DIAGNOSTICS OF SPINE TUMORS

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Annotation: This article reviews the diagnosis and pathophysiology of spinal tumors. Spinal tumors occur in intramedullary, extramedullary, intradural and extradural forms, which cause different clinical symptoms depending on their location and histological composition. Methods such as physical examination, neurological assessment, pulse oximetry, X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and fetal or neonatal echocardiography are important in the diagnostic process. Histological types of tumors include glial, neuroectodermal, meningioma, schwannoma, and metastatic forms, which result in a variety of clinical manifestations. Pathophysiologically, tumors cause regional neuronal dysfunction through compression, hypoxia, and circulatory compromise, and their rapid growth and invasive nature lead to rapid progression of patient symptoms. The article also reviews the efficacy of diagnostic approaches, the role of surgical intervention, and future research directions. This work will serve as a useful resource for rapid and complete detection of spinal tumors in clinical practice and the development of effective treatment strategies.

Keywords: Spinal cord tumors, Intramedullary tumors, Extramedullary intradural and extradural tumors, Pathophysiology, Clinical features, Diagnostics (MRI, CT), Neurological evaluation, Surgery, Metastasis, Glial tumors, Meningioma, Radicular pain

Introduction. Intramedullary tumors (IMTs) are rare tumors of the spinal canal.

The most common types are ependymomas and astrocytomas, with hemangioblastomas being the third most common type. Other types of spinal tumors are relatively rare.(1)

Spinal infection is a rare disease that can have a variety of causes and outcomes. The incidence of this disease varies in different regions of the world and accounts for 2–7% of infections affecting the muscles and bones. Spinal infections can occur in both adults and children, and can affect the vertebral body, intervertebral discs, and the spinal cord. The infection can also spread to nearby soft tissues, the epidural space, or the spinal canal. If the disease affects the intervertebral discs, it is called spondylodiscitis; if the vertebral body is primarily affected, it is called vertebral osteomyelitis or spondylitis. Spinal infections can be life-threatening and can also cause disc damage, spinal instability, and spinal deformities, reducing the patient's quality of life.(2) Primary spinal cord tumors are about 10 times less common than brain tumors, although their tissue structure is similar. Spinal cord tumors are generally divided into three types: extradural, intradural, and extramedullary, and intradural and intramedullary. Extradural tumors are the most common and are often metastases from other sites. Intradural and intramedullary tumors account for 20–30% of all primary spinal tumors. The remaining 70–80% are intradural extramedullary tumors. Intradural tumors occur most frequently in the thoracic spine, followed by the cervical and lumbar regions.(3) The incidence of primary spinal cord tumors (PST) is approximately 2.5–8.5 per 100,000 people per year. This under-reporting of the disease is often due to late or incorrect diagnosis. One of the most dangerous errors in the diagnostic process is mistaking PST for metastasis, because although the spine is a rare site for primary bone tumors, metastases are common. Typically, primary tumors affecting the spine are spinal bone tumors, tumors of the surrounding soft tissues, or tumors of the nervous system, such as schwannomas or neuromas. However, metastases from different organs can affect the spine, causing varying degrees of bone destruction and resulting in local complications such as

vertebral fractures or spinal cord compression.(2)

A number of genetic factors have been associated with intramedullary spinal tumors (IMSCT). Understanding the different genetic alterations can help to better understand the symptoms, progression, and treatment of these tumors. In addition, a brief understanding of the genetic characteristics of the tumors can help to determine how they relate to lesions in other parts of the body. Currently, clinical conditions associated with IMSCT include neurofibromatosis 1 and 2 (NF-1, NF-2) and von Hippel-Lindau disease (VHL).(3)

In newborns, spinal cord injury is rare and often not fully recognized, making it difficult to obtain accurate information about its occurrence and prevalence. Because the causes of the injury vary, the diagnosis is delayed and the treatment and outcome can vary. Depending on the location and extent of the injury, neurological complications can be serious.(4)

Imaging is the most important diagnostic modality in the diagnosis of IMT (intraspinal tumors).

The primary modality used is magnetic resonance imaging (MRI), with other imaging modalities used as adjuncts, such as computed tomography (CT), vascular imaging (Doppler ultrasound, CT or MR angiography, intraarterial angiography), and positron emission tomography (PET/CT, PET/MR). CT myelography was previously used in patients in whom MRI was not possible, but is now rarely used.(1)

Objective:

The aim of this article is to review current diagnostic methods for the early and accurate diagnosis of spinal tumors.

Main article:

Demyelinating diseases of the spinal cord, including multiple sclerosis and neuromyelitis optica spectrum disorder (NMOSD), can sometimes present with a

clinical picture similar to intramedullary tumors. However, such lesions are usually multiple, do not produce a mass effect, and do not enhance strongly with contrast media (only annular enhancement may be observed in the early stages). In cases of uncertainty, MRI of the brain and orbit, as well as clinical signs, electrophysiological studies, and CSF analysis, are essential for making a definitive diagnosis.(1) Recently, the number of infectious diseases of the spine has increased, even in areas previously considered to be cleared. Since some radiological signs of infection can be misinterpreted, they can confuse the physician. Therefore, such diseases should not be ignored when diagnosing spinal tumors. The distinction between spinal tumors and infections is clinically important, as approximately half of all cases of infection are initially misdiagnosed as tumors. (2) Histologically, acute infection is purulent and ill-defined. Suppuration is also present in the subacute stage, but it is localized and manifests as an abscess. In chronic infection, the degree of suppuration is variable and is accompanied by bone remodeling and remodeling. Therefore, it is important to consider the stage of the disease in the differential diagnosis. (2) Hemangioblastomas are small, benign, densely vascularized, and usually solitary tumors, most of which do not exceed one or two vertebral segments. Although they are more common in the cerebellum, they can also occur in the spinal cord, mainly in the posterior or posterolateral part of the spinal canal. Although hemangioblastomas are often incidentally found in the spinal cord, they are often associated with VHL. They account for approximately 2–8% of all intramedullary spinal tumors.(3) Astrocytomas are reddish-gray, shiny, ill-defined, and usually infiltrative tumors. They are the second most common type of intramedullary spinal tumors (IMSCT) in adults, accounting for 30–35% of all tumors, and the most common type in children, accounting for 90% of cases. herefore, tumors in or around the spinal cord can cause severe neurological impairment, causing pain, loss of motor and sensory functions, and autonomic dysfunction, which greatly affects the patient's quality of life.

(6) The Japanese Orthopaedic Association (JOA) scores were used to assess neurological status: cervical myelopathy (JOA-C), thoracic myelopathy (JOA-T), and back pain (JOA-B). These scores were recorded one month before surgery and at the last follow-up, and the difference between the last and preoperative scores was also analyzed. The total JOA-C score is 17 points, of which 8 points are assigned to upper and lower motor functions, 6 points to sensory functions, and 3 points to urinary-patric function. The JOA-T consists of 11 points and is calculated by subtracting the parameters of the upper extremities from the JOA-C. The JOA-B has a total score of 29: 9 points for 3 subjective symptoms, 6 points for 3 clinical signs, and 14 points for 7 activities of daily living.(7) Many primary spinal tumors, especially astrocytomas, have a poor life expectancy. These tumors are usually associated with a high degree of disability, resulting in paresis, bowel and bladder dysfunction, and sensory impairment. Life expectancy in children is lower than in adults (20–64 years), which is due to the difference in histological subtypes found in the two age groups.(8)

Pathophysiology and tumor types:

Spinal tumors arise from tumor processes that originate in the tissues of the spinal cord and have a variety of clinical manifestations depending on their location and histological composition (1,3,5). Tumors can be intramedullary (within the brain), extramedullary intradural (within the dura, outside the brain), and extradural (outside the dura) (1,3). Intramedullary tumors usually arise from myelin-producing or neuroglial cells, which directly affect brain tissue and cause motor and sensory impairment (1,3). Extramedullary intradural tumors compress nerve roots in the spinal canal and cause radicular pain, muscle weakness, and reflex changes (2,7). Extradural tumors, on the other hand, often present as metastatic or bone tumors, damaging the vertebral structure and causing symptoms through mechanical pressure (2,7). The histological types of tumors are also important. The most common intramedullary tumors are glial

(astrocytoma, ependymoma) and neuroectodermal tumors (1,3). Extramedullary intradural tumors manifest as meningiomas and schwannomas, while extradural tumors are tumors associated with metastases and osteogenesis (1,2,7). Pathophysiologically, tumors cause regional neuronal dysfunction by compressing the spinal cord tissues, hypoxia, and impaired blood flow (3,6). However, the rapid growth and invasive nature of the tumor lead to rapid development of symptoms in the patient and complicate the surgical approach (6)

Clinical signs and symptoms:

Spinal tumors present with a variety of clinical signs, depending on the type, location, and growth rate of the tumor. The most common symptom is back or neck pain, which may radiate into the arms or legs (1,3). The pain is often present at rest and is worse at night (1,3). When spinal tumors compress nerve roots or spinal cord tissue, motor and sensory deficits occur, including muscle weakness, numbness, tingling, and loss or increase of reflexes (1,3). Large tumors or canal stenosis can cause patients to have difficulty walking, balance problems, and fatigue (3). In some cases, especially in the thoracic and lumbosacral segments, tumors can cause autonomic dysfunction, such as difficulty with urination and bowel control (2,3). Notably, spinal tumors often develop slowly, so the initial symptoms may be vague. However, intramedullary tumors tend to develop symptoms more quickly, making early diagnosis important (1,3,4). The identification of clinical signs and symptoms is important in assessing the location and type of tumor and is a key tool in determining subsequent radiological and surgical diagnostic strategies. (1,3,6,7).

Diagnostic methods:

In diagnosing spinal tumors, it is important to first assess the patient's symptoms and clinical signs (2,3). Physicians will examine the patient for pain, reflex changes, and motor and sensory functions (2,3). Neurological examination is the first step in

determining the location and extent of tumors (3,5). Plain radiographs show changes in the vertebral structure but are limited in detecting soft tissue tumors (1,5). Computed tomography (CT) is used primarily to detect extramedullary tumors and bone lesions (1,2). Magnetic resonance imaging (MRI) is the most sensitive and reliable tool for detecting intramedullary and extramedullary intradural tumors (1,3). MRI provides detailed visualization of tumor size, location, invasiveness, and peritumoral changes (1,3,6). The use of contrast agents can better demonstrate tumor vascularity and margins (1,6). Special MRI protocols and echocardiography may be used in neonatal and fetal patients (4). Pulse oximetry and some blood biomarkers support the diagnostic process but are not considered primary tools (4,6).

Nuclear imaging techniques such as PET-CT and SPECT are useful in identifying metastatic or aggressive tumors (2,6). Patients may also have blood tests and inflammatory markers (3,6). Genetic and epigenetic analyses can help characterize tumors and guide treatment strategies (3,6). Intraoperative imaging technologies, such as high-speed OCT and robotic focusing systems, are used to identify tumors and delineate their margins during surgery (6). MRI and CT scans before surgical approaches such as hemilaminectomy can help determine the location and size of tumors (7). Differential diagnosis is also important, as infections and other spinal pathologies can cause symptoms similar to tumors (2). Therefore, clinical assessment, imaging, and laboratory findings are considered together (2,3). The histological type and grade of tumors are determined by biopsy and microscopic examination (1,3,5). This information is necessary to guide treatment strategies and reduce surgical risks (1,3). Neurological monitoring, intraoperative neurophysiological studies, and vascular imaging provide additional support for tumor detection (6,7). A multimodal approach—combining clinical evaluation, imaging, laboratory, and genetic testing—is the most effective diagnostic tool (1–7). This allows for better surgical planning, improved treatment

outcomes, and a more accurate prognosis (1–7). High-resolution MRI protocols also clearly differentiate myelin and neuroglial tissue, which is helpful in identifying intramedullary tumors (1,3). MRI can also assess tumor growth rate and peritumoral edema (1,6). CT angiography is useful in determining the vascularity and invasiveness of tumors (6). Ultrasonography is used in some cases, especially in neonatology and pediatric patients, for rapid imaging (4). Fetal echocardiography allows for the monitoring of neurovascular tumors in fetal patients (4). Laboratory tests can help assess the degree of tumor inflammation and immunological response (3,6). PET-CT can clearly identify the spread of metastatic tumors.

Discussion:

Diagnosis of spinal tumors is a multistep and complex process that involves clinical evaluation, imaging studies, and additional laboratory methods. The literature shows that early diagnosis is crucial in preventing neurological complications and improving treatment outcomes (3,8). Clinically, spinal tumors often present with pain, neurological deficits, and sensory disturbances, but these signs are nonspecific, making diagnosis difficult based on clinical findings alone (3). Therefore, imaging techniques play a key role. Although magnetic resonance imaging (MRI) is the most important imaging modality in modern practice, computed tomography (CT) is of additional importance in the evaluation of bone structures (1,2). MRI can determine the intramedullary, extramedullary, or extradural location of tumors, which is important for differential diagnosis and treatment planning (1,3). At the same time, the use of contrast media can more clearly demonstrate the vascular characteristics of the tumor and its boundaries. CT is especially effective in detecting bone destruction or metastatic processes (2). One of the important diagnostic problems is the differentiation of tumors from infectious and inflammatory diseases. In some cases, imaging features can be similar, which can lead to misdiagnosis (2). Therefore, it is necessary to analyze radiological results in

conjunction with clinical and laboratory parameters. In recent years, new diagnostic technologies, including intraoperative imaging and high-resolution optical methods, allow for real-time assessment of tumors (6). This helps to increase the accuracy of surgical intervention and preserve healthy tissue to the maximum extent. Historically, spinal tumors were mainly detected at late stages and were based on limited diagnostic methods (5). Nowadays, thanks to a comprehensive diagnostic approach, the possibility of early detection of the disease and the development of an individual treatment strategy has expanded. Thus, a single method is not enough to diagnose spinal tumors. The most effective approach is a comprehensive and multidisciplinary evaluation that includes clinical, radiological and modern technologies (1,2,3,8).

Conclusion:

Diagnosis of spinal tumors is one of the important and complex issues in modern medicine. Studies show that early and accurate diagnosis is crucial for preserving the neurological status of patients and increasing the effectiveness of treatment. In addition to clinical assessment, imaging methods, especially magnetic resonance imaging (MRI), play a key role in the diagnostic process. MRI has a high accuracy in determining the location, size and spread of tumors and plays an important role in differential diagnosis. At the same time, computed tomography (CT) provides additional information in determining the damage to bone structures. Nevertheless, it remains difficult to distinguish tumors from infectious and other pathological processes in some cases, which indicates the need for an integrated approach. The development of modern technologies expands the possibilities of increasing diagnostic accuracy and choosing an individual treatment strategy.

In conclusion, the most effective approach to detecting spinal tumors is a comprehensive diagnostic system that includes clinical, radiological and innovative methods.

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