



Understanding the Pathophysiology and Clinical Management of Cervical Radiculopathy: An Updated Review

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Abstract:

Background: Cervical radiculopathy is a prevalent condition that results from the compression or irritation of spinal nerve roots, causing pain and functional limitations in the neck, arms, chest, and upper back. It significantly affects quality of life and contributes to workplace absenteeism. This condition can be caused by disc herniation, degenerative spine changes, and age-related factors, making it a multifactorial disorder.

Aim: This review aims to provide an updated overview of the pathophysiology, clinical management, and treatment strategies for cervical radiculopathy, focusing on non-surgical and surgical interventions, and the importance of early diagnosis and intervention.

Methods: A comprehensive literature review was conducted, analyzing the etiology, epidemiology, pathophysiology, diagnostic methods, and management options for cervical radiculopathy. The review also explores the role of physical therapy, pharmacological treatments, and surgical approaches, emphasizing interprofessional care for optimal outcomes.

Results: The review identifies common causes of cervical radiculopathy, such as disc herniation in younger individuals and degenerative spine changes in older adults. Non-surgical interventions, including physical therapy, anti-inflammatory medications, and epidural steroid injections, provide significant symptom relief for the majority of patients. Surgical options, such as discectomy and fusion, are effective in cases with persistent symptoms or neurological deterioration. The importance of early intervention is highlighted, as most acute cases improve spontaneously within 8-12 weeks.

Conclusion: Cervical radiculopathy is a complex condition requiring a multifaceted approach to management. Non-surgical treatments, especially physical therapy, play a crucial role in alleviating symptoms and improving recovery. Surgery should be reserved for patients with severe or refractory symptoms. A team-based approach involving physical therapists, neurologists, and surgeons is essential for effective management.

Keywords: Cervical radiculopathy, pathophysiology, treatment, physical therapy, non-surgical management, surgical intervention, rehabilitation.

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Introduction:

Neck pain is a highly prevalent condition that can significantly impact on individuals' quality of life, resulting in considerable discomfort and disability across various age groups. It is particularly burdensome in the workplace, as individuals suffering from neck pain are responsible for up to 40% of work absenteeism [1][2][3]. One common cause of neck pain is cervical radiculopathy, a condition in which the nerve root of a spinal nerve becomes compressed or irritated, leading to symptoms that radiate beyond the neck. These symptoms can affect other areas of the body such as the arms, chest, upper back, and shoulders. In addition to pain, the compression of the nerve root may result in muscle weakness and impaired deep tendon reflexes. As a result, cervical radiculopathy not only contributes to neck discomfort but can also cause substantial functional limitations, impacting daily activities and overall productivity. The condition can vary in severity, with some individuals experiencing mild, intermittent pain, while others suffer from debilitating, persistent symptoms. Although the cause of cervical radiculopathy is multifactorial, the condition remains one of the most common musculoskeletal disorders affecting the cervical spine, necessitating effective diagnosis and management to alleviate the symptoms and prevent long-term disability. Early detection and intervention are critical in addressing this debilitating condition and improving patient outcomes.

Etiology

The etiology of cervical radiculopathy primarily involves conditions that result in compression or irritation of the spinal nerve root. In younger individuals, typically between their third and fourth decades, the most frequent cause of nerve root impingement is disc trauma and herniation, which occurs when the intervertebral disc ruptures or shifts and exerts pressure on the nerve root [4]. In contrast, as individuals age, particularly in their fifth and sixth decades, the cause of cervical radiculopathy often shifts toward degenerative changes in the spine. Disc degeneration becomes more prevalent with age and contributes to nerve root compression through the loss of disc height, leading to narrowing of the intervertebral space. By the seventh decade, the primary cause of cervical radiculopathy is foraminal narrowing, a result of arthritis and related degenerative changes in the cervical spine. This narrowing occurs in the foraminal spaces where the nerve roots exit the spinal canal, causing increased pressure on the nerves. The age-related progression from disc herniation to degenerative changes highlights the complex nature of cervical radiculopathy and the impact of aging on spinal health. Understanding the underlying etiology is essential for developing targeted treatment strategies to manage the condition effectively and prevent further spinal deterioration.

Epidemiology

Cervical radiculopathy is less common than lumbar radiculopathy, but it still represents a significant clinical concern, with an incidence rate of approximately 85 cases per 100,000 individuals. Among the various cervical nerve roots, the C7 nerve root is the most frequently affected, accounting for more than 50% of all cases. The C6 nerve root follows, with about 25% of cases involving this level. Nerve roots C1 to C5 and C8 are less commonly involved in cervical radiculopathy. The distribution of affected nerve roots provides insight into the typical patterns of compression and its associated symptoms. Several risk factors contribute to the development of cervical radiculopathy. Occupational activities, particularly those involving manual labor, such as heavy lifting, driving, or operating vibrating equipment, increase the likelihood of developing the condition. These activities can place excessive strain on the cervical spine and contribute to nerve compression over time. Chronic smoking is another significant risk factor, as it can exacerbate degenerative changes in the spine and negatively impact disc health. The combination of environmental and lifestyle factors, along with natural aging processes, plays a critical role in the epidemiology of cervical radiculopathy. Identifying these risk factors can help in the development of preventative measures and early interventions to mitigate the occurrence of cervical radiculopathy in high-risk populations.

Pathophysiology

The pathophysiology of cervical radiculopathy is characterized by inflammation of the nerve root, which is a common feature in nearly all cases of the condition. This inflammation typically results from the acute herniation of an adjacent cervical disc that impinges upon the nerve root. When the intervertebral disc protrudes or ruptures, it compresses the nerve root, triggering an inflammatory response that exacerbates symptoms such as pain, numbness, tingling, and weakness. In addition to acute disc herniation, degenerative changes in the cervical spine can also contribute to inflammation and nerve root compression. Over time, the intervertebral discs may lose hydration and elasticity, leading to disc dehydration and the formation of osteophytes, or bony growths, which can encroach upon the nerve root. These degenerative changes often worsen the inflammatory response, further intensifying the pain and functional impairments associated with cervical radiculopathy. The direct compression of the nerve root by disc herniation or osteophytes impairs normal nerve function, leading to sensory disturbances such as tingling or numbness and motor deficits such as weakness. In more severe cases, these effects can significantly impact the individual's ability to perform daily activities. Understanding the underlying inflammatory processes is crucial for developing targeted therapies to reduce pain and promote nerve healing in individuals with cervical radiculopathy.

History and Physical Examination

When evaluating patients with complaints of radicular pain or muscle weakness, a comprehensive history should be obtained, including inquiries about occupational risk factors, any history of trauma, and the patterns of pain experienced. Cervical radiculopathy typically manifests unilaterally, although in rare instances, both nerves at the same spinal level may be involved. These uncommon presentations can complicate physical diagnoses, necessitating the use of advanced imaging, particularly in cases where trauma is a contributing factor. During the physical examination, positioning the patient appropriately is critical to isolate specific reflex arcs, which facilitates a more accurate assessment of reflex responses. Since deep tendon reflexes can vary considerably between individuals, it is more relevant to compare reflex responses between the affected and unaffected sides of the neck rather than focusing solely on their overall magnitude. If nerve impingement is present, the reflexes on the affected side will typically be diminished in comparison. Muscle strength, particularly in muscles innervated by the affected nerve, should also be assessed as a significant weakness that may indicate nerve root compression. The Spurling test, which involves compressing the foramina of the cervical spine, is a common diagnostic tool. A positive result occurs when pain radiates down the ipsilateral upper limb during head extension and rotation. Additionally, cervical traction may offer symptom relief in some cases of radicular pain.

Evaluation

The evaluation of cervical radiculopathy often begins with plain x-ray imaging of the cervical spine to assess for structural abnormalities that could explain neck and upper extremity pain. Lateral x-ray views may reveal disc space narrowing, while oblique views can identify foraminal narrowing at the level of the radicular symptoms. Open-mouth views are typically reserved for suspected atlantoaxial joint disruptions [5][6][7][8]. In acute cases, a computed tomography (CT) scan can be valuable in detecting traumatic injuries that may lead to radicular symptoms. However, CT scans have limited utility in chronic cases due to their poor soft tissue resolution. Magnetic Resonance Imaging (MRI) is the gold standard for evaluating radiculopathies, as it provides superior visualization of soft tissue abnormalities, such as disc herniations and nerve compressions. Although MRI findings like disc herniations and foraminal narrowing correlate strongly with radicular symptoms, these abnormalities do not always cause the symptoms, highlighting the potential for false positives. Electromyography (EMG) can help confirm nerve root dysfunction, while selective nerve root blocks serve both as diagnostic tools and short-term pain relief measures, helping to confirm the source of radiating pain.

Treatment and Management

Management of cervical radiculopathy follows a stepwise approach, as most cases resolve without the need for surgery. Over 85% of acute cervical radiculopathy cases improve spontaneously within 8 to 12 weeks without specific interventions [9][10][11]. However, to alleviate nerve root inflammation and promote recovery, non-surgical treatments are essential. Oral anti-inflammatory medications, physical therapy, and translaminar epidural steroid injections are commonly employed to reduce inflammation and alleviate symptoms. A well-structured physical therapy program is particularly effective in providing relief, and it can also aid in recovery following surgical interventions. Medical devices such as cervical pillows used during sleep or a soft cervical collar worn temporarily may offer symptomatic relief. Since inflammation is the primary cause of pain in cervical radiculopathy, non-steroidal anti-inflammatory drugs (NSAIDs) are typically used for a period of 1 to 2 weeks to provide relief. Oral steroids should be limited to short durations due to concerns regarding their prolonged use. Adjunct medications, such as tricyclic antidepressants and gabapentin, have also shown efficacy in managing symptoms. The routine use of opioid pain medications is not recommended, as they may lead to prolonged recovery and delayed return to work, particularly in patients who may eventually require surgical intervention [12][13]. Additionally, studies have demonstrated that epidural steroid injections can provide substantial pain relief and speed up functional recovery, with many patients experiencing 50% or greater relief for several weeks after treatment. Complementary therapies, such as acupuncture, can also provide significant symptomatic relief. However, certain treatments, like chiropractic manipulation, may exacerbate radicular symptoms. In contrast, osteopathic techniques that are indirect may help alleviate symptoms.

For patients who fail to respond to conservative treatments, surgical intervention may be necessary. The two primary approaches for surgery are anterior and posterior techniques. The anterior approach generally involves performing a discectomy, followed by fusion or disc replacement, whereas the posterior approach may involve laminectomy, partial discectomy, and foraminotomy, with or without fusion. Both approaches have proven to be effective, but surgery is typically reserved for cases with failed conservative treatment or significant neurological deterioration. Like any surgical procedure, cervical spine surgery carries risks, including complications from anesthesia and potential procedure-related issues, such as nerve palsies, vascular injury, or laryngeal nerve damage.

Differential Diagnosis

When diagnosing cervical radiculopathy, several other conditions must be considered to differentiate them from radiculopathy itself. These include brachial plexus injuries, which are common in sports medicine and can mimic symptoms similar to radiculopathy. Cervical disc injuries also need to be differentiated, as they can present with similar neurological deficits due to compression of nerve roots. Additionally, cervical discogenic pain syndrome may present with radicular-like symptoms, but its origin lies in disc degeneration rather than nerve root compression. Cervical facet syndrome, another potential diagnosis, involves pain originating from the small joints in the cervical spine and can be mistaken for radiculopathy. Cervical spine sprains, resulting from trauma or excessive movement, could also cause pain and stiffness that mimics radiculopathy. Finally, rotator cuff injuries and strain injuries should also be considered, as they can produce shoulder and upper limb pain that might be confused with radicular pain originating from the cervical spine.

Postoperative and Rehabilitation Care

Rehabilitation for cervical radiculopathy often incorporates manual-based treatments, such as traction, mobilization, and manipulation. Among these, traction is considered a cornerstone of rehabilitation, supported by available literature for its effectiveness in relieving radicular symptoms. Additional manual therapies, including massage, stretching, strengthening exercises, and neurodynamic exercises, are frequently included in rehabilitation protocols to address muscle weakness and nerve involvement. Research comparing mechanical traction to manual traction suggests that mechanical traction may provide superior outcomes, although the evidence remains limited and further investigation is needed to fully

validate these findings. These therapeutic strategies have demonstrated several benefits, including pain reduction, improved functional outcomes, and accelerated recovery, particularly when initiated promptly and applied aggressively. Despite these advantages, the specific effectiveness of individual therapies has yet to be conclusively proven in the literature. A combined approach utilizing these interventions has been found to significantly alleviate radiculopathy symptoms. Nonetheless, additional studies are required to provide a more thorough understanding of the optimal treatment strategies for cervical radiculopathy [14][15].

Enhancing Healthcare Team Outcomes

Effective management of cervical radiculopathy necessitates an interprofessional approach involving a neurologist, neuro or orthopedic surgeon, physical therapist, nurse practitioner, and primary care provider. This team-based approach ensures comprehensive treatment and management of the condition. While surgery can offer relief in certain cases, the evidence suggests that it does not consistently provide superior outcomes when compared to non-surgical treatments in the acute phase. In fact, over 85% of acute cervical radiculopathy cases resolve spontaneously within 8 to 12 weeks, without the need for any specific interventions [17][18]. Supportive care primarily consists of non-surgical treatments, including the use of anti-inflammatory medications, physical therapy, and translaminal epidural steroid injections. Although a range of surgical options exists for those who do not respond to conservative measures, these procedures carry inherent risks and complications. Moreover, there are instances where surgical interventions fail to provide significant improvement, leaving patients with persistent, chronic disabilities. For such patients, surgical options should be considered only as a last resort when all non-surgical methods have been exhausted, and symptoms continue to impair function and quality of life.

Physical Therapy Interventions and Guidelines:

Physical therapy (PT) is a cornerstone of conservative treatment for cervical radiculopathy, aimed at alleviating pain, improving function, and preventing further deterioration of the condition. The therapeutic interventions are typically individualized, depending on the severity of symptoms, the patient's overall health, and the specific stage of radiculopathy.

Initial Phase: Pain Reduction and Protection

In the acute phase of cervical radiculopathy, the focus of physical therapy is on pain management and protection of the cervical spine. Manual therapy techniques, such as soft tissue mobilization and gentle joint mobilizations, are used to reduce pain and muscle spasm. Traction (manual or mechanical) is often employed to relieve nerve root compression and improve spinal alignment. Cold therapy may also be utilized to decrease inflammation and swelling in the initial stages. A soft cervical collar may be recommended for short-term use to provide support and reduce strain on the cervical spine during movement. Additionally, postural education plays a crucial role in this phase, as poor posture can exacerbate symptoms by placing additional pressure on the cervical spine.

Intermediate Phase: Strengthening and Flexibility

Once acute pain is under control, the focus shifts to improving muscle strength, flexibility, and postural stability. Strengthening exercises targeting the deep cervical flexors and the upper back muscles are essential for stabilizing the cervical spine and preventing recurrence of symptoms. Exercises such as chin tucks and isometric holds can help strengthen the cervical extensor muscles. Neurodynamic exercises, which aim to improve nerve mobility and reduce irritation, are also integral to treatment. Stretching exercises for the cervical spine, upper back, and shoulders help alleviate tension and improve flexibility, further reducing the likelihood of nerve impingement.

Advanced Phase: Functional Training and Return to Activity

In the later stages of rehabilitation, functional training is crucial to ensuring the patient can return to normal daily activities. This includes exercises designed to enhance range of motion and endurance in the neck and upper extremities. Core strengthening exercises and activities that promote ergonomics are

emphasized to ensure that the patient can maintain proper posture during work or physical activity. Aerobic exercises, such as walking or stationary cycling, are also beneficial to improve overall conditioning without exacerbating symptoms.

Patient Education and Long-Term Maintenance

Through physical therapy, education on self-management strategies is vital. Patients are taught how to avoid postural strain, how to perform ergonomically correct movements at work or home, and how to incorporate exercises into their daily routine for long-term maintenance. Regular follow-up sessions may be necessary to ensure sustained improvement and address any recurring symptoms or challenges. Overall, physical therapy plays a pivotal role in treating cervical radiculopathy by addressing both the acute symptoms and long-term functional deficits. A multidisciplinary approach involving collaboration with other healthcare providers is essential for optimal patient outcomes.

Conclusion:

Cervical radiculopathy is a common, yet complex disorder caused by nerve root compression in the cervical spine. Its multifactorial etiology includes factors such as disc herniation, degenerative spine changes, and foraminal narrowing, which increase with age. Understanding these underlying causes is essential for effective diagnosis and treatment. The clinical manifestations of cervical radiculopathy—ranging from pain and numbness to muscle weakness—can significantly affect daily functioning, making early diagnosis and intervention crucial in preventing long-term disability. Non-surgical management remains the first-line treatment for most cases. A combination of physical therapy, anti-inflammatory medications, and corticosteroid injections has been shown to alleviate symptoms and promote recovery. Physical therapy interventions, including manual therapy, traction, and neurodynamic exercises, are particularly beneficial in addressing the inflammation, muscle weakness, and functional impairments associated with the condition. The use of cervical collars or pillows may also provide short-term relief during sleep and rest periods. For patients who do not respond to conservative treatments, surgical options such as discectomy, fusion, or laminectomy may be considered. Surgical interventions are typically reserved for cases with progressive neurological deficits or severe, unrelenting symptoms that do not improve with non-surgical management. Both anterior and posterior surgical techniques are effective, but they come with inherent risks, including anesthesia complications and potential nerve damage. It is important to note that while surgery can offer relief, it does not always result in superior outcomes compared to conservative treatments, especially in the acute phase. Over 85% of acute cases resolve spontaneously within 8-12 weeks, highlighting the importance of avoiding unnecessary surgical interventions. For patients with chronic, persistent symptoms, a comprehensive rehabilitation program that includes manual therapies and strengthening exercises can greatly improve functional outcomes and quality of life. In conclusion, the management of cervical radiculopathy requires an interprofessional approach involving neurologists, orthopedic surgeons, physical therapists, and other healthcare providers. Early detection and a tailored, stepwise treatment plan can significantly reduce the burden of this condition and improve long-term recovery outcomes. Future research should focus on optimizing non-surgical therapies and identifying the most effective rehabilitation techniques to further enhance patient outcomes.

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الملخص:

الخلفية: اعتلال الجذور العنقية هو حالة شائعة تنتج عن الضغط أو التهيج على جذور الأعصاب الشوكية، مما يسبب الألم والقيود الوظيفية في الرقبة، والذراعين، والصدر، والظهر العلوي. تؤثر هذه الحالة بشكل كبير على جودة الحياة وتساهم في غياب الموظفين عن العمل. يمكن أن تكون هذه الحالة ناتجة عن انزلاق غضروفي، وتغيرات تنكسية في العمود الفقري، وعوامل تتعلق بالعمر، مما يجعلها اضطرابًا متعدد العوامل.

الهدف: تهدف هذه المراجعة إلى تقديم نظرة محدثة حول الفيزيولوجيا المرضية، والإدارة السريرية، واستراتيجيات العلاج لاعتلال الجذور العنقية، مع التركيز على التدخلات غير الجراحية والجراحية، وأهمية التشخيص المبكر والتدخل.

الأساليب: تم إجراء مراجعة شاملة للأدبيات، حيث تم تحليل الأسباب، وعلم الأوبئة، والفيزيولوجيا المرضية، وطرق التشخيص، وخيارات العلاج لاعتلال الجذور العنقية. كما تستعرض المراجعة دور العلاج الطبيعي، والعلاجات الدوائية، والنهج الجراحية، مع التركيز على الرعاية المشتركة بين المهنيين لتحقيق أفضل النتائج.

النتائج: تحدد المراجعة الأسباب الشائعة لاعتلال الجذور العنقية، مثل الانزلاق الغضروفي لدى الأفراد الأصغر سنًا، والتغيرات التنكسية في العمود الفقري لدى كبار السن. توفر التدخلات غير الجراحية، مثل العلاج الطبيعي، والأدوية المضادة للالتهابات، وحقن الستيرويد فوق الجافية، تخفيفًا كبيرًا للأعراض لمعظم المرضى. تعتبر الخيارات الجراحية، مثل استئصال القرص والدمج، فعالة في الحالات التي تستمر فيها الأعراض أو يحدث تدهور عصبي. تم التأكيد على أهمية التدخل المبكر، حيث تتحسن معظم الحالات الحادة تلقائيًا خلال 8-12 أسبوعًا.

الخلاصة: يعتبر اعتلال الجذور العنقية حالة معقدة تتطلب نهجًا متعدد الجوانب في إدارتها. تلعب العلاجات غير الجراحية، وخاصة العلاج الطبيعي، دورًا حيويًا في تخفيف الأعراض وتحسين التعافي. يجب أن تكون الجراحة مخصصة للمرضى الذين يعانون من أعراض شديدة أو مقاومة للعلاج. يعد النهج الجماعي الذي يشمل أخصائي العلاج الطبيعي، وأطباء الأعصاب، والجراحين أمرًا أساسيًا للإدارة الفعالة.

الكلمات المفتاحية: اعتلال الجذور العنقية، الفيزيولوجيا المرضية، العلاج، العلاج الطبيعي، الإدارة غير الجراحية، التدخل الجراحي، إعادة التأهيل.