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Innovations in the treatment of cervical spine myelopathy – a comprehensive review

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Abstract:

Introduction and aim of the study

Myelopathy of the cervical spine is a set of symptoms resulting from compression of the spinal cord. There are many causes that may lead to this disorder, including degenerative changes, ligament ossification and tumors. Middle-aged and older patients usually suffer from it, and its diagnosis is expected to increase as the population gets older. Due to non-specific and initially mild symptoms, cervical myelopathy is usually diagnosed in later stages, often when the patient's fitness and independence are significantly impaired. The aim of the study is to present the current state of knowledge about myelopathy of the cervical spine, methods of its effective diagnosis, and to present available therapeutic options, because early diagnosis and optimal treatment enable patients to maintain their ability to work and improve their overall quality of life.

Materials and methods

The literature included in the PubMed, BioMed Central and Polish Medical Platform databases is searched by means of the words such as cervical myelopathy, decompression, spinal cord, corpectomy, discectomy. Quoted sources in selected works were also used.

Conclusion

Surgical treatment is the most effective method to improve the clinical condition of people suffering from cervical myelopathy. Both anterior and posterior approach surgeries are characterized by similar effectiveness, and the choice of a specific method depends on the patient's general condition, the degree of cervical lordosis, and the number of affected spinal segments. Due to the correct diagnosis of the disease and applying treatment, it is possible to slow down the progression of the disease and improve the quality of life of patients.

Key words:

Cervical myelopathy, spinal cord, decompression, laminoplasty

Introduction

Cervical myelopathy is a disorder involving symptoms caused by compression and damage to the cervical spinal cord as a result of spinal stenosis. In 1928, this affliction was first described by Stookey. Cervical myelopathy is relatively common, mainly among middle-aged patients, and is usually a consequence of degenerative changes. Due to the variety of symptoms, it may resemble many neurological diseases. The aim of the study is to present the etiopathogenesis, diagnostic process and therapeutic options among patients suffering from cervical myelopathy, because its correct diagnosis and treatment may contribute to improving the psychophysical condition and quality of patients' lives. [1, 2]

Epidemiology

There are no clear research results showing the prevalence of cervical myelopathy. The reason is the lack of uniform nomenclature in the literature and cases of failure to recognize the disease due to its often asymptomatic process despite changes in imaging tests. Cervical myelopathy is most often associated with degenerative changes. It is also the most common cause of non-traumatic spinal cord injury among adult patients. Men are more often exposed to it (3:1) and it is usually diagnosed in middle age (40-60 years). [1, 3] It was estimated that the frequency of hospitalizations due to cervical myelopathy associated with degenerative changes is 4.04 per 100,000 person-years, while the number of people operated on for this reason was estimated at 1.6 per 100,000 inhabitants. In another study, the prevalence of cervical myelopathy in North America was estimated at 4.1 to 60.5 per 100,000 inhabitants. [4-6] Presence of cervical myelopathy in the 3rd-4th year decade of life usually indicates a secondary process to congenital spinal stenosis. Myelopathy due to degenerative causes occurs later in life, among men at 13% in the 3rd decade of life and almost 100% in the 7th decade of life, and among women at 5% in the 4th decade and 96% in the 7th decade of life. [2] In patients with rheumatoid arthritis, radiological changes in the cervical spine are observed in 43-86%, neurological deficits in 7-36%, and cervical myelopathy occurs in 5% of patients. [7, 8] A 17% incidence of cervical myelopathy is also observed in patients with idiopathic normotensive hydrocephalus (iNPH). [9]

Etiopathogenesis

There are many factors that can lead to the occurrence of cervical myelopathy. Due to the type of mechanism leading to its formation, they can be divided into static, dynamic and biomolecular factors. [10]

Static factors are related to congenital or acquired spinal stenosis. The most common cause is degeneration of the cervical spine. It usually appears after the fifth decade of life. As the body gets older, the nucleus pulposus becomes dehydrated, followed by fibrosis and displacement within the disc, as well as damage to the annulus fibrosus. As a result of these changes, the intervertebral disc may bulge or prolapse into the spinal canal, which may lead to pressure on the spinal cord. There are also often productive changes in the facet joints, thickening of the yellow ligaments, and the formation of osteophytes (bone outgrowths) on the front surface of the shafts. Other static factors leading to myelopathy include ossification of the posterior longitudinal ligament and yellow ligament, congenital stenosis of the spinal canal, and other lesions that may cause compression, such as tumors and calcifications. [10–12].

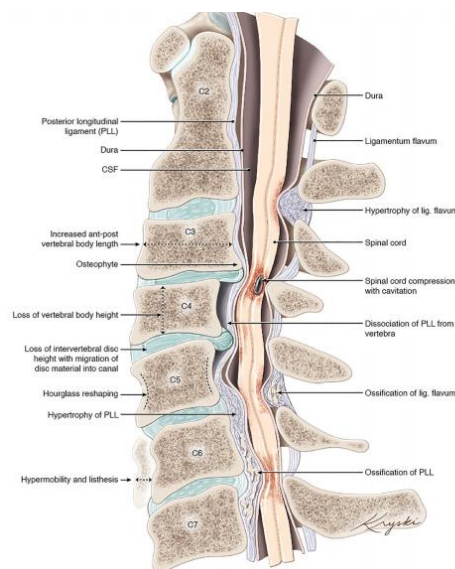


Fig. 1. Static factors influencing spinal canal narrowing and spinal cord compression.

J. Gibson, A. Nouri, B. Krueger, N. Lakomkin, R. Nasser, D. Gimbel, J. Cheng,
Degenerative cervical myelopathy: A clinical review, Yale Journal of Biology and Medicine, t.

91, nr 1. 2018.

Dynamic causes include repetitive neck flexion and extension movements that lead to micro-injuries to the spinal cord. It was shown that the diameter of the spinal canal from the posterior surface of the vertebral body to the yellow ligament, compared to the neutral position, was larger during flexion and smaller during extension. Moreover, the thickness of the yellow ligament was greater during extension and smaller during flexion. Compared to the neutral spine position, the sagittal diameter of the cervical spinal cord decreased during both flexion and extension. Additionally, the elongation of the spinal cord results in increased membrane permeability, which leads to electrolyte imbalance and loss of axonal conduction. It has been shown that in the neutral position, at C4-C6, the diameter of the spinal canal is the smallest, the disc bulge is the largest, and the yellow ligament is the thickest, therefore the spinal cord is more susceptible to compression at these levels. [13, 14]

Biomolecular causes include neuronal damage that are secondary to compressive lesions causing disturbances in blood circulation. Oligodendrocytes are susceptible to ischemic changes occurring in the process of venous fibrosis, hyaline degeneration of arteriolar walls, and compression of anterior spinal vessels. These changes result in demyelination and apoptosis of axons. It was estimated that most of the damage concerned the gray substance of the brain. [15]

Clinical symptoms

Despite degenerative changes visible in imaging tests, the disease is often asymptomatic. Disc degeneration or narrowing of the intervertebral space may occur in up to 57%, and osteophytes in 40% of patients without clinical symptoms. People who are over 60, may have this rate above 85%. However, cervical myelopathy is diagnosed in only 7.5% of patients. [16] Clinical symptoms are varied. There is no relationship between the degree of spinal compression and the severity of symptoms, but their type depends on the level of the spine affected by the compression. Most often, the damage occurs at the C4-C6 level, due to the narrowest spinal canal and the widest yellow ligaments, as well as the greatest mobility at this height. Symptoms may be mild and include only pain in the neck area. In cervical myelopathy resulting from compression of the roots or spinal cord, the first symptom is usually difficulty in walking (spastic gait).

There is a characteristic triad of symptoms including neck pain, shoulder pain, and pelvic limb weakness. Additionally, bladder sphincter dysfunction, positive Lhermitte's sign, loss of mobility and atrophy of hand muscles, as well as disturbances in pain, temperature and touch sensation may occur. In the pelvic limb, positive neurological symptoms are observed more often than in the thoracic limb - Hoffman's, Babiński's and/or Chaddock. Symptoms may be asymmetric. [16, 17]

Diagnosics

Due to the heterogeneous clinical picture and similarity in course to other disease entities, the diagnosis of cervical myelopathy causes many difficulties. Magnetic resonance imaging (MRI) is considered as the gold diagnostic standard due to its ability to visualize not only bone structures, but also pathologies within ligaments, intervertebral discs and the spinal cord. Increased spinal cord signal intensity on T2-weighted MR imaging is believed to reflect pathological changes in the spinal cord. If there are contraindications to MRI, computed tomography (CT) may be used. [16] X-ray in the lateral projection can be used to determine the width of the spinal canal and to visualize changes in the bony structures of the spine. It is believed that a spinal canal diameter below 11-13 mm may be a predictor of clinical symptoms of cervical myelopathy. [18–20]

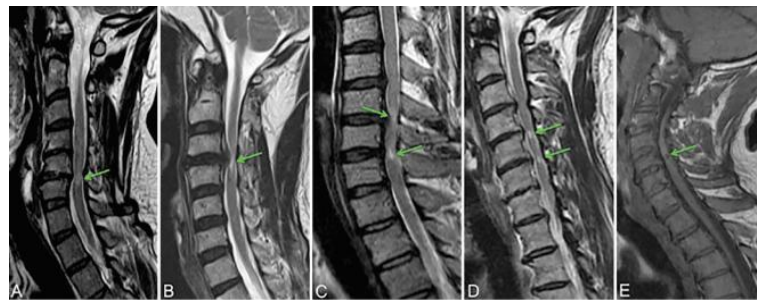


Fig. 2. Visible bulging of the intervertebral disc as well as changes in the intensity of the spinal cord in the MR image. (A-D) T2-weighted image, (E) T1-weighted image.

J. Gibson, A. Nouri, B. Krueger, N. Lakomkin, R. Nasser, D. Gimbel, J. Cheng, *Degenerative cervical myelopathy: A clinical review*, Yale Journal of Biology and Medicine, t. 91, nr 1. 2018.

There are also many scales that can help in the clinical assessment of patients, for example: Japanese Orthopedic Association (JOA), Neck Disability Index (NDI), Nurick scale,

European Myelopathy Score (EMS), and Myelopathy Disability Index (MDI). The JOA scale or its modified version is the most commonly used all over the world, which allows determining the degree of neurological dysfunction. It is used for qualifying a patient for surgery and to assess the effectiveness of the procedure. Four components are assessed - hand function, lower limb function, bladder function and sensation. The Nourick scale is also useful, as it allows the expected results of surgery to be determined based on an indicative assessment of walking. It ranges from 0 (no symptoms of the disease) to 5 (patient lying in bed or in a wheelchair). Patient self-assessment using the Cervical Disability Index (NDI) may also be useful. It determines how pain affects the patient's daily functioning. The universal analogue pain scale VAS can also be used to assess pain. [21, 22]

It is believed that clinical symptoms combined with abnormalities in imaging tests may be an indication for surgery. [21]

Some suggest that among patients with cervical myelopathy, nerve conduction testing using somatosensory evoked potentials (SSEP), motor evoked potentials after magnetic stimulation (MEP), and electromyography (EMG) may be useful. They enable differentiation between peripheral and central damage, localization of compression on the ventral or dorsal side of the spinal cord, and can also be used in intraoperative monitoring. Additionally, the utility of MRI combined with EMG has been suggested for diagnosis and for predicting surgical outcomes. [20, 23]

The clinical picture of cervical myelopathy may resemble many diseases. The differential diagnosis should include amyotrophic lateral sclerosis (ALS), multiple sclerosis (MS), parkinsonism, spinal cord tumors, vitamin B12 deficiency, Hakim syndrome, syringomyelia, or other diseases of inflammatory, infectious, demyelinating or related etiology. with intracranial disorders or motor neuron disorders. In addition to imaging tests, blood and cerebrospinal fluid tests may be performed during differential diagnosis. [23]

Treatment

Depending on the severity of the disease, as well as individual indications and contraindications, treatment of cervical myelopathy can be divided into conservative and surgical.

In the case of mild clinical symptoms, in the absence of deepening neurological deficits, physiotherapeutic treatments and the use of painkillers, especially from the group of non-steroidal anti-inflammatory drugs, neuromodulating drugs (gabapentin, pregabalin) or tricyclic antidepressants (amitriptyline, nortriptyline), may be considered. The use of a soft or stiff cervical collar may be helpful. However, it is suggested that if surgical interventions are not used and only conservative treatment is used, neurological deterioration is observed in time among 20-60% of patients. [16, 24]

Among patients with moderate or severe condition, as well as with worsening neurological deficits, after assessing the cervical spine in imaging tests, surgery may be considered, the primary goal of which is to decompress the spinal cord and its circulation. Surgical treatment methods can be divided into anterior, posterior or combined anterior-posterior approaches. The choice of method depends mainly on the type and extent of the affected areas, as well as the degree of cervical kyphosis or lordosis. The effectiveness of all methods is comparable. [24]

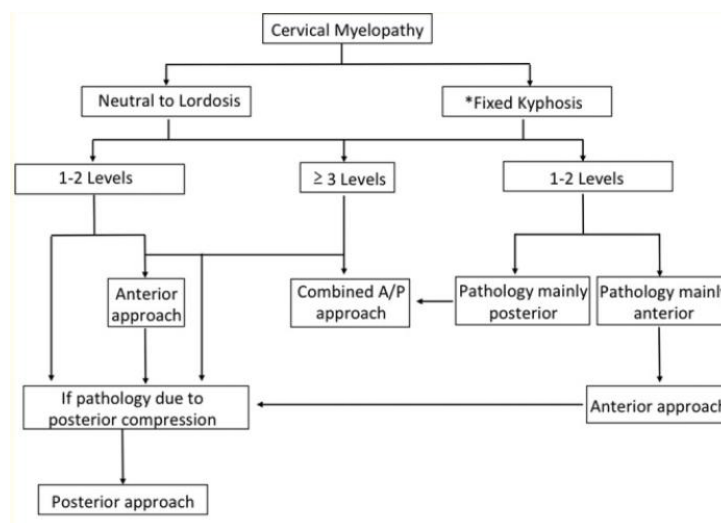


Fig. 3. Scheme for selecting surgical treatment access.

J. Bakhsheshian, V. A. Mehta, J. C. Liu, *Current Diagnosis and Management of Cervical Spondylotic Myelopathy*, Global Spine Journal, vol. 7, no. 6. 2017

When qualifying a patient for surgical treatment, the Cobb method can be used to determine the cervical angle. Its measure is the angle of intersection of vertical lines drawn from lines parallel to the surfaces of the lower C2 and C7 vertebrae. Preserved lordosis is considered when the angle is $>10^\circ$. Also useful is the sagittal vertical axis of the spine (SVA), which is measured as the deviation of the vertical line from the center of the C2 vertebral body to the posterior superior edge of the C7 vertebral body. According to some authors,

when qualifying for treatment, it may be useful to determine the ratio of the Cobb angle to the T1 slope (T1S). The angle of inclination T1 is defined between the horizontal plane and a line parallel to the upper surface of the T1 vertebral body. [3, 25, 26]

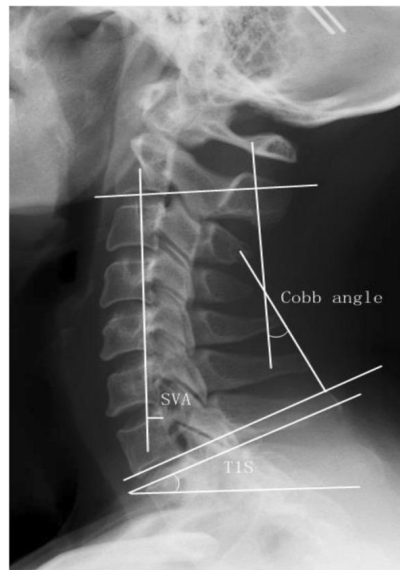


Fig. 4. Determination of the Cobb angle, SVA and T1 inclination angle.

X. W. Fan, Z. W. Wang, X. Da Gao, W. Y. Ding, D. L. Yang, *The change of cervical sagittal parameters plays an important role in clinical outcomes of cervical spondylotic myelopathy after multi-level anterior cervical discectomy and fusion*, J. Orthop. Surg. Res., t. 14, nr 1, 2019

Surgical treatment using an anterior approach

Treatment using an anterior approach is usually used for cervical kyphosis and for pathology affecting one or two vertebral levels. Currently, however, its use in multi-segment changes is becoming more and more popular. Among the procedures performed using the anterior approach, the most common are anterior cervical discectomy with fusion and anterior corpectomy with fusion. During the procedure, it is possible to remove the intervertebral disc, parts of the vertebral body, as well as osteophytes and/or the anterior longitudinal ligament of the spine, responsible for pressure on the spinal cord. Decompression is performed with the patient lying down, and access is obtained through a transverse incision for surgery at one or two levels, or an oblique incision parallel to the medial edge of the sternocleidomastoid muscle for surgery at three or more levels. [1]

The discectomy procedure allows the removal of osteophytes, the ossified posterior longitudinal ligament, as well as part or the entire intervertebral disc that causes pressure on the spinal cord. If the disc is completely removed, a prosthesis or a special cage filled with artificial bone is implanted in its place to achieve fusion. Implantation of an autograft taken from the iliac bone plate or an allograft may be used. [1]



Fig. 5. Discectomy in the cervical spine with fusion.

J. Bakhsheshian, V. A. Mehta, and J. C. Liu, *Current Diagnosis and Management of Cervical Spondylotic Myelopathy*, Global Spine Journal, vol. 7, no. 6. 2017

Corpectomy allows removal of the vertebral body as well as the intervertebral disc. It is also possible to remove osteophytes and the posterior longitudinal ligament. The removed vertebral body is replaced with a titanium mesh or a bone autograft taken from the patient's hip or an allograft. In addition, it is necessary to stabilize the spine by screwing in a metal plate that holds the bones in the right position. The graft fuses with the vertebra located above and below. [27]

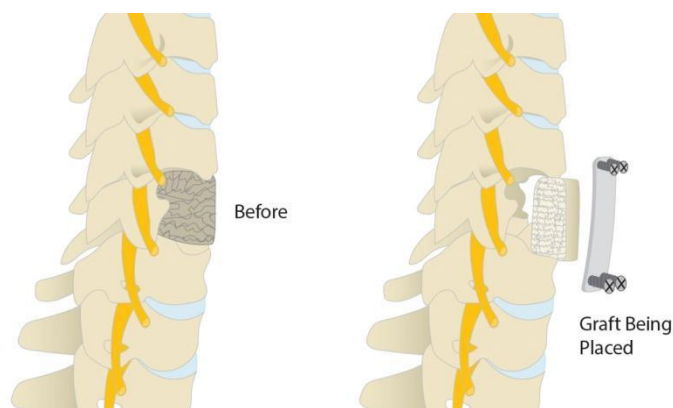


Fig. 6. Corpectomy

<https://atlantaspineinstitute.com/spinal-treatment-options/cervical-corpectomy/>

It is also possible to use a hybrid method - combining a single-level discectomy with a one- or two-level corpectomy and then attaching a stabilizing plate. This method aims to reduce the number of complications. [27]

Adverse symptoms after anterior approach surgery occur with a frequency ranging from 1.6% to 31.3% and may include: dysphagia, permanent or temporary hoarseness, C5 root paralysis, airway obstruction resulting from postoperative edema or hematoma, CSF leak, and infection. . [23, 28]

Surgical treatment using a posterior approach

Treatment using a posterior approach is particularly considered when the pathology affects three or more vertebral levels (multi-segment) with preserved lordosis. Decompression is achieved by performing laminectomy with or without fusion, as well as laminoplasty in the "open door" or "French door" approach.

Laminectomy involves removal of the spinal cord by removing the spinous processes and vertebral arches, often together with the interspinous and supraspinous ligaments, as well as the yellow ligament. With the patient under general anesthesia, lying on his stomach, access is obtained between the paraspinal muscles, and then with a medial approach after cutting the nuchal ligament. Laminectomy may have a negative impact on the stability and axial load of the spine, as well as lead to the formation of scars after surgery that is why it is often associated with postoperative kyphosis and neck pain. Laminectomy is usually performed in conjunction with spinal stabilization using special screws and rods, but this procedure may be associated with postoperative degeneration of adjacent structures and subsequent neurological deterioration. [29]

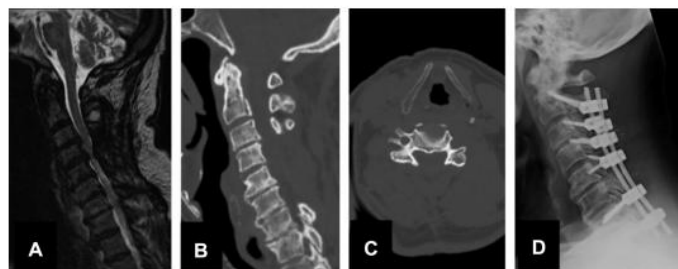


Fig. 7. Pressure changes on the spinal cord in the MR image (A), condition after laminectomy in the CT image (B,C), X-ray, stabilization of the spine after laminectomy (D).

F. H. Abduljabbar, A. R. Teles, R. Bokhari, M. Weber, C. Santaguida, *Laminectomy with or Without Fusion to Manage Degenerative Cervical Myelopathy*, *Neurosurgery Clinics of North America*, vol. 29, no. 1. W.B. Saunders, pp. 91–105, Jan. 01, 2018

In the case of laminoplasty, the widening of the spinal canal is achieved by cutting and spreading the vertebral arches while maintaining the anatomical bone cover along with the ligaments and joints attached to it. Depending on the place of the incision, there are "open-door" laminoplasty (ODL) - an incision of the lamina of the vertebral arch on one side, while the other side acts as a hinge, and "French door" laminoplasty (FDL) - a central incision of the spinous processes without an incision laminae of vertebral arches. The fragments are connected after cutting by using special microblades or sutures. Spinal motion is preserved and the risk of postoperative kyphosis is lower than with laminectomy. Comparing both methods, it was shown that the canal dilatation is greater in the case of ODL, but there are no significant differences in the frequency of bleeding and postoperative pain, C5 palsy, JOA scores or the recovery rate. [29–33]

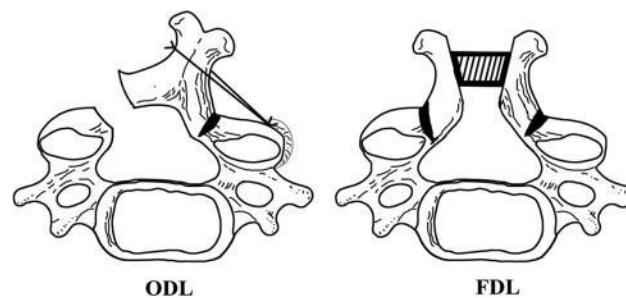


Fig. 8. Laminoplasty open door (ODL) i french door (FDL).

L. Wang, Y. Wang, B. Yu, Z. Li, X. Liu, *Open-door versus French-door laminoplasty for the treatment of cervical multilevel compressive myelopathy*, *Journal of Clinical Neuroscience*, vol. 22, no. 3. 2015

Conclusions

Cervical myelopathy is a chronic, progressive disease which, due to the multitude of neurological symptoms, may significantly affect the daily functioning of patients. The diagnosis can be made based on clinical symptoms and changes visible in imaging tests. Surgical treatment is the most effective method to improve the clinical condition of people suffering from cervical myelopathy. Both anterior and posterior approach surgeries are characterized by similar effectiveness, and the choice of a specific method depends on the

patient's general condition, the degree of cervical lordosis, and the number of affected spinal segments. Due to the correct diagnosis of the disease and applying treatment, it is possible to slow down the progression of the disease and improve the quality of life of patients.

Disclosures

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Investigation- Marta Kozikowska, Agnieszka Pociecha, Bożena Kmak

Writing-rough preparation- Bożena Kmak, Marta Kozikowska, Agnieszka Pociecha

Writing-review and editing- Agnieszka Pociecha, Bożena Kmak, Marta Kozikowska

Visualization- Agnieszka Pociecha, Bożena Kmak, Marta Kozikowska

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