Cervical radiculopathy is a general term describing a set of symptoms. This symptom complex may arise from several causes, including nerve root irritation, myofascial pain syndromes, and soft tissue injuries. This review will concentrate on cervical syndromes that are caused by radiculopathy.

Cervical radiculopathy is a pathologic process involving the nerve root, arising from cervical disc herniation, cervical spondylosis, tumor (benign or malignant), or trauma causing nerve root avulsion. Cervical radiculopathy may also occur in a setting in which no definite cause can be determined. Historical, physical examination, and laboratory features seen in cervical radiculopathy of any cause are addressed. This review will also delineate the clinical, physical, and laboratory features, highlight similarities, emphasize ways to distinguish the various etiologies, discuss differential diagnosis, outline certain laboratory and testing procedures, particularly computed tomography (CT) scan, magnetic resonance imaging (MRI) and electrodiagnostic testing, and address treatment and prognosis.

We review the clinical aspects of cervical radiculopathy and cite research performed, but this review does not represent a meta-analysis of all research on this topic. Articles were obtained through a Medline search of the literature of the past 10 years, a review of bibliographies in text books, and a review of bibliographies in the articles found in the Medline search. Articles were selected based on historical, clinical, or research data they contained.

HISTORICAL PERSPECTIVE

Cervical radiculopathy or “radiculitis” particularly associated with intervertebral disc rupture as a cause of “brachial pain” was not distinguished from other causes of upper extremity pain attributed to “neuritis,” “fibrositis,” and “myalgia” in the early 20th century.1 As early as 1936, however, there were descriptions of shoulder girdle, arm, and precordial pain attributed to “cervical arthritis” resulting in “irritation or inflammation of the cervical spinal roots.”2 Cervical disc herniation resulting in cord compression and myelopathy was recognized as a syndrome in the early 20th century, but was initially attributed to spinal cord tumors termed “chondromas.”3 This syndrome of cord compression was defined as a ruptured disc by Mixter and Ayer in 1935, shortly after the report by Mixter and Barr in 1934 of disc herniation as the etiology of “sciatica” in the lumbar region.

It was not, however, until the early 1940s that Semmes and Murphey and shortly thereafter Spurling and Scoville, and Michelsen and Mixter6 directly related “cervical radiculitis,” in the absence of cervical myelopathy, to ruptured cervical intervertebral discs. At that time, Spurling and Scoville also described the “neck compression test,” which has since become known as Spurling’s test. Subsequent articles published at the end of that decade defined the relationship between cervical radiculopathy, upper extremity pain, and protruded cervical intervertebral discs.

ANATOMY

There are seven cervical vertebra that articulate via the zygoapophyseal (facet) joints located at the posterior portion of the vertebrae. The uncovertebral joints, or joints of
Luschka, are located on the lateral aspect of the vertebral body and composed of the sharply defined bony margins about the superior rim of each vertebra articulating with the facet of the vertebra above it. This area is often the site of abnormal bony overgrowth that can compromise the vertebral canal or neural foramen. The eight cervical nerve roots exit via intervertebral foramina, which are bordered anteromedially by the vertebral disc, and posterolaterally by the facet joints. The foramina are largest at C2-3 and progressively decrease in size to C6-7. The nerve root occupies about 1-4 to 1-3 of the space in the foramina, accompanied by spinal radicular arteries and intervertebral veins. The first cervical nerve root exits between the occiput and atlas (C1 vertebra) and all subsequent roots exist above their correspondingly numbered cervical vertebral except the C8 root, which exits below C7 and above T1. Therefore, C5-6 disc herniation or foraminal narrowing will affect the C6 root, and a similar C6-7 lesion will affect the C7 root. Due to differential growth of the vertebra and spinal cord, the lower cervical vertebrae are at the same level as the next lower spinal segment. The C5-6 interspace is therefore opposite the C7 spinal level where the C7 nerve root arises and the C6 root exits. The C7 root then descends from this level to exit between the C6 and C7 vertebrae. Myotomal and dermatomal distributions of the cervical nerve roots are depicted in table 1 (myotomes) and the figure (dermatomes).

**PATHOANATOMY AND PATHOPHYSIOLOGY**

The nerve root is vulnerable to compression in the intervertebral foramen by three structures: the facet joint, the uncovertebral joints, and the disc. The most common cause of cervical radiculopathy is a herniated cervical disc, followed by cervical spondylosis with or without myelopathy. Hypertrophic facet and uncovertebral joints can encroach on the nerve root, and the disc may rupture or become calcified. The effect of these processes may be enhanced when there is congenital narrowing of the spinal canal. The disc herniations have been divided into "soft" and "hard," the former being ruptured nucleus pulposus, the latter referring to an intraforaminal spur from the uncovertebral or facet joint or to disc hardening, thickening, or calcification causing a median ridge and potential root and cord pressure. Recent literature refers to the "hard disc" as cervical spondylosis either with or without myelopathy or radiculopathy.

The precise mechanism whereby disc herniation or spondylosis causes radicular pain is still unclear. Experimentally, referred pain can be generated from several structures in the cervical spine probably including the disc (shown to have innervation to the outer third of the annulus), from the periosteum, ligaments, fascia, or the nerve root. Direct pressure on the root, however, does not necessarily cause pain, and pure motor deficit may occur. Proposed mechanisms for pain in radiculopathy include increased discharge of dorsal root ganglia whose axons have undergone neurotmesis, mechano-sensitivity or chemo-sensitivity of the nerve root itself, or direct pressure on chronically injured axons or normal dorsal root ganglia. Causes of cervical radiculopathy other than disc herniation or cervical spondylosis include tumor, trauma, sarcoidosis, arthritis, and athetoid and dystonic cerebral palsy.

**CLINICAL PICTURE**

The most commonly involved nerve roots in cervical radiculopathy are the sixth and seventh cervical roots, which are caused by C5-6 or C6-7 disc herniation, or spondylosis. Which of these is the most commonly involved nerve seems to depend on the case series. Odom, in a series of 246 cases, found C7 root with C6-7 disc involvement in 70% of cases, the C6 root with C5-6 disc in 24% of cases, whereas Lundsford, in a series of 334 patients, found 48% C6 root with C5-6 herniation, and 37% C7 root with C6-7 herniation. The series of 846 patients by Henderson and colleagues demonstrated some of the difficulty in determining the level of the radiculopathy. Triceps weakness (C7) was present in 37% of the patients, and biceps (C6) weakness in 28%. Surgery based on sensory findings and myelographic abnormalities was performed on 449 cases (53.1%) at C5-6 (C6 root) and only 45.6% at C6-7 (C7 root). Most studies determining radiculopathy on a clinical basis however found a preponderance of C7 radiculopathies (table 2).

**Symptoms and History**

The symptoms of cervical radiculopathy are pain, paresthesia or weakness, or a combination of these symptoms. Evaluation for radiculopathy should include a careful history to delineate the precipitating cause, the distribution, duration, and frequency of pain, paresthesia or weakness, occurrence

| Myotomal root innervation based on a series of 255 operated patients (Treanor personal communication); Mayo Clinic's Clinical Examinations in Neurology. See Hollinshead for a full discussion of individual variation. Underscores represent the primary root innervation most used. | |

| Rhomboids | 5 |
| Supraspinatus | 5 6 |
| Infraspinatus | 5 6 |
| Deltoid | 5 6 |
| Brachialis | 5 6 |
| Biceps Brachii | 5 6 |
| Brachioradialis | 5 6 |
| Supinator | 5 6 |
| Ext. C. Rad. Longus | 5 6 7 |
| Ext. C. Rad. Brevis | 5 6 7 |
| Pronator Terca | 5 6 7 |
| Serratus Anterior | 5 6 7 |
| Pectoralis Major Upper | 5 6 7 |
| Pectoralis Major Lowern | 5 6 7 8 |

Table 1: Myotomes

| Latissimus Dorsi | 6 7 8 |
| Flex. Car. Radialis | 6 7 8 |
| Triceps Brachii | 6 7 8 |
| Ext. Carp. Ultn. | 6 7 8 |
| Ext. Dml. Comm. | 6 7 8 |
| Ext. Pollicis Longus | 6 7 8 |
| Flex. Dml. Super | 6 7 8 |
| Flex. Dml. Profundus | 6 7 8 |
| Flexor Pollicis Longus | 6 7 8 |
| Flex. Carp. Ulnaris | 6 7 8 |
| Abd. Polll. Brevis | 6 7 8 |
| Opponens Pollicis | 6 7 8 |
| Ist Dorsal Interoseous | 6 7 8 |
| Abd. Digits Quanti | 6 7 8 |
Arrangement of the dermatomes on the anterior (a) and posterior (b) aspects of the upper extremity. (Note: According to ASIA Standards, the forefinger is C6 and ring finger is C8 dermatome. Other differences are not substantive). (Reprinted with permission.)

Physical Examination

Physical examination should begin with careful observation of the neck position and movement during the history and physical examination. The presence of atrophy may help in “dating” the radiculopathy. Areas to observe carefully for atrophy include for C5 or C6 root the suprascapular and infrascapular areas (supraspinatus and infraspinatus) and upper lateral arm (deltoid); for C7 root the posterior arm (triceps); for C8 root the thenar eminence; and for T1 root between the thumb and index finger (first dorsal interosseous). The patient should also be observed and tested for scapular “wringing,” which may occur with C6 or C7 radiculopathy. At times, palpation of the above-mentioned muscles may allow the examiner to detect abnormalities before atrophy can be visually detected.

Manual muscle testing is of prime importance and has been shown by Yoss to have greater specificity than either reflex or sensory examination. There may be overlap in the myotomes, although this is less likely to be variable than dermatomal overlap. Some of this variation may be due to intradural connections between nerve roots described to occur at the level of posterior (sensory) and anterior (motor) rootlets. Despite the variations in clinical findings, single root level involvement can be diagnosed by clinical means 75% to 80% of the time. Manual muscle testing should be performed in the antigravity position using the techniques described by the Medical Research Council (MRC) to detect minimal weakness. Attempts should be made to detect weakness in the myotomal distribution of the nerve root involving at least two or three peripheral nerves in order to exclude a peripheral nerve lesion as the etiology of the weakness. For example, C6 root entrapment causes weakness in shoulder abduction and external rotation (axillary and suprascapular nerve) and elbow flexion (musculocutaneous nerve). The distribution of motor weakness present with various root involvement is listed in Table 3. To detect minimal weakness, test external shoulder rotation for C5 or C6 nerve root; finger extension or elbow extension with the elbow in 90° of flexion for the C7 nerve root. Sensory examination for cervical radiculopathy is much less reliable than motor because of the considerable overlap of dermatomes. The most common patterns of sensory and reflex changes are outlined in Table 3 and normal sensory distribution is depicted in the figure. Gait and lower extremity reflexes, motor and sensory function must be examined to detect cord compression. This may occur (albeit rarely) with soft disc herniation (eg, central) but is more frequently caused by cervical spondylitis.

The neck compression test, first described by Spurling in 1944 helps to localize the symptom to the cervical spine. It is extremely helpful in the diagnosis of cervical radiculopathy when present because of its high specificity, although its sensitivity is low and thus its absence does not preclude

<table>
<thead>
<tr>
<th>Root Level</th>
<th>Odom</th>
<th>Lundsford</th>
<th>Yoss</th>
<th>Honet</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>2%</td>
<td>10%</td>
<td>2%</td>
<td>0</td>
</tr>
<tr>
<td>C6</td>
<td>27%</td>
<td>48%</td>
<td>19%</td>
<td>15.8%</td>
</tr>
<tr>
<td>C7</td>
<td>65%</td>
<td>37%</td>
<td>9%</td>
<td>75.6%</td>
</tr>
<tr>
<td>C8</td>
<td>2%</td>
<td>2%</td>
<td>10%</td>
<td>14.6%</td>
</tr>
</tbody>
</table>

* Five patients with 2 level root involvement.
Differential Diagnosis

There are a number of disorders that must be distinguished from cervical radiculopathy or cervical radiculopathy with myelopathy. Idiopathic brachial plexopathy (IBP) or neuralgic amyotrophy is a disorder of undetermined etiology that may affect any combination of nerves in the upper limb, cranial nerves, or less commonly, a single upper limb nerve.5,57 IBP usually presents with severe pain later followed by weakness and eventually by atrophy. At its onset, it may be difficult to distinguish from cervical radiculopathy, particularly when the upper trunk of the brachial plexus is involved, mimicking a C5 or C6 cervical radiculopathy. Distinguishing features of IBP are the high intensity of the pain followed by weakness, reproduction of pain with local maneuvers (Yergason's sign, painful arc), and local tenderness help distinguish these disorders. If initial treatment does not resolve the problem, electrodiagnostic studies and further radiologic studies should be performed.

Upper limb nerve entrapments (median, ulnar, and radial) are characterized by pain, paresthesia, and weakness in the distribution of a single peripheral nerve in contrast with the multiple nerve pattern of cervical radiculopathy. Median neuropathy at the wrist, however, may present with proximal symptoms as high as the neck. Tinel's sign, tapping with a finger or instrument over a peripheral nerve, results in radiating pain or paresthesia in the distribution of the nerve, and is often present with peripheral nerve entrapment. These entrapments may coexist with cervical radiculopathy as reported in the "double crush" phenomenon.56 EMG, by defining the distribution of abnormalities, helps to differentiate between an entrapment syndrome and a monoradiculopathy.57,58

When cervical radiculopathy occurs with myelopathy, syringomyelia and motor neuron disease—particularly amyotrophic lateral sclerosis (ALS)—should be excluded. These disorders may pose some of the most difficult diagnostic challenges. The diagnosis of syringomyelia has been greatly facilitated by MR.59 Clinically, a band of paresthesia, especially involving the upper thorax, may be present with cervical syringomyelia.

ALS is characterized by the absence of sensory abnormality and presence of motor neuron abnormalities in the lower limb(s). The latter may be detected only with careful electromyographic examination. If ALS is suspected, careful electrodiagnostic examination of the tongue, facial muscles, and
sternocleidomastoid or trapezius to detect bulbar disease may be the key to making the proper diagnosis if bulbar motor neuron disease is present.

Multiple sclerosis has also been described in association with radiculopathy, particularly cervical radiculopathy. It should be suspected if symptoms or signs such as diplopia or dysarthria suggest abnormalities above the foramen magnum.60

**DIAGNOSTIC STUDIES**

Diagnostic studies are used to evaluate structural (eg, x-ray, CT, MR) or functional abnormalities (eg, EMG, nerve conduction, SSEP). These areas will be briefly addressed.

**Imaging Techniques**

The diagnosis of radiculopathy cannot be based only on spinal imaging. Brain in 195261 first determined that radiologic evidence of disc degeneration did not necessarily imply disc herniation. Although comparative radiologic studies such as those by Tapiovaara in 195262 and Friedenberg in 196363 found a statistically greater amount of disc degeneration, foraminal narrowing, or uncovertebral joint abnormalities in patients with cervico-brachial pain, the difference was not great enough to permit clinical decision making in individual cases.62,63 This is particularly true because 70% of asymptomatic women and 95% of asymptomatic men between the ages of 60 and 65 have been shown to have degenerative changes of the cervical spine on x-ray.64 Similarly, cervical myelograms have been shown to be abnormal in 21% of asymptomatic individuals in a classic study by Hitselberger in 1968.65 More recently, these findings, albeit in the lumbar spine, have been extended to CT66 and MR.67

Imaging techniques can be a valuable adjunct to the diagnosis and treatment of patients with cervical radiculopathy by defining the structural abnormality leading to the radiculopathy, but there is wide agreement that they must be used only with proper clinical correlation.68,69 There is also agreement that further study is needed to define precise algorithms for the most appropriate sequence of performing these imaging studies.68-70 Even when algorithms are proposed, they usually address which technique to use next rather than when the study is indicated based on ongoing or changing clinical findings.71 The following, therefore, represents the authors’ viewpoint using whatever support the literature offers.

The cervical spine radiograph can be used as an initial screening tool, but need not be performed until treatment is attempted.72-74 An AP and lateral film, including flexion and extension views, should be performed and are of particular value in determining spine stability after trauma or in cases of rheumatoid arthritis or ankylosing spondylitis. They may detect unsuspected fractures or tumors. The cost effectiveness of multiple views has been questioned in relation to the lumbar spine,69 and cervical spine.75 The value of spinal radiographs in nontraumatic disorders has also been questioned,75,76 however, the studies regarding the cervical spine were performed outside of the United States, and each individual practitioner must evaluate the standard of practice in his or her community.

The performance of imaging studies beyond the plain cervical spine radiograph is usually not initially indicated. Imaging studies should be reserved for patients when symptoms and findings are not classic and lead to suspicion of one of the disorders outlined in the differential diagnosis; cervical myelopathy is present, especially acutely or subacutely, the patient is not improving with treatment as expected; progression of the neurologic deficit is occurring; or surgical treatment is contemplated.

The preferred imaging method has been much discussed in the literature, and several studies have compared CT, myelography, and MR.77-79 Initial studies found a close correlation between the three techniques. Later investigations demonstrated a higher correlation of MR findings with operative findings than either myelogram80 or CT.81 This was particularly true if plain cervical spine x-rays were used to supplement the MR scan.80 Current radiologic opinion is that MR is the technique of choice in cervical radiculopathy.82

The clinician should be aware of several caveats: (1) MR results are technique-specific and dependent on the quality of the magnet used and the expertise of the neuroradiologist interpreting the image, (2) If MR is unavailable and CT is used for cervical spine imaging, contrast enhancement significantly improves sensitivity in identifying disc herniation83; (3) If the imaging is performed presurgically, the surgeon may feel most comfortable with a certain technique and should be consulted prior to ordering the study; (4) Each practitioner should become familiar with interpreting these scans since they are valuable only when they are correlated with clinical findings.84

**Electrodiaagnosis**

Electrodiaagnostic studies are an important adjunct in the diagnosis of cervical radiculopathy because they identify the physiologic abnormality in the nerve root and help determine if a visualized anatomic defect is causing axonal pathology, or if axonal pathology is present in the absence of an anatomic defect. The electrophysiologic diagnosis of radiculopathy has been the subject of two recent thorough reviews.84,85

Electromyography is a well proven technique in the evaluation of radiculopathy84 and shows a close correlation with myelography and operative findings.86 This has been investigated more thoroughly in lumbar radiculopathy where EMG has been found to correlate with surgical or clinical findings as well, or better, than CT or myelography.87-89 EMG in the cervical region has been studied by Marinacci86 who studied 161 patients in 1966. In this series, the correlation between surgical findings, EMG, or myelogram approached 90%. Neogrín and colleagues80 found a concurrence of approximately 77% between the EMG root abnormality and the level shown on myelography. Partanen and coworkers88 studied 360 patients retrospectively. In 77 of 360 patients who underwent both EMG and myelography with subsequent surgery, 26 patients had sensory impairment, and only 34 had motor weakness or atrophy. They found an “accurate diagnosis” by EMG in 57% of the patients. Only 36% of their patients with a negative EMG showed improvement after surgery. However, Partanen’s group did not correlate the EMG abnormalities with motor weakness. This points out the difficulty
in some of these studies, particularly in view of studies by Hitselberger and Boden indicating that large percentages of normal individuals may have abnormalities on myelogram or MR of the cervical spine.

The EMG will provide the anatomic distribution of the abnormalities thereby facilitating diagnosis and differentiating cervical radiculopathy from some of the syndromes in the Differential Diagnosis Section. Careful electromyographic examination can help "date" the lesion. The age of the lesion can be roughly approximated using needle electromyography. The first abnormality, which may be seen immediately after motor root compromise, is decreased recruitment. Positive waves and fibrillation potentials will first occur 18 to 21 days after the onset of the radiculopathy. The fibrillation potentials are larger in early, and smaller in long-standing peripheral nerve lesions, but within the first 6 months post lesion there is a variability in the amplitude. The clinical usefulness of this method in cervical radiculopathy remains unproven. The motor units will increase in size, duration, and number of phases in radiculopathies where collateral sprouting occurs. Some of these changes, particularly polyphasia, may occur as early as 3 to 4 weeks after the onset of the lesion. In "old" radiculopathies, large motor unit action potentials may be the only abnormal finding. The amplitude of the evoked motor response in motor conduction studies can help differentiate between axonal loss and neuropraxia thereby aiding in determining prognosis.

In the presence of severe motor involvement, sensory conduction studies can be useful in distinguishing cervical radiculopathy from a more distal source of paresis. In cervical radiculopathy or root avulsion, the sensory evoked potential will be normal because the root lesion is proximal to the dorsal root ganglia, whereas with a peripheral lesion (eg, plexopathy) there may be severe reduction or absence of the sensory evoked potential.

Electrodiagnostic techniques other than standard EMG and nerve conduction studies are much less useful in the evaluation of cervical radiculopathy and need be used only under special circumstances. The H-reflex is consistently obtainable only from the tibial nerve, although a number of studies have convincingly demonstrated that it can be obtained from the median nerve by placing the active electrode over the flexor carpi radialis. These have not found their way into general electrodiagnostic practice.

The F-wave, although initially believed to be of value in evaluating cervical radiculopathy, has since been shown to be of limited value. Its usefulness is limited because there are at least two roots innervating almost every muscle, and the F-response may be traveling along the uninvolved root. With mild lesions, even the involved root may have sufficient unaffected fibers such that the F-response will still be normal because only between 1% and 20% of axons produce the F-response. The usefulness of somatosensory evoked potential (SSEP) testing in the diagnosis of radiculopathy remains controversial, although theoretically it should be of added benefit, especially with pure sensory lesions. For a thorough discussion, the reader is referred to Weichers, who outlines all of the issues and cites the numerous studies addressing this technique.

Precisely when to use electrodiagnosis in the evaluation of a patient with cervical radiculopathy is a clinical decision and has not been well studied.

The major use of electromyography is to diagnose radiculopathy in cases where it is uncertain whether the patient has any neurologic lesion, or in distinguishing cervical radiculopathy from other lesions where they cannot be distinguished clinically. EMG can also be used when it is unclear whether the anatomic lesion seen on imaging techniques is resulting in nerve root pathology. The authors have also used EMG in the industrial setting to distinguish musculoskeletal from neurologic pain, and in circumstances when the patient appears to be improving clinically, but continues to complain of symptoms. In general, the authors find this an important test to correlate with the clinical picture and physical findings, and to substantiate the presence of a radiculopathy. In patients with less severe clinical findings, performance of the EMG should be delayed for at least 3 to 4 weeks after symptom onset to permit detection of the positive waves and fibrillation potentials, which would be the hallmark of the diagnosis in these instances.

**Treatment**

There are no medically related outcome studies that have compared operative to nonoperative treatment of cervical radiculopathy. One prospective study evaluating various nonsurgical treatments is The British Association of Physical Medicine Study, which also discussed some of the difficulties in evaluating treatment of this disorder. The authors stated how little is known of the natural history of this common syndrome, that the patients in their study were a highly select group, were followed for a maximum of 6 months, that only certain forms of treatment were investigated, and only outpatient therapy was used. Consequently, the treatment is based on individual experience with various interventions that have been applied with the description of the results.

The major objectives of treatment are the reduction or resolution of pain, improvement, or resolution of the neurological deficit and avoidance of spinal cord complications. The treatment indicated depends on the patient's symptoms and physical findings. The treatment, including physical therapy prescription, must be specific and is dependent on the severity of the symptoms and on the underlying etiology of the radiculopathy.

**Activity Limitation**

Specific studies comparing outcome with and without limitation on activities or work have not been performed, but individual patient tolerance in response to treatment should guide the practitioner.

Heavy or moderately heavy activities, and occupations that require use of the neck in vulnerable positions, such as extension and ipsilateral flexion and rotation, should be avoided during the acute stage. Depending on the occupation, some patients can continue to work and, on rare occasions, can continue with noncontact sporting activities. Patients with severe radiculopathy are usually unable to work and may even require bed rest.
Neck Positioning

It has been suggested that the patient must be instructed in proper neck position to avoid further irritation of the involved nerve root. The telephone user must avoid ipsilateral neck flexion. A headset can help eliminate this motion.109 The bifocal eyeglass wearers should be instructed in proper position of the head to avoid neck extension. In occupations where close work is necessary at eye level or above, placement of the reading segment at the top of the lens can result in symptom relief.105 When watching theatrical or sporting events, the patient must be instructed in proper positioning, depending on the seating location and, specifically while following a sporting activity, be told not to rotate the neck ipsilaterally to the involved side. Sleeping in a sitting position, either in a lounge chair or in bed with a bolster for the upper back and with the knees flexed or with pillows will suffice to position the head in the partially flexed position, thereby relieving pain. None of these suggestions have been studied to determine their value.

There are many collars that have been studied regarding the motion restrictions they afford.106-108 More rigid collars, particularly with chin extensions, can provide greater restriction of cervical motion than soft collars, which do not significantly restrict flexion and extension.109,110 The issue of patient compliance and outcomes with the use of collars that restrict motions have received little attention in the literature. In a series of 22 patients comparing two different types of relatively hard collars, there was only a 68% to 72% compliance rate in the use of the collars.111 A soft cervical collar can increase patient comfort,112 although it has not been shown to change long-term outcome.103,113 The authors prescribe soft cervical collars which, together with patient education, can serve to maintain relative flexion of the neck. Except in rare instances such as the patient with a positive L’Hermittes sign, a patient with rheumatoid arthritis and atlanto-axial subluxation, the attachment, which is usually the narrower part of the collar, is worn in front, thus maintaining the neck in a neutral or slightly flexed position. The soft collar should be worn for as long as possible during the day, using comfort as a guide. As symptoms improve, it can be worn only while engaged in strenuous activities and while driving, and can be discontinued completely when appropriate. It is difficult to judge the exact time to decrease or discontinue collar use, but improvement in extremity pain, disappearance of Spurling’s sign, and improvement in motor deficit can be used as guides.

Modalities

Thermotherapy may be used for pain relief.114,115 It may also be used prior to or at the time of cervical traction for muscle relaxation. Cold may be applied for 15 to 30 minutes, one or four times a day, or heat for 30 minutes, two to three times a day if the cold is not effective. The decision regarding which modality to use is pragmatic, and is often based on the patient’s perception of pain relief.116 Cervical traction is frequently used in patients with cervical radiculopathy. Intermittent cervical traction can produce a greater separation of the vertebra at a 50-pound than at a 30-pound force. It has been studied at a 24° angle of pull, and there was no difference in separation at 7, 30, and 60 seconds of tractive force.117 When a 30-pound tractive force was used for a period of 7 seconds, with a rest period of 5 seconds, it was found that the maximum mean vertebral separation occurred at 25 minutes, and that there was only minimal anterior cervical separation 20 minutes after traction ceased.118 Although the efficacy of cervical traction has not been proven,103 and has even been reported to cause temporomandibular joint problems,119 nevertheless it is commonly used120-122 and is believed by some to be of benefit.123 For home use, over the door traction may be tried when properly used, for example, with the patient facing the door and with the head flexed at 20 to 30°.124 A water bag with 10 pounds can be used initially with the weight increasing to 20 pounds as tolerated. Ten pounds of cervical traction in the seated position counterbalances the weight of the head and 20 pounds is usually an effective distracting force. A home pneumatic traction device may be useful as an alternative to using weight.126 Recumbent traction is also useful and may be more comfortable but is more difficult to set up and apply. The patient must be adequately instructed in the use of home traction because of possible errors in weight and head positioning.119 Traction reportedly is contraindicated in patients with significant or severe spondylosis who have myelopathy, a positive L’Hermittes sign, or rheumatoid arthritis with atlanto-axial subluxation.127,128 Traction can be used at home two to three times a day for 15 minutes each time. It can be continued fewer times per day, for 4 to 6 weeks, even after the patient is improved from the point of view of pain and/or neurologic deficit. In the authors’ experience, some patients are benefited by using traction on a long-term basis. Range of motion exercises of the cervical spine should not be used during the acute stage of cervical radiculopathy.129 In the authors’ opinion, range of motion exercises, particularly those that mimic Spurling’s maneuver or prolonged neck extension, should be avoided even when the pain abates. Exercises that precipitate arm pain should also be avoided because there are no controlled studies showing that exercise will improve outcome or prevent recurrence,126 and there is potential for increasing symptomatology or neurologic deficit. This is particularly true when forceful cervical manipulation is used.127 Isometric strengthening neck exercises may be used when the pain abates.126 Manipulation should not be used in patients with this problem.128

Medications

In the authors’ opinion, medications should be used sparingly. They are indicated for pain relief or presumably to decrease “inflammation” around the nerve root, although a true inflammatory response at the level of the nerve root or disc has not been demonstrated. In patients who are instructed in proper neck positioning and who use a cervical collar, adequate pain relief is usually achieved with aspirin or other nonsteroidal anti-inflammatory agents.103,129 Other medications of clinical benefit include diazepam (Valium) 2 to 5mg at bedtime, especially in very anxious patients, low dose tricyclic antidepressants (eg, amitriptyline [Elavil] 10 to 25mg at bedtime), and narcotic analgesics only if needed. It is speculative that in some patients with severe radiculopathy, of less than 10 days duration, high-dose oral steroids...
will rapidly decrease the pain and shorten the course of the disease; eg, prednisone 60mg daily for 7 days and then tapering doses for the 5 following days. The effectiveness of steroids, as with most interventions in radiculopathy, remains controversial,\textsuperscript{120–133} and has not been thoroughly studied in cervical radiculopathy.

**Epidural Steroids**

Instillation of steroids into the cervical epidural space reportedly is of benefit in patients with pain who do not improve with the above therapy.\textsuperscript{134} It must be performed by a physician who is well trained and facile in the technique. Shulman found that 64% of the 25 patients who received no relief from “conservative therapy” underwent 45 epidural steroid injections with good to excellent response.\textsuperscript{135} Warfield and associates\textsuperscript{136} treated 16 patients with epidural injections and noted improvement in pain in 12, and in 6 of these, improvement in their neurological deficit. The architecture of the cervical spine makes its contents vulnerable to damage and thus this procedure is used infrequently and with great care in experienced hands.

**Surgery**

For discussion of the various surgical approaches, the reader is referred to the surgical literature.\textsuperscript{17,19,33,42,137–143} We believe the decision to operate should be predicated on the patient having received appropriate nonsurgical treatment and/or fulfilling clinical requirements, as outlined later.

**Outcome and Sequence of Treatment**

Medically related outcome measures include: pain relief, return of neurologic deficit to normal, return to previous occupation, leisure or sporting activities, and return to full lifestyle. The ideal outcome is return to full pre-illness lifestyle without pain and complete reversal of the neurologic deficit; a good outcome includes minimal residual neurologic deficit and ability to return to work. Martin and Corbin\textsuperscript{104} treated 61 ambulatory patients with cervical radicular symptoms nonoperatively and obtained good to excellent results in 49 (80.3%). Surgery was performed in the remaining 12 patients. Rubin\textsuperscript{129} reported that 90% of 84 patients with cervical radiculopathy responded well to nonoperative treatment. Nonoperative treatment was also helpful in providing temporary or more lasting relief in a majority of patients who had pain in the neck and arm.\textsuperscript{103} Sixty-six of 82 patients (80%) treated by Honet and Puri\textsuperscript{134} had good to excellent results with nonoperative treatment. One to two year follow-up on their patients revealed that 71% of the patients with excellent results continued to do well. None of these studies were controlled regarding types of treatment, so no conclusions regarding individual nonoperative treatments can be made based on their results. Nevertheless, it may be concluded when groups of patients with proven cervical radiculopathy are treated nonoperatively, ideal outcomes may occur in 80% to 90% of patients.\textsuperscript{54,104,129} All of the authors analyzed their data retrospectively.

The sequence of treatment should be guided by individual history, physical examination, patient needs and circumstances, as well as the progress of disease and result of therapy.\textsuperscript{144} Patient progress, depending on severity of the problems, should be evaluated every 1 to 3 weeks. As mentioned earlier, pain, by careful characterization, and neurologic deficit using manual muscle and reflex testing are used as guides for patient progress.

Early treatment can include activity modification, cervical collar, medication, thermotherapy, and traction. The patient should be strongly advised to avoid any activities (even therapeutic ones) that accentuate the extremity pain, and a well-informed patient should be part of the decision making process to help decide the proper sequence of treatment.

If symptoms improve with treatment, then activities can progressively be increased and treatment discontinued or decreased. If there is no improvement or worsening of pain with a stable neurologic deficit, cervical epidural steroids may be considered. At this point, in the authors’ opinion, complete evaluation including MRI and EMG is warranted. In the 10% to 20% of patients in whom symptoms persist despite treatment, surgical intervention should be considered. There are no guides for how long nonsurgical treatment should be continued prior to consideration of surgery, but if neurologic progression or myelopathy are not present, or neurologic improvement is occurring, patient comfort and ability to return to a normal lifestyle need be the only guides. Neurologic deficit, even in the presence of large disc herniations, has been shown to improve with nonoperative management in patients with lumbar radiculopathy,\textsuperscript{145,146} and we believe the same holds true for cervical radiculopathy.

When cervical radiculopathy is documented and accompanied by significant upper motor neuron findings in the lower limbs, treatment options in sequence are different than that described above. Treatment of the cervical syndrome with myelopathy is beyond the scope of this article.

Surgical outcomes vary between 64% and 96% good results.\textsuperscript{17,19,33,139,140,141,147} Many of the surgical studies, however, deal with patients who have spondylotic radiculopathy or myelopathy, and none clearly delineate the nonoperative treatment used.

**CONCLUSION**

Cervical radiculopathy may have various underlying etiologies. Its most common causes are cervical disc herniation and cervical spondylosis. It can usually be diagnosed by history and physical examination, and most diagnostic studies are needed only when the clinical presentation is unusual, there is poor response to initial treatment, or surgery is contemplated.

The large majority of patients with single root involvement improve with nonsurgical treatment, although which precise treatment hastens or affords resolution of the disorder is not yet determined by carefully controlled studies. Surgery should be considered in patients who have persistent pain despite careful nonsurgical treatment, progressive weakness, or new or progressive cervical myelopathy.

**References**

CERVICAL RADICULOPATHY, Ellenberg 351

118. Colachis SC, Strohm BR. Effect of duration of intermittent cervical
CERVICAL RADICULOPATHY, Ellenberg


