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Embolization of Spinal Tumors: Vascular Anatomy, Indications, and Technique

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Involvement of the spine by primary and secondary tumors can be associated with mechanical instability, pain, and neurologic complications, all of which can adversely affect a patient's quality of life. When surgical excision is planned, preoperative embolization of spinal tumors reduces intraoperative blood loss, making surgery safer and easier. Embolization of spinal tumors can also be used to palliate pain and improve neurologic symptoms in patients with unresectable tumors. A detailed knowledge of the spinal vascular anatomy is essential before performing spinal tumor embolization. Indications, contraindications, embolization technique, and potential complications must be fully understood to ensure a safe and effective procedure. Although the technique used may vary among operators and institutions, familiarity with embolization goals and strategies can ensure sufficient tumor devascularization.
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The spine is the most common site of osseous metastases, and between 5% and 10% of cancer patients develop spinal metastases during the course of their disease.[1] Primary spinal tumors are less common than secondary spinal tumors. Involvement of the spine by primary or secondary tumors is often associated with mechanical instability; pain, which tends to be progressive and intractable; and neurologic complications, such as radiculopathy and compression myelopathy,[2] paresis, paresthesia, sexual dysfunction, and loss of bowel or bladder control. Spinal tumors thus severely affect function and quality of life.

Because chemotherapy is usually ineffective, radiotherapy and/or surgery is most often used in the treatment of spinal tumors. Most oncologists use radiotherapy as the first-line treatment in these patients. Surgery is generally used for patients with radioresistant tumors (such as sarcoma or renal cell carcinoma) or spinal instability. Surgery can also be used after radiotherapy in patients who develop tumor progression, progressive neurologic symptoms, or spinal cord compression. Posterior decompressive laminectomy, which was viewed as the only surgical option until the mid-1980s, provides no greater benefit than radiotherapy in terms of neurologic improvement and pain control.[3,4] However, in the mid-1980s, surgeons began using an anterior approach and vertebrectomy, followed by reconstruction and stabilization of the spine; they found that complete removal of the vertebral body and circumferential decompression of the spinal cord achieves better results than posterior laminectomy.[1,5]

Transarterial embolization of spinal tumors was first reported by Benati et al[6] in 1974. When surgery is planned, preoperative embolization decreases intraoperative blood loss and improves visualization of the tumor and adjacent structures, thus facilitating complete tumor removal. Spinal tumors previously considered unresectable may be resectable after tumor embolization. Embolization of spinal tumors can reduce the mass effect and palliate symptoms, relieve spinal cord compression, and possibly slow tumor growth.[7] With the advent of microcatheters, microwires, and new embolic agents, as well as advances in digital subtraction imaging over the past 20 years, embolization of spinal tumors has become a standard procedure. In this article, we will review the normal and variant spinal vascular anatomy, indications, and contraindications for embolization of spinal tumors, technique, and possible complications of the procedure.

Vascular Anatomy

The spinal cord is supplied by 3 longitudinal arteries: 1 anterior spinal artery and 2 posterior spinal arteries. The ante-

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rior spinal artery runs in the groove of the anterior median fissure from the level of the foramen magnum to the conus medullaris and supplies blood to the anterior two-thirds of the spinal cord. The 2 posterior spinal arteries run parallel to each other on the posterolateral surface of the spinal cord and supply blood to the posterior one-third of the spinal cord. The most cephalic portion of the anterior spinal artery is formed by small branches from 1 or both vertebral arteries. The blood supply to the most cephalad portion of the posterior spinal arteries arises from small branches of either the vertebral or the posterior inferior cerebellar arteries.[8]

Along their course, the anterior and posterior spinal arteries receive contributions from the spinal branches of the segmental arteries, which are also called radiculomedullary arteries. The radiculomedullary arteries also supply the spinal roots, dura, and bony wall of the spinal canal.[9] The radiculomedullary arteries divide into the anterior and posterior radiculomedullary arteries, which accompany the anterior and posterior nerve roots. There are 6 to 8 anterior radiculomedullary arteries that make functional connections to the anterior spinal artery and 11 to 16 posterior radiculomedullary arteries (also called the radiculopial arteries) that supply the posterior spinal arteries.[10] Near the midline, each anterior radiculomedullary artery divides into ascending and descending branches that anastomose to form the anterior spinal artery. The descending branch of the anterior radiculomedullary artery joins the midline anterior spinal artery in a characteristic "hairpin" configuration that can be identified on spinal angiography. The junctions between the posterior radiculomedullary arteries and the posterior spinal arteries also exhibit a characteristic hairpin configuration, but the posterior arterial junctions are located off the midline.

At the cervical level, the radiculomedullary arteries arise from the vertebral artery and the ascending and deep cervical arteries. A prominent radiculomedullary artery, the artery of the cervical enlargement, is present at the level of cervical vertebra C5 or C6. This artery originates from the vertebral artery; however, as a variant, it can also originate from the branches of the costocervical and thyrocervical trunk. Additional contributions may be present from anastomoses with the external carotid artery via the occipital and ascending pharyngeal arteries.[11]

At the thoracolumbar level, the radiculomedullary arteries arise from the supreme intercostal, posterior intercostal, and lumbar arteries. The blood supply to the sacrum and the cauda equina are via the lateral sacral and the iliolumbar arteries from the internal iliac artery. There is also a small contribution from the median sacral artery. The anterior and posterior spinal arteries are connected through a basket-shape anastomotic network at the level of the conus medullaris.[9]

The posterior intercostal and lumbar arteries originate from the posterior wall of the aorta. These arteries curve posteriorly and divide at the level of the transverse process into a ventroparietal branch and a dorsospinal branch (Fig. 1). Small branches arise from the main trunk of the segmental artery and perforate the anterior surface of the vertebral body. The ventroparietal branch continues as the intercostal or

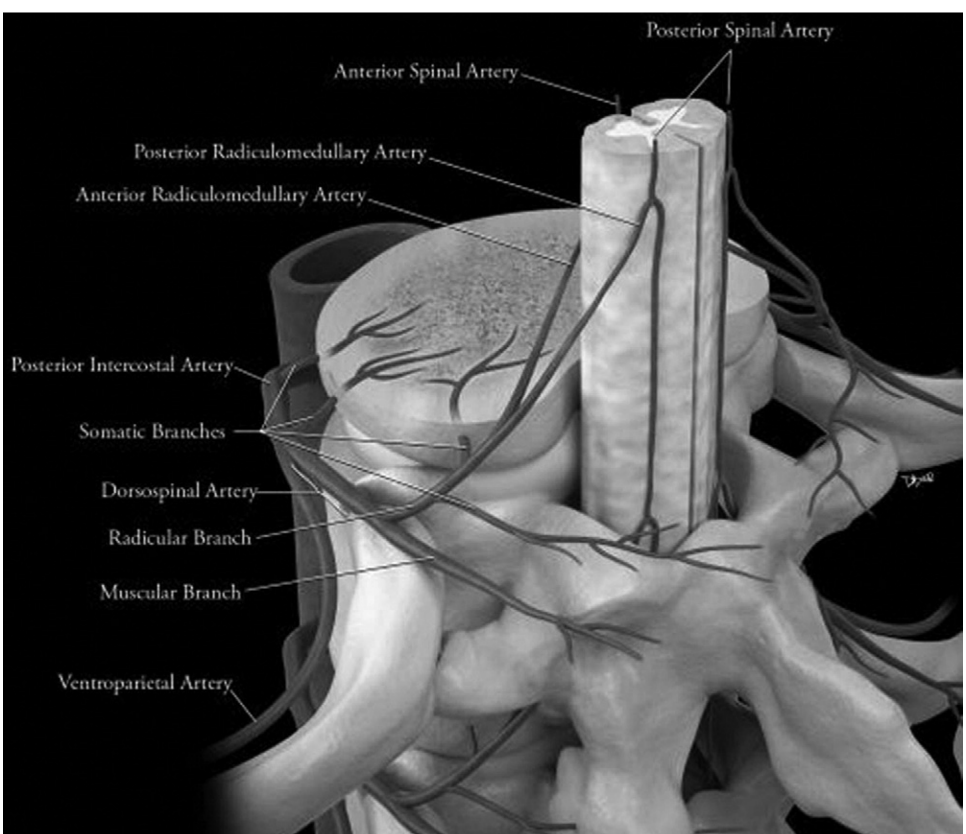

Figure 1 Three-dimensional image illustrating the anatomy of the arterial blood supply to the spine and spinal cord.