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Analysis of Spondylodiscitis as a Disease with a Literature Review on its Etiopathogenetic Status

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Annotation: Spondylodiscitis, an infectious condition involving intervertebral discs and adjacent vertebrae, presents distinct pathophysiological features in children and adults due to differences in vascular anatomy. In children, well-developed intraosseous vascular anastomoses prevent bone necrosis, localizing the infection to intervertebral discs. In adults, the avascular nature of intervertebral discs and the regression of vascular anastomoses contribute to extensive bone necrosis and infection spread, leading to vertebral endplate erosion, osteolysis, and spinal instability. The primary routes of infection include hematogenous spread from sources such as the genitourinary system, skin, and intravenous implants, as well as iatrogenic causes related to spinal surgeries and diagnostic procedures. Tuberculosis predominantly affects the thoracic spine and involves multiple segments, contrasting with purulent spondylodiscitis, which more frequently affects the lumbar region. Complications such as paravertebral abscesses, meningitis, and myelitis can arise, highlighting the need for early diagnosis and management. This study emphasizes the importance of understanding the etiopathogenesis and clinical presentations of spondylodiscitis to improve diagnostic accuracy and treatment strategies.

Keywords: Spondylodiscitis, intervertebral disc infection, spinal infections, hematogenous spread, vertebral necrosis, tuberculosis, paravertebral abscess, iatrogenic infection.

Spondylodiscitis, an infectious and inflammatory condition affecting the intervertebral discs and adjacent vertebrae, is a critical clinical entity with significant diagnostic and therapeutic challenges. It represents a broad spectrum of disease manifestations, ranging from localized pain and mild discomfort to severe neurological deficits and systemic complications.[1] The condition's etiopathogenesis involves a complex interplay of hematogenous bacterial or fungal dissemination, direct inoculation from surgical procedures, or contiguous spread from adjacent infections.

Despite advancements in diagnostic tools, including magnetic resonance imaging (MRI) and molecular techniques, spondylodiscitis often remains underdiagnosed due to its nonspecific early symptoms, such as back pain and low-grade fever. The condition primarily affects individuals with underlying risk factors, such as diabetes mellitus, immunosuppression, chronic infections, or recent invasive medical procedures. The most commonly identified pathogens include *Staphylococcus aureus*, Gram-negative bacilli, and *Mycobacterium tuberculosis*, depending on geographic and population-specific prevalence.

A thorough understanding of the etiopathogenetic mechanisms of spondylodiscitis is essential to address the gaps in early diagnosis and management. This literature review seeks to explore the current knowledge on the disease's pathogenesis, including microbial factors, host responses, and predisposing conditions, and evaluates the implications of these findings for clinical practice. By synthesizing the existing data, this study aims to provide a foundation for developing improved diagnostic criteria and personalized treatment strategies, ultimately enhancing patient outcomes.

Non-specific infectious and inflammatory diseases of the spine (NIIIDS) encompass a range of pathological processes characterized by inflammatory damage to the anterior and posterior bony structures of the spine, intervertebral discs, spinal canal tissues, and the development of nosological forms such as spondylitis, spondylodiscitis, discitis, and epiduritis [9; 17; 18].

Epidemiology

The prevalence of clinical and morphological forms of NIIIDS varies significantly and includes the following: discitis, observed in 1 case per 100,000–200,000 population [3; 4; 5]; epidural abscess, with 0.5 to 3 cases per 10,000 hospitalized individuals annually [12]; and spondylodiscitis, which occurs at a rate of 2.8 to 7.5 cases per 100,000 people, depending on the region or country [8].

Between 2015 and 2022, the annual incidence of spondylodiscitis in Europe ranged from 0.5 to 2.8 new cases per 100,000 people. During the pre-COVID-19 period, *Staphylococcus aureus* and *Mycobacterium tuberculosis* were identified as the leading causative agents, with the lumbar spine being the most commonly affected area [4-6].

In Central Asia, the incidence of spondylodiscitis ranges from 3.4 to 7.6 cases per 100,000 people [5.6]. Among these, spondylodiscitis, involving inflammation of intervertebral discs and vertebral bone structures, is the most prevalent and accounts for 2% to 20% of fatal outcomes among spinal diseases [5.7].

In developed countries, spondylodiscitis is reported at a rate of 4 to 25 cases per million people annually [1, 3, 5]. Numerous studies highlight a bimodal age distribution, with peaks occurring before the age of 20 and between 50 and 70 years. However, the disease can manifest at any age. Males are nearly twice as likely to develop the condition compared to females. Elderly individuals, patients with chronic endocrine disorders (notably diabetes mellitus), those undergoing long-term cytostatic or hormonal therapy, intravenous drug users, and individuals with a history of spinal surgeries are particularly vulnerable.

Despite the widespread use of antibiotic therapy, the mortality rate associated with spondylodiscitis remains high, ranging from 2% to 17% [1, 3, 4, 7, 9-11].

One of the critical predisposing factors for the development of non-specific infectious and inflammatory diseases of the spine (NIIIDS) includes underlying conditions such as diabetes mellitus, alcoholism, drug addiction, hemodialysis, smoking, urinary tract infections, cancer, rheumatoid arthritis, chronic pulmonary diseases, HIV, and hematological disorders. Spinal infections are often associated with infections at other sites, including urinary and genital tract infections, urological and gynecological surgeries, or the presence of permanent intravenous catheters [2].

Currently, non-specific purulent-inflammatory lesions of the spine (NPILS) are rare but pose significant diagnostic and therapeutic challenges due to their severe and complex course [11]. The increasing relevance of addressing these issues lies in their rising incidence, delayed diagnosis (with the interval between the onset of symptoms and confirmation of the diagnosis ranging from 2 to 9 weeks), and a high rate of diagnostic errors, reported in 30-85% of cases. Furthermore, the disability rate reaches up to 85% [5]. The emergence of antibiotic-resistant strains of microorganisms, the severity of the disease, the potential for systemic infection, the lack of unified surgical tactics, and suboptimal treatment outcomes contribute to the prolonged and complicated course of the disease [3, 6, 7].

Pyo-inflammatory processes can potentially involve any part of the spine and surrounding tissues. NPILS encompasses a group of inflammatory and destructive diseases of the spine and its structural components, including vertebral bodies, intervertebral discs, musculoligamentous structures, and intervertebral joints. These conditions are caused by non-specific and conditionally pathogenic microflora [4]. Among the regions affected, the lumbar spine accounts for 50-55% of cases, the thoracic spine for 20-35%, and the sacral and cervical spine for up to 10-25% [8]. Adjacent infections often result in the formation of paravertebral abscesses and vertebral soft tissue involvement.

Males are 2-3 times more likely to develop these conditions compared to females [4, 5]. In 90% of cases, the route of infection in spondylodiscitis is hematogenous [6]. Other transmission pathways include secondary post-traumatic, contact, iatrogenic, and idiopathic mechanisms [1, 5].

Currently, Gram-positive flora, particularly *Staphylococcus aureus*, is the most prevalent pathogen, especially among diabetic patients, accounting for 30-80% of cases [10]. Gram-negative microorganisms, such as *Escherichia coli*, are responsible for 21-25% of all NPILS cases [1]. Other pathogens include *Klebsiella pneumoniae* (15%) and *Pseudomonas aeruginosa* (10%) [5], with an increasing incidence of these infections being observed [1, 4].

In children, intraosseous vascular anastomoses are well-developed, with some extending into the intervertebral discs. As a result, when infectious agents are introduced via the hematogenous route, bone necrosis does not typically occur, and the infection remains primarily localized within the intervertebral disc [10]. In adults, however, intraosseous anastomoses undergo involution, and the intervertebral disc becomes avascular. When pathogenic microorganisms infiltrate, extensive bone necrosis develops, and the infection spreads to adjacent structures. This progression leads to the classic presentation of spondylodiscitis, characterized by erosion of the vertebral endplates, osteolysis, and compression fractures. Such changes can result in spinal instability and deformity, significantly increasing the risk of spinal cord and nerve root compression [6].

Infection may also involve surrounding tissues, causing the formation of paravertebral and lumbar abscesses. If the pathogen infiltrates the spinal canal, it can lead to epidural and subdural abscesses, meningitis, and myelitis [9].

The hematogenous route is the most common pathway for infection, originating from various sources, including the genitourinary system (17%), skin and soft tissues (11%), intravenous implants (5%), gastrointestinal tract (5%), respiratory system (2%), and oral cavity (2%). Purulent spondylodiscitis frequently affects the lumbar spine, less often the thoracic spine, and only rarely the cervical spine. Tuberculosis, in contrast, predominantly involves the thoracic spine and often affects more than two segments, distinguishing it from purulent spondylodiscitis [3].

Iatrogenic infection pathways are becoming increasingly common, attributed to the growing frequency of surgical interventions and the widespread use of various diagnostic procedures involving the spine [3]. The rarest route of infection is microbial infiltration from adjacent tissues, which may occur in cases such as esophageal hiatus hernia, retropharyngeal abscess, and other inflammatory conditions [11].

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