CURRENT STATE OF RADIOLOGICAL DIAGNOSIS OF ISOLATED AND COMBINED STENOSIS OF THE CERVICAL AND LUMBAR SPINAL CANAL: A LITERATURE REVIEW

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ABSTRACT:

This literature review examines the contemporary status of radiological diagnosis concerning isolated and combined stenosis of the cervical and lumbar spinal canal. Degenerative isolated and combined stenosis are prevalent spinal pathologies. The narrowing of the spinal canal is mainly a result of various pathogenic processes affecting the bony and soft tissue components of the spine, occurring due to age-related and static wear and tear. These degenerative processes may affect single or multiple spinal segments within the cervical and lumbar regions.

Diagnosing tandem stenosis in patients with prominent clinical symptoms at the lumbar level is challenging. Therefore, a thorough evaluation of radiography and MRI results for other spinal levels is necessary for patients suspected of tandem stenosis, especially when degenerative spinal stenosis and signs of ligament ossification are detected. This diagnostic approach is particularly crucial if there is no significant improvement in the clinical symptoms after decompression at one level.

KEYWORDS: isolated stenosis, combined stenosis, radiological diagnosis, spinal canal.

DOI: 10.48047/ecb/2023.12.8.666

INTRODUCTION

Spinal stenosis is a common degenerative condition that can lead to nerve compression, resulting in various neurological symptoms. It can be classified into isolated cervical stenosis, isolated lumbar stenosis, or combined cervical and lumbar stenosis

By the present time, a multitude of fundamental studies [3, 19, 38, 71, 88] have accumulated, demonstrating that degenerative isolated and combined stenosis of the spinal canal is a rather common condition among spinal pathologies. Degenerative stenosis primarily results from various pathogenic processes affecting the bone and soft tissue components of the spinal canal, occurring due to age-related and static degeneration of the spine. These degenerative processes can develop in a single spinal motion segment or involve two or more segments in the cervical and lumbar regions of the spine.

According to N.S. Kosinskaya (1961) and other researchers [28, 39, 67, 91], all degenerative-dystrophic spinal disorders can be divided into three major groups: intervertebral disc lesions (osteochondrosis), vertebral body lesions (spondylosis), and spinal joint lesions (spondyloarthritis). While these three types share a common degenerative process, their distinct anatomical localizations and clinical symptoms necessitate individual consideration, although they often coexist in combination. Determining the predominant process contributing to the development of degenerative stenosis can be challenging.

The first report of spinal canal narrowing due to pathological spinal deformities was made by Antuan Portal in 1803, establishing a connection between spinal canal deformity and compression of the spinal cord. Clinical symptoms of spinal canal stenosis were also described by Von Bechterew in 1893 and B. Sachs and J. Frankel in 1900 (cited by Antipko L.E., 2001). Lumbar spinal stenosis, known as a nosological form of pathology, was extensively described by Ң. Verbiest in the 1950s. The clinical manifestations of lumbar spinal stenosis include neurogenic intermittent claudication, while cervical stenosis is associated with myelopathic symptoms.

A.V. Yarikov et al. (2020) present data indicating that American orthopedists, led by S. Arnoldi (1976), proposed the term "lumbar spinal stenosis" for any type of narrowing of the spinal canal or intervertebral foramen leading to neurological symptoms. The prevalence of this pathology significantly increases in individuals over 50 years old. According to their findings, the signs of "lumbar spinal stenosis" are observed in 80% of patients at the age of 70, with an annual frequency of 5.0-11.5 cases per 10,000 population. According to Z.I. Adamboeva (2018), various authors diagnose spinal canal stenosis in 5.0-62.2% of patients with long-standing degenerative processes in the spinal motion segment. S.M. Elsenstein (1977) found spinal canal stenosis in 6.3% of autopsy cases. S. Kokubun et al. (1996) reported a prevalence of spinal canal stenosis in 16 cases per 1000 population. H.G. Deen (1995) considers spinal stenosis a clinical-anatomical syndrome, while I.I. Larkin et al. (2003) define spinal canal stenosis as a diffuse or limited pathological reduction in the size of the spinal canal, resulting in compression of the spinal cord and its nerve roots. Y.A. Orlov et al. (2017) describe stenosis as a long-standing chronic process leading to narrowing of the spinal canal. R.V. Khalepa et al. (2018) discovered degenerative spinal changes in 90% of individuals over 60 years old, with signs of spinal canal stenosis being observed in 80% of those aged 70 and older. However, according to Y.E. Pedachenko (2009), the term "stenosis" should not be applied to cases of spinal canal narrowing without characteristic clinical signs. He emphasizes that diagnosing "Spinal Canal Stenosis" solely based on additional examination data, without considering clinical manifestations, is unacceptable.

This compilation of evidence highlights that spinal stenosis is a complex combination of compression and degenerative disturbances in the spinal cord, resulting from compression of the spinal cord due to the reduction in the size of the central canal (central stenosis) and the lateral recesses (foraminal stenosis), either involving the nerve roots. The literature reveals various classifications of spinal stenosis. Notably, N. Verbiest (1954) introduced the widely known classification of stenotic lesions of the spinal canal, which categorizes stenosis as "relative" if the sagittal diameter of the spinal canal is up to 12 mm and "absolute" if it measures 10 mm or less. If both relative and absolute stenosis occur at different levels of the spinal canal, it is termed "mixed." H. Verbiest further classified stenosis according to its etiopathogenesis as congenital, acquired, or developmental stenosis (caused by disproportionate patient growth during adolescence).

Later on, M.S. Huckman (1992), V.D. Usikov et al. (2002), Sh.Sh. Shotursunov and S.S. Kokchartayev (2002), E.V. Ulrich and A.Y. Mushkin (2004), H.E. Polischuk et al. (2012) proposed their classification of spinal stenosis. Among them, the most comprehensive classification of spinal canal stenosis was suggested by V.F. Kuznetsov (1992), which considers possible causes, probable clinical manifestations,

and various course variants. The analysis of literature sources related to spinal canal stenosis and the causes leading to different clinical-morphological presentations appears to be extensive, making it challenging to fit them into a single classification structure, especially since diverse etiological factors may result in similar clinical pictures. All these factors significantly complicate the diagnosis of this pathology.

Studies by V.A. Byvaltsev et al. (2016), I.A. Ilyasevich et al. (2020), A.A. Sufiyanov et al. (2021) indicate that despite advancements in the diagnosis and treatment of one of the most common diseases, isolated degenerative stenosis of the cervical spinal canal, the relevance of this pathology remains. In this case, the dominant function is not supporting but rather facilitating head movement with sensory organs. The cervical vertebrae have a complex anatomical structure with smaller dimensions compared to other spinal segments, and the facet joints are oriented at different levels in different planes, providing high mobility of the cervical region. The high mobility of cervical vertebrae, limited reserve space in the spinal canal, frequent combinations of compressive factors, along with multilevel involvement of several vertebrae, define the difficulties in diagnosing multilevel stenosis of the cervical region.

According to E.G. Ippolitova et al. (2015), monosegmental cervical spinal stenosis was found in 77.2% of patients, and two-segmental stenosis in 22.8%. In terms of localization, monosegmental stenosis was distributed as follows: C3-C4 = 8.5%, C4-C5 = 22.9%, C5-C6 = 28.6%, C6-C7 = 40%. The leading causes of cervical spinal canal stenosis were bone-cartilaginous exostosis in 83% of patients, intervertebral disc herniation in 8.5% of patients, and a combination of bone-cartilaginous exostosis with disc herniation in 8.5% of patients.

In recent years, much attention has been given by many researchers (A.N. Prodan-2008; V.A. Byvaltsev et al. - 2018; G. Andreisek et al. - 2014; S. Hall et al. - 2015; D. J. Choi et al. - 2019; G. Jannelli et al. - 2020) to the problem of isolated lumbar spinal stenosis of various etiologies. The causes of lumbar stenosis include osteophytes, ossified intracanal ligaments, ossified disc herniations, hypertrophy of intervertebral joints, and more.

Lumbar spinal stenosis is a common spinal pathology, affecting two-thirds of patients with long-standing degenerative processes in the lumbar region, and it is considered one of the final stages of the disease. Central stenosis of the spinal canal occurs in 21% of cases, lateral stenosis in 26.2%, combined stenosis in 52.8%, and multilevel stenosis in 21% (C.L. Levitz et al. - 1997; J. Luzie - 2016).

According to P.A. Zharkov et al. (2002), R.W. Molinari et al. (2012), A. Krishnan et al. (2014), Overley et al. (2017), the clinical pictures of degenerative processes at the cervical and lumbar levels manifest as isolated or more complex combined tandem stenosis. It has been observed that the frequency of tandem spinal canal stenosis increases with age. Usually, the cause of combined tandem stenosis is the degeneration of vertebrae and intervertebral discs. Tandem stenosis at the cervical and lumbar levels is observed in 5-25% of patients, with one of these regions dominating the clinical symptoms. The simultaneous occurrence of lumbar and thoracic spinal stenosis or cervical and thoracic stenosis is low, comprising about 1% of cases (Bajwa N.S. et al. - 2012; Fushimi K. et al. - 2013). Multiregional spinal canal stenosis at three levels: cervical, thoracic, and lumbar, is an extremely rare observation (Hong et al. - 2015). The severity of stenosis is determined by the degree of these disturbances: from intermittent, transient, and moderate to severe, where spinal cord conduction is compromised. Combined spinal stenosis at the cervical and lumbar levels often occurs due to ossified disc herniations, hypertrophy of intracanal ligaments, and facet joint arthrosis. Detecting tandem stenosis can be challenging, as it may present without pronounced clinical symptoms at one of the affected levels. V.M. Feniksov et al. (2021), G.M. Ghobrial et al. (2014), T. Yamada et al. (2018) note that the probability of

developing tandem stenosis increases to 15.3% when diagnosing spinal canal stenosis at one level and reaches 32.4% over time. Despite the presence of neurovisualization signs, tandem stenosis can often be asymmetric. It has been found that the most mobile spinal regions (cervical and lumbar) are prone to stenosis. S.H. Lee et al. (2010) identified that 23% of patients with intermittent claudication experienced asymptomatic cervical spinal stenosis.

M.D. Drevyal (2016), A. Rahmanian et al. (2014), V.K. Menon et al. (2015) believe that due to the polymorphism of symptoms and the multifactorial substrate leading to the narrowing of the spinal canal at multiple levels, further in-depth research is needed to understand the formation of degenerative tandem spinal stenosis. While the diagnosis of isolated spinal stenosis usually does not pose difficulties, diagnosing tandem spinal stenosis is quite challenging since its clinical picture consists of multiple symptoms that can even mislead experienced specialists and lead to delayed diagnosis. Often, the clinical presentation is dominated by symptoms related to changes in the lumbar spine, while the timely diagnosis of cervical stenosis may be missed (R.W. Molinari et al. - 2012; J.C. Schaffer et al. - 2015).

The diagnosis of isolated and tandem spinal canal stenosis in all cases is based on the use of radiological imaging methods. Different radiological diagnostic methods in vertebrology have their specific tasks, goals, and indications, and they can fulfill their role effectively when used together correctly (V.A. Byvaltsev et al. - 2018).

According to A.N. Mikhailov (2015), A. Stabler et al. (2001), and other authors, radiological studies remain an indispensable and reliable method in vertebrology due to their relatively high informativeness, even with the wide implementation of modern methods. X-ray examination has been used for over 125 years for diagnosing developmental anomalies, tumors, and degenerative pathologies of the spine, which are considered some of the causes of spinal canal stenosis. X-ray in two projections allows detecting changes such as reduced intervertebral disc space height, osteophyte formation, subchondral osteosclerosis, calcification of the nucleus pulposus or fibrous ring, and segmental instability during functional tests (A. Stabler et al. - 2001; O.B. Chelpachenko et al. - 2014).

To avoid errors in radiometric measurements of vertebral bodies, intervertebral discs, and spinal canal, some authors use indices to characterize these structures (O.B. Chelpachenko et al. - 2014; V.A. Byvaltsev et al. - 2018). Among various proposed indices, the Johnson-Thompson canal-body index has retained its value in diagnosing spinal canal stenosis until recent years. According to A.I. Prodan et al. (2008), a canal-body index of 1:2 (the ratio of the average sagittal dimension of the spinal canal to the average sagittal dimension of the vertebral body) indicates a sufficiently wide lumbar spinal canal, while a ratio of 1:4 or more suggests lumbar spinal stenosis.

The introduction of new imaging methods, such as CT with CT angiography (CTA) and multislice CT (MSCT) and MRI, has enabled the visualization not only of bony structures forming the spinal canal but also the soft tissues located inside the canal. Therefore, further research into the morphometry of the spinal canal, taking into account its anatomical structural elements in different planes, appears promising for diagnosing spinal canal stenosis (V.A. Sorokovnikov et al. - 2010; V.V. Lebedev et al. - 2017).

Contemporary methods have established normal and pathological dimensions of the spinal segment, such as sagittal and frontal dimensions of the spinal canal, dural sac, interfacet distance, cross-sectional area of the spinal canal, thickness of intracanal ligaments, and others.

R.V. Khalepa et al. (2018) aimed to clarify factors contributing to spinal cord and nerve root compression by conducting MRI investigations and defining several parameters of the vertebral-motor segment. The criteria for diagnosing spinal canal stenosis included a sagittal dimension of the spinal canal less than 13

mm, a dural sac less than 10 mm, frontal dimension less than 15 mm, interfacet distance less than 15 mm, and cross-sectional area of the dural sac less than 130 mm².

Willen (as cited by L.E. Antipko, 2001) in 1997 used MRI methodology to determine the cross-sectional area of the spinal canal and considered an area less than 100 mm² as indicative of relative stenosis, while an area less than 75 mm² indicated the presence of absolute stenosis.

A.V. Pelegenchuk et al. (2017) conducted MRI studies on patients over the age of 60 and identified signs of spinal canal narrowing in 21% of them, of which only 33% presented typical symptoms of stenosis. The possibility of obtaining an overview of several motor segments simultaneously in the sagittal plane makes MRI particularly informative. According to them, MRI remains the only method that allows visualizing the spinal cord and its elements over the necessary extent.

According to Y.E. Pedachenko (2009) and T. Uamada et al. (2018), the diagnosis of tandem stenosis remains a poorly studied and debatable issue in modern vertebrology. The criteria for comparing clinical-neurological symptoms and pathomorphological compressive factors of combined tandem stenosis, visualized by radiological methods, are not fully presented.

V.M. Feniksov and P.V. Zelenkov (2021) note that according to literature [42, 58, 90], signs of tandem stenosis are observed in 7-60% of cases during radiological examinations. Often, stenosis in one spinal segment may cause pronounced symptoms, while stenosis in another segment may be asymptomatic and only detected through radiography, CT, or MRI studies. The prevalence of asymptomatic stenosis in the cervical segment of patients with MRI signs of lumbar stenosis can reach up to 25%.

Radiological signs such as spondylosis, spondylolisthesis, or the number of stenosis levels in one segment are not reliable diagnostic criteria for tandem stenosis. It is necessary to be cautious about the presence of tandem stenosis in patients with isolated stenosis, as the clinical picture of stenosis at one level may mask symptoms of stenosis in another spinal segment.

CONCLUSION

Thus, the diagnosis of tandem stenosis in patients with more pronounced clinical manifestations at the lumbar level remains challenging. Consequently, when detecting degenerative spinal stenosis, especially with signs of ossification of the posterior, longitudinal, and yellow ligaments, a comprehensive evaluation of instrumental examination results (radiography and MRI methods) for other spinal levels in patients suspected of tandem stenosis is required. Conducting such diagnostic searches is particularly important if there is no significant improvement in the clinical picture after decompression at one level.

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