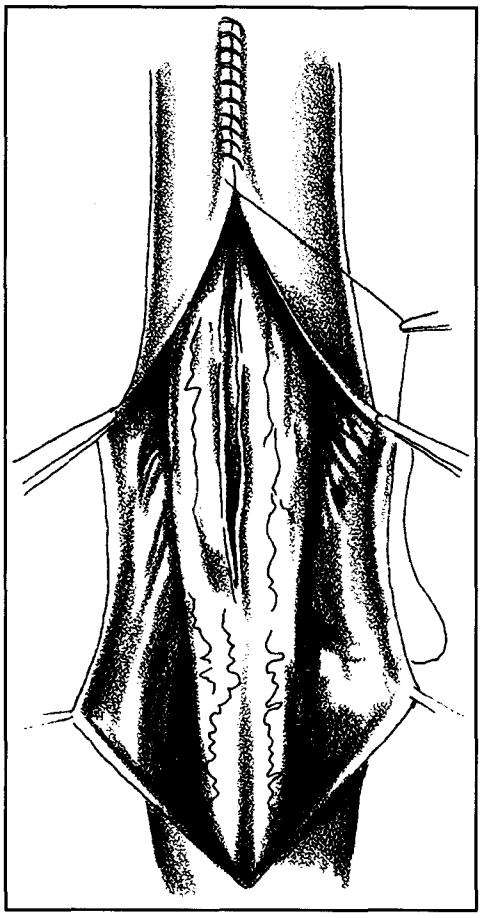

Figure 7. *Closure of the dura using a running, locking, nonabsorbable stitch, which creates a watertight seal. (Adapted from Kemp LG.* Operative Neurosurgery. *1986;118.)*

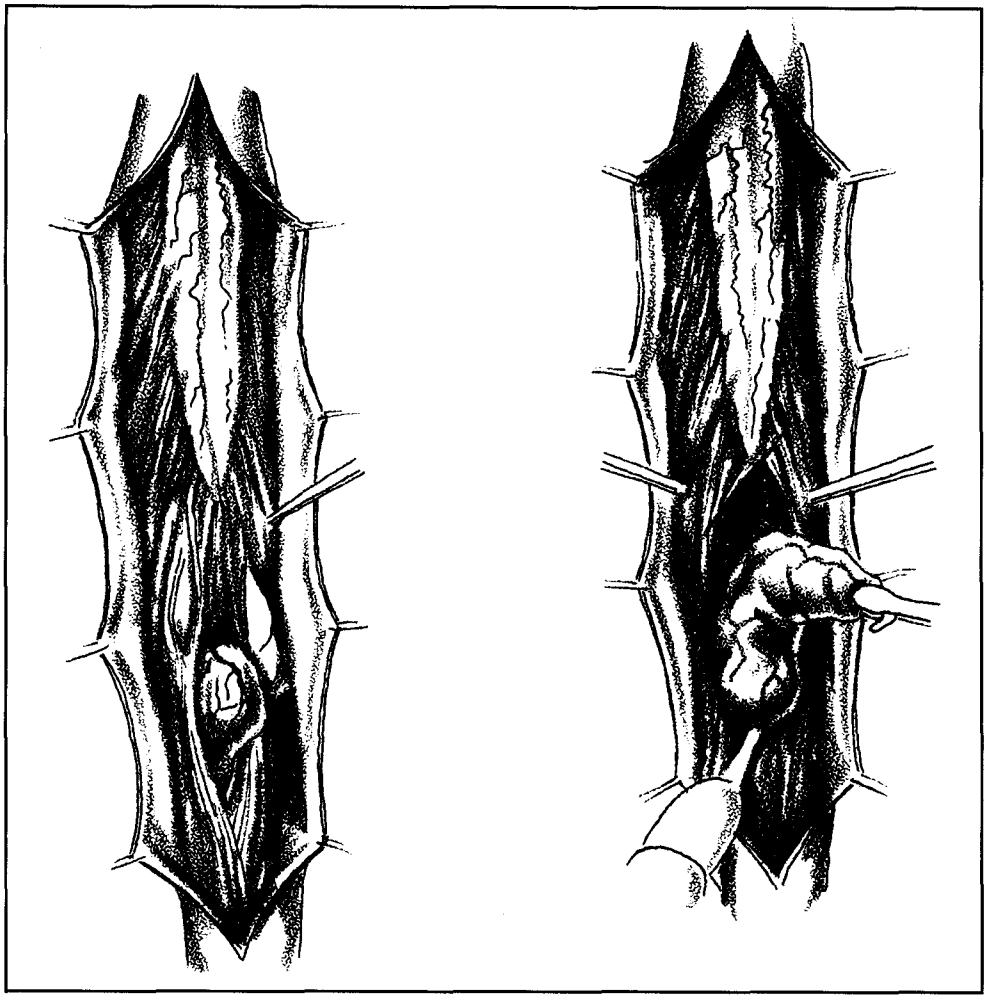

Figure 8. Left, *An ependymoma connected to the filum terminale.* Right, *The tumor is resected caudally to prevent damage to the conus. (Adapted from Kemp LG.* Operative Neurosurgery. *1986;121.)*

substance of the spinal cord is rare. Intramedullary ependymomas can be resected through a longitudinal myelotomy between the posterior columns of the spinal cord.[6] Intraoperative evoked potentials are useful to assess dorsal column function throughout the operation.[4]

A laminectomy is performed over the affected levels, and the thecal sac is opened by performing a dorsal midline durotomy. If the tumor has the filum terminale at its origin, the procedure is technically less difficult than if the tumor lies in the substance of the spinal cord itself. The terminus of the spinal cord is equal with the level of the first to second lumbar vertebral bodies. Below this level, the cauda equina is the substance that occupies the space inside the thecal sac. The tumor may be tangled in the numerous filament-like structures that make up the cauda equina. Careful dissection can lead to complete removal of this tumor (Figure 8). Meticulous hemostasis is achieved after the tumor is resected to ensure that a hematoma does not exist inside the thecal sac. The wound is thoroughly irrigated with antibiotic-laden saline and closed in standard fashion.

Resection of tumors located in the spinal cord substance may be the most difficult spinal cord surgery. A laminectomy is performed over the level of the tumor, and the dura is opened in usual fashion. Once the tumor has been identified, a longitudinal myelotomy is performed between the posterior columns of the spinal cord (Figure 9, p. 16). Careful dissection with microinstruments is required to resect the tumor with minimal damage to the surrounding spinal cord. The dentate ligament—a fibrous band of pia mater that extends laterally between the spinal cord, spinal nerves, and the inner aspect of the dura—may need to be cut to allow for manipulation of the tumor.[6] Resection of this tumor must be done piecemeal because any excessive traction or pressure on the spinal cord will have disastrous effects.[4] At the end of the procedure, the dura is closed in usual fashion, and the incision is closed in the manner described earlier.

The use of a postoperative drain is contraindicated in any procedure where the dura had been opened. If a small leak occurs in the dural closure, the CSF will

flow to the area of least possible resistance—the closed-suction drainage device. If this happens, a CSF fistula may develop. This complication is dangerous because of the high risk of seeding the CSF with meningitis-causing bacteria.

Neurosurgical procedures for malignant tumors often lead to the patient's demise. However, as neurosurgical technology continues to develop, techniques used to remove spinal cord tumors of all types will become less invasive and therefore safer.

Case Reviews

Case Number One
A 42-year-old male with a 4-month history of band-like chest pain was initially thought to have a cardiac problem. The patient underwent cardiac catheterization, the results of which appeared to be normal. He was admitted to the hospital with a 3-month history of ataxic gait. An emergency thoracic MRI was obtained that revealed an extradural mass extending dorsally from T-7 down to T-8 with severe spinal cord compression and myelopathy (Figure 10). The neurosurgical examination revealed that the patient had an ataxic gait, lower-extremity spasticity, bilateral hyperreflexia in the lower extremities, and a T-6 to T-8 sensory level.

The patient underwent an emergency thoracic laminectomy at the T-7 to T-8 levels and a tumor resection. Intraoperatively, the tumor appeared to arise from the left T-6 nerve root. The T-6 root foramen appeared to be 8 to 10 times larger than normal. This suggested the tumor was benign with a long growth duration. Additionally, the tumor adhered to the dura laterally at the T-7 level. This dura was excised to render intradural metastatic extension of the tumor impossible. The left T-6 nerve root was sacrificed to allow for complete resection of the tumor. An intraoperative frozen section revealed a highly cellular tumor with nests of lymphocytes throughout, which was atypical for what appeared to be a schwannoma. The final pathology revealed Rosi Dorfman disease, which is characterized by a rare, benign tumor.

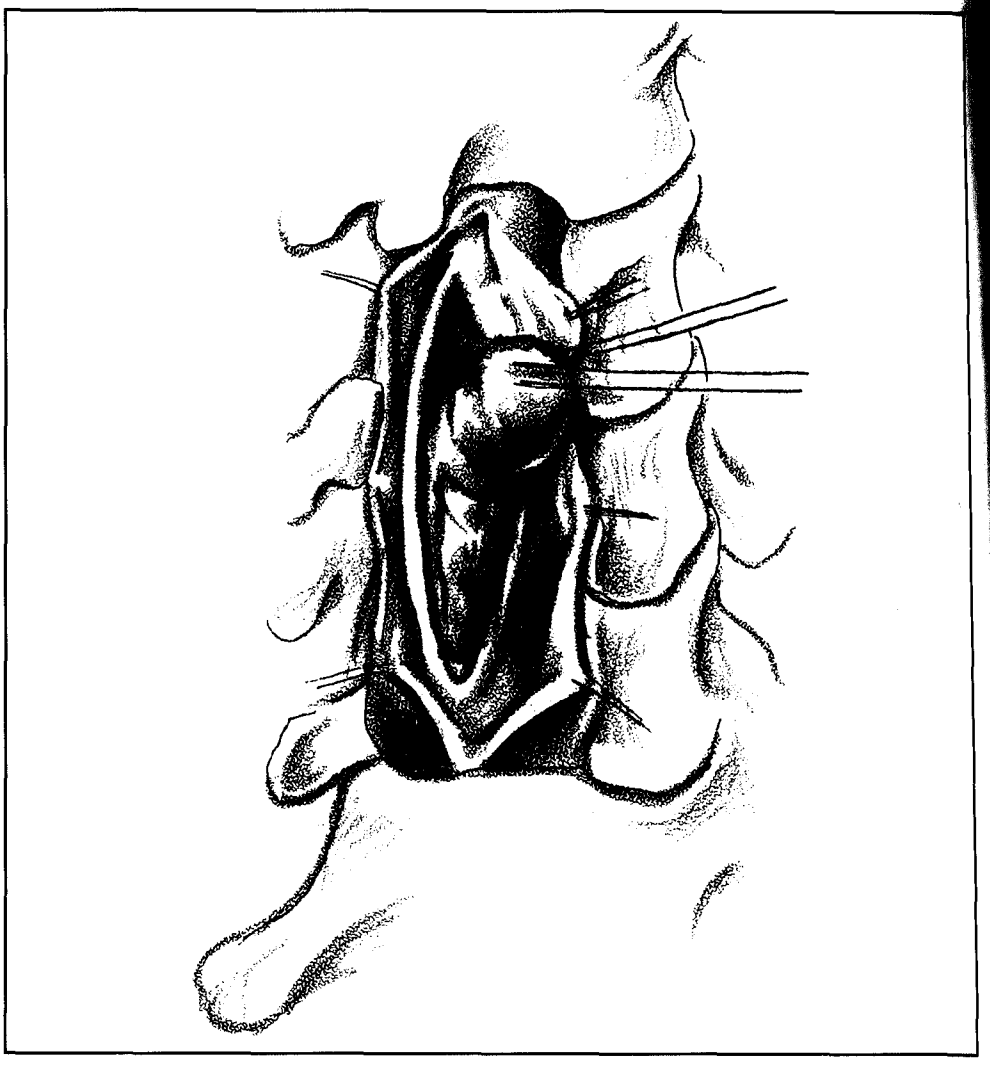

Figure 9. *An intramedullary tumor in the cervical spine. (Adapted from Tumors of the Cervical Segment of the Spinal Cord.* Archives of Neurosurgery. *1940;44:1-16. Printed with permission from the American Medical Association.)*

Postoperatively, the patient was anemic with a hemoglobin level of less than 10 gm resulting from the 1,000-ml blood loss intraoperatively. While the patient retained a band-like numbness around the upper abdomen, which was secondary to the injury to the T-6 nerve root, normal ambulation was achieved following physical therapy.

One year postoperatively, the patient developed a lump in his left breast. This was biopsied and found to be free of tumor cells. At one year and six months postoperatively, the patient had an MRI, which revealed normal postoperative changes and no recurrence of the tumor. The patient returned to a normal lifestyle.

Case Number Two
A 33-year-old male with a 5-year history of numbness bilaterally from his upper back to his feet had preoperative symptoms including lower back pain, occasional left axilla pain with movement, bilateral anterior thigh numbness, bilateral numbness in the gastrocnemius muscles, some degree of numbness in both feet, and stiffness in his legs, which caused ambulatory problems. Other symptoms included difficulty emptying his bladder and sexual dysfunction. However, he had no indication of bowel dysfunction.

An MRI revealed an intradural-extramedullary lesion at the T-3 to T-4 level (Figure 11, p. 18). Radiographically, this lesion had the characteristics of a schawnnoma. The patient was examined by a urologist; additionally, a baseline evoked potential was performed. Following tests, a T-2 to T-5 laminectomy was performed, and the intradural-extramedullary tumor was resected uneventfully.

Postoperatively, the patient received outpatient physical therapy for 1 month and then returned to work fulltime as a forklift operator. At his 6-month postoperative visit, the patient was asymptomatic with no numbness or gait disturbance, and bladder function had returned to normal.

Case Number Three

The emergency room admitted a 66-year-old male to the hospital after a fall from a porch. The patient had crawled into the house to call for help. His several-year history of thoracic pain, ambulatory problems, urinary incontinence, and progressive leg weakness was exacerbated by the fall. Thoracic spine x-ray films taken in the emergency room revealed T-6 and T-8 compression fractures. A neurosurgical evaluation of spinal cord compression revealed T-6 sensory level to pinprick. The myelogram and postmyelogram CT scan demonstrated a blockage at the T-6 level and severe narrowing at the T-8 level. However, the sensation to light touch below the T-6 was intact. The patient exhibited a patulous anal sphincter tone, absent abdominal reflexes, bilateral right-greater-than-left decreased sensation, lower extremity weakness, and absent ankle-jerk reflexes. He was given high-dose steroid therapy in accordance with National Spinal Cord Injury Protocol, and a thoracic laminectomy was performed from the T-4 to the T-9 levels.

Intraoperatively, a frozen section of the T-6 lamina revealed a plasmacytoma. The left sixth rib appeared to be consumed by a tumor extending approximately 2 cm laterally from its attachment point at the T-6 vertebra. Abnormal tissue at the laminae was encountered at every level from T-5 to T-9. At the T-6 level, the dissection was carried out to the anterior aspect of the vertebral body. Copious bleeding from the abnormal myeloma tissue was encountered at every level. Bilateral titanium rods and laminar hooks were placed to provide postoperative stabilization (Figure 12, p. 18).

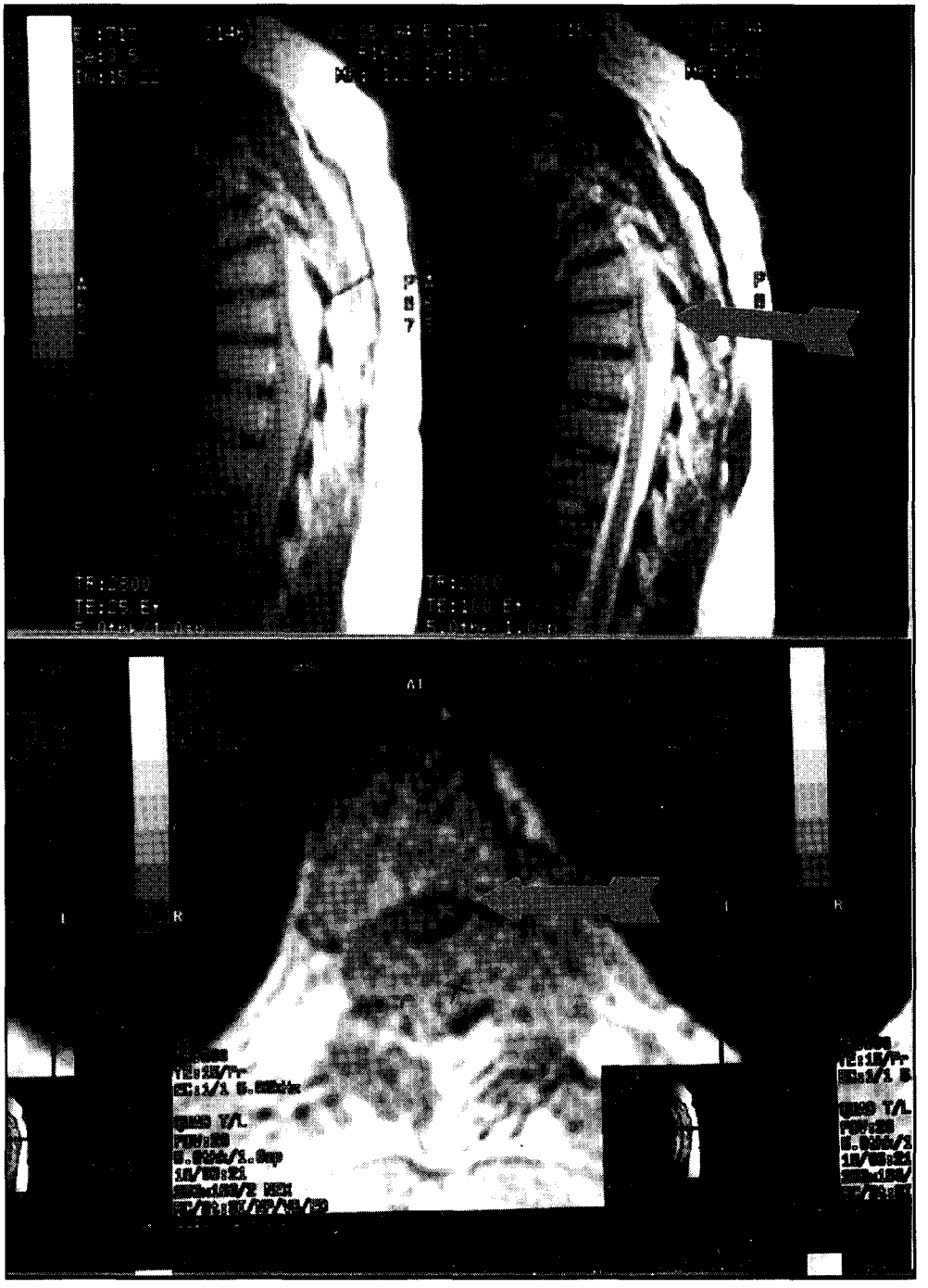

Figure 10. Top, *Sagittal view showing severe compression of the thoracic cord.* Bottom, *In the transverse view, the arrow points to the spinal cord. Two "Xs" are marked on the tumor.*

Postoperatively, the patient received both chemotherapy and radiation therapy. He resided in a nursing home for 2 months. Physical therapy helped him regain the ability to ambulate independently so he could return home. The patient died approximately 3 years later of hemorrhagic diathesis. Δ

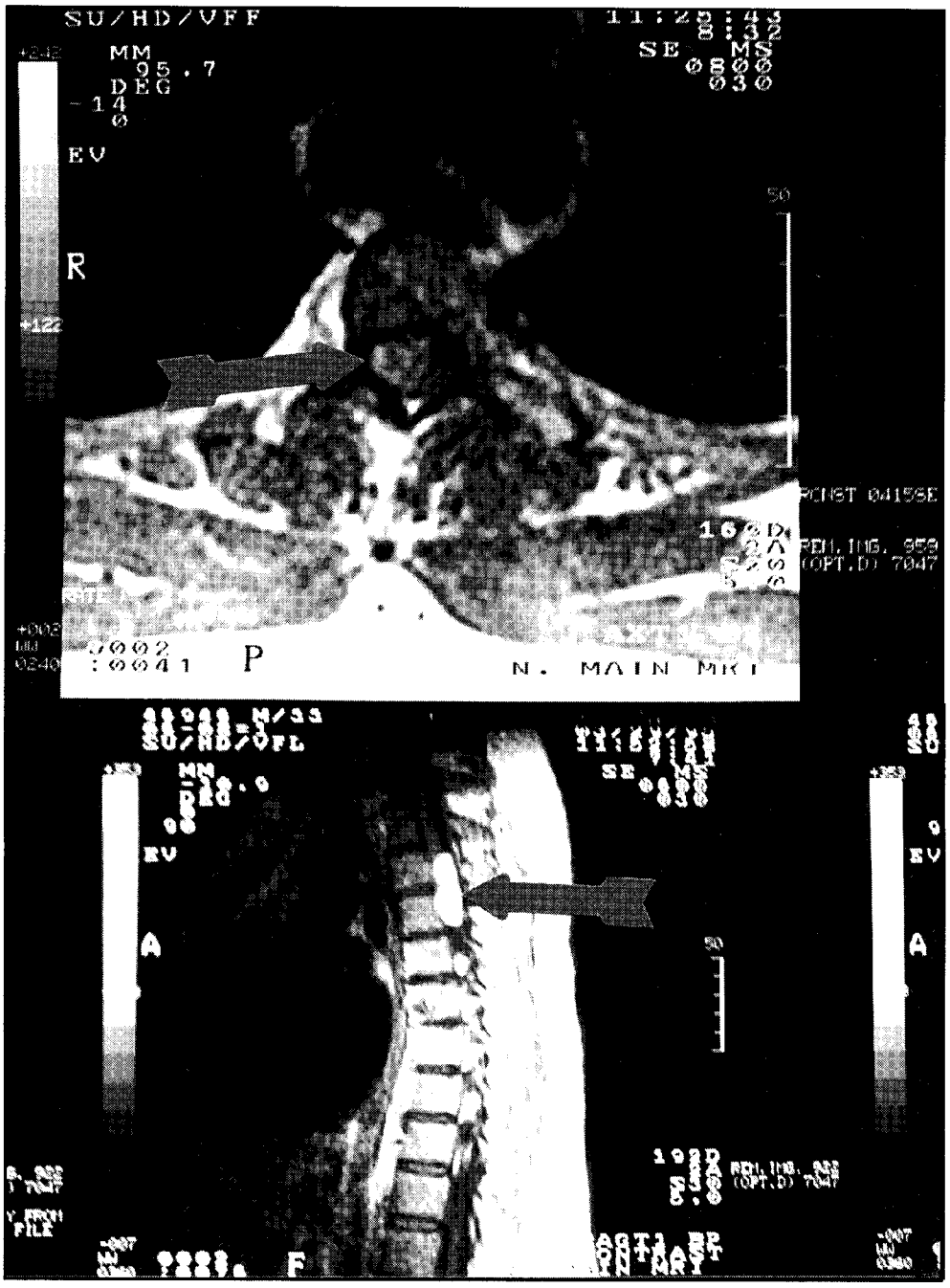

Figure 11. Top, *The transverse view shows severe displacement of the spinal cord.* Bottom, *The sagittal view shows a large thoracic spinal cord extramedullary tumor. In both views, the arrows point to the cord.*

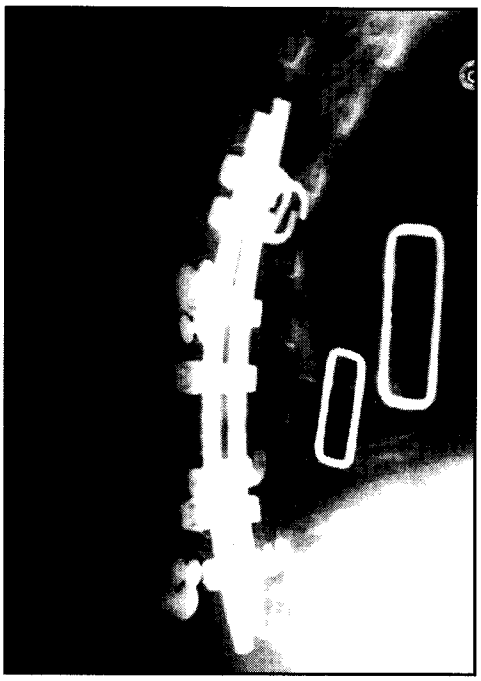

Figure 12. *Postoperative view of titanium rods and hooks used to stabilize the spine after a partial vertebrectomy and laminectomy. The rectangular metal devices are part of a thermoplastic support brace.*

James O. Willey, CST/CFA, *received his technician training through the United States Air Force. He was employed as a CST/CFA by Dr. Larkins of Southwest Ohio Neurosurgery, Inc. Currently, he works for Kettering Medical Center as a staff CST/CFA. He has been in the field for 7 years.*

Mark V. Larkins, MD, *is a board-certified, fellowship-trained neurosurgeon who did his neurosurgical residency at The Cleveland Clinic Foundation, and a skull base, microsurgical fellowship at the University of Pittsburgh. He has had a solo practice in the Dayton, Ohio, area for the past 3 1/2 years.*

References

1. Gowers WR, Horsley V. A Case of Turnout of the Spinal Cord: Removal, Recovery. *Med-Chir Trans London.* 1988;71:377.
2. Taber CW. *Taber's Cyclopedic Medical Dictionary.* 16th ed. Philadelphia, Pa: F.A. Davis; 1985: 1721-1722.
3. Rothman RH, Simeone FA. *The Spine.* 2nd ed. Philadelphia, Pa: W. B. Saunders Co; 1982;2:1041-1052.
4. Larkins MV. Personal communication. May 1996. .
5. Gurr KR, McAfee PC, Shih CM. Stress Factors of Surgical Metals. *J Bone Joint Surgery.* 1988; 70A: 1182-1191.
6. Yomans JR. *Neurological Surgery.* 3rd ed. Philadelphia, Pa: W.B. Saunders Co; 1990; 5: 3548-3568.
7. Raskin NH. *Headache.* 2nd ed. New York, NY: Churchill Livingstone; 1988:294.