CHAPTER 2

Neck and Neck/Arm Complaints

Context

The cervical spine serves a unique function as a positioner of the head in space. This function requires a proprioceptive integration that results in optimization of head position through reflex setting of muscle tone. Although having the head perched atop the cervical spine allows better appreciation of the surrounding environment, this arrangement creates a potentially damaging lever arm in acute injury events that force the head to move quickly into extremes of flexion, extension, or lateral flexion. In addition to the cervical spine itself, soft tissue and neural structures may be damaged in the extremes of these movements. The lever effect also is operative in a more insidious manner when a forward head position is maintained for prolonged periods, as in a computer work environment. The demands on posterior musculature are dramatically increased by the weight of the head as it moves forward of the body.

The cervical spine is a focus for investigation of complaints that involve the head and upper extremities. The unique association between the upper cervical spinal nerves and the trigeminal nerve is postulated to have effects that result in complaints of headache, facial pain, or ear pain. Upper extremity complaints may be caused or augmented by cervical spine pathology that affects the spine, nerve roots, or brachial plexus.

Common patient presentations include the following:

- Acute injury neck and/or arm pain (e.g., whiplash, cervical "stingers")
- Acute, pseudotorticollis (not a true torticollis but a painful limitation of all neck movement)
- Postural pain or stiffness due to poor ergonomics in the work environment
- Osteoarthritis associated stiffness or pain
- Headaches

When arm complaints accompany neck pain, it is essential to make the determination of whether nerve root irritation or a referred phenomenon is the source. Chiropractors are often faced with patients who, upon examination, demonstrate no objectifiable neurologic deficit in the arm(s) even though numbness/tingling or weakness is part of their complaint. Many of these patients appear to obtain relief from chiropractic procedures, suggesting a referral connection between what is manipulated and what causes the "phantom" symptoms. This is most likely the facet joint. Whether the complaint is local to the neck or referred to the arm, Bogduk[1] states that facet joint pain accounts for the majority of patient complaints. Neck and arm complaints also require a consideration of brachial plexus or peripheral nerve involvement.

The National Board of Chiropractic Examiners (NBCE) Job Analysis 2005[2] estimates that neck pain accounts for approximately 18.7% of all chiropractic visits. In a Canadian study, Cote et al.[3] found that the age-adjusted lifetime prevalence for neck pain was 66.7% and the point prevalence was 22.2%. According to the National Health Interview Survey (NHIS) 13.8% of the population in the United States reported having neck pain in 2004.[4] Data reported in the Task Force on Neck Pain and Its Associated Disorders provides a range for the 12-month prevalence of 12.1% to 71.5% in the general population and 27.1% to 47.8% in workers (Haldeman). However, the one-year prevalence of disability due to neck pain was between 1.7% and 11.5% in the general population. A more narrow range of only 11% to 14.1% of workers report being limited in their activities during a one-year time frame. Only about 25% of individuals with neck pain seek conventional medical care. However, one to five years after the initial episode of neck pain, 50% to 85% of

individuals will again report neck pain. Data from three national surveys indicates that 64% of ambulatory visits for neck pain resulted in a pain diagnosis rather than a pathology diagnosis. In hospitals, 94% of patients with neck pain received a pathology diagnosis with 79% of those patients requiring surgery.

The appropriateness of chiropractic manipulation of the cervical spine for various conditions has been addressed in two major publications: the 1995 scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders[5] entitled "Redefining 'Whiplash' and Its Management," and the 1996 Rand Corporation report[6] entitled *The Appropriateness of Manipulation and Mobilization of the Cervical Spine.* More recently the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders[7] has reviewed the literature and made recommendations regarding evaluation and management. Manipulation is one of the approaches recommended for mechanical neck pain. Although the literature support is not as strong as for the low back, both studies recognize the potential value of manipulation in the management of some cervical spine complaints.

General Strategy

History

- Screen the patient for "red flags" that indicate the need for either immediate radiographs/special studies or referral to or consultation with a specialist, including severe trauma, direct head trauma with loss of consciousness, nuchal rigidity, bladder dysfunction associated with onset of neck pain, associated dysphasia, associated cranial nerve or central nervous system (CNS) signs/symptoms, onset of a "new" headache, and preexisting conditions such as rheumatoid arthritis, cancer, Down syndrome, alcoholism, drug abuse, or an immunocompromised state.
- If there is a history of trauma, determine the mechanism and severity.
- For patients involved in a motor vehicle accident (MVA), take a thorough history with regard to angle of collision; speed; use of brakes, seat belt, shoulder harness, and air bag; position of the patient in the car; subsequent legal concerns with regard to police reports; and so forth (**Exhibit 2–1**).
- Determine whether the complaint is one of pain, stiffness, weakness, or a combination of complaints.
- Determine whether the complaint is limited to the neck or is radiating to the head or upper extremity unilaterally or bilaterally.
- Determine the level of pain and functional capacity with a questionnaire such as the Neck Disability Index (**Exhibit 2–2**) with a pain scale (e.g., Visual Analog Scale [VAS]).

Examination

- For patients with nuchal rigidity and/or a positive Brudzinski's or Kernig's sign, refer for medical management.
- For patients with suspected fracture or dislocation (e.g., MVA, compressive or distractive injury to the neck), infection, or cancer, obtain radiographs of the cervical spine.
- For patients with neck pain only, perform a thorough examination of the neck, including inspection, observation of the patient's movements, palpation of soft and bony tissues, motion palpation of the spine, passive and active range of motion (using a goniometer or inclinometer), a functional assessment (e.g., according to Janda[8]), and a brief orthopaedic screening.
- For patients with neck and arm pain, add a thorough orthopaedic/neurologic examination, including compressive and neural stretch maneuvers to the neck in various positions, nerve stretch maneuvers, deep tendon reflex testing, sensation testing (include pain, temperature, light touch, and vibration), and myotome testing.
- Radiographs should be obtained for patients who have radicular findings, including an anteroposterior (AP), AP-open mouth, lateral, and oblique. Flexion-extension views may be added when searching for instability.
- Special imaging, including computed tomography (CT) or magnetic resonance (MR), should be reserved for the differential of radicular or myelopathic cases where there is a need for further distinction among stenosis, tumor, herniated disc, or multiple sclerosis. Electrodiagnostic studies should be reserved for cases where the cause of radicular complaints remains unclear.

Exhibit 2–1

Automotive Crash Form

Billing Information

Patient name:
Date of injury: _____ Time of injury: _____ ☐ AM ☐ PM
City and street where crash occurred: _____
What is the estimated damage to your vehicle? $ _____
☐ Yes ☐ No Do you have automobile medical insurance coverage? _____
_____
Name/address/phone _____
_____
What is your car insurance medical coverage limit? $_____
What is the claim number? _____
☐ Yes ☐ No Do you know the claims adjuster's name? _____
☐ Yes ☐ No Have you reported this injury to your car insurance company? _____
☐ Yes ☐ No Did the police come to the accident scene and make a report? _____
☐ Yes ☐ No Is an attorney representing you? Name/address/phone: _____

Auto Accident Description

Describe how the crash happened _____
_____
_____
_____
_____
_____
_____
_____
_____

Collision Description
Check all that apply to you:

☐ Single-car crash ☐ Two-vehicle crash ☐ More than thee vehicles
☐ Rear-end crash ☐ Side crash ☐ Rollover
☐ Head-on crash ☐ Hit guardrail/tree ☐ Ran off road

You were the
☐ Driver ☐ Front passenger ☐ Rear passenger

Describe the vehicle you were in
Model year and make: _____
☐ Subcompact car ☐ Compact car ☐ Mid-sized car
☐ Full-sized car ☐ Pickup truck ☐ Larger than 1-ton vehicle

Describe the other vehicle
☐ Subcompact car ☐ Compact car ☐ Mid-sized car
☐ Full-sized car ☐ Pickup truck ☐ Larger than 1-ton vehicle

Estimated crash speeds
Estimate how fast your vehicle was moving at time of crash. _____ mph
Estimate how fast the other vehicle was moving at time of crash _____ mph

(*continues*)

Exhibit 2–1 (continued)

At the time of impact your vehicle was

☐ Slowing down ☐ Stopped ☐ Gaining speed ☐ Moving at steady speed

At the time of impact the other vehicle was

☐ Slowing down ☐ Stopped ☐ Gaining speed ☐ Moving at steady speed

During and after the crash, your vehicle

☐ Kept going straight, not hitting anything
☐ Kept going straight, hitting car in front
☐ Was hit by another vehicle
☐ Spun around, not hitting anything
☐ Spun around, hitting car in front
☐ Spun around, hitting object other than car

Describe yourself during the crash

Check only the areas that apply to you:

☐ You were unaware of the impending collision.
☐ You were aware of the impending crash and braced yourself.
☐ Your body, torso, and head were facing straight ahead.
☐ You had your head and/or torso turned at the time of collision:
  ☐ Turned to left ☐ Turned to right
☐ You were intoxicated (alcohol) at the time of crash.
☐ You were wearing a seat belt.
  If yes, does your seat belt have a shoulder harness? ☐ Yes ☐ No
☐ You were holding onto the steering wheel at the time of impact.

Indicate if your body hit something or was hit by any of the following:

Please draw lines and match the left side to the right side.

Head	Windshield
Face	Steering wheel
Shoulder	Side door
Neck	Dashboard
Chest	Car frame
Hip	Another occupant
Knee	Seat
Foot	Seat belt

Check if any of the following vehicle parts broke, bent, or were damaged in your car

☐ Windshield ☐ Seat frame ☐ Knee bolster
☐ Steering wheel ☐ Side/rear window ☐ Other _____
☐ Dashboard ☐ Mirror ☐ Other _____

Rear-end collisions only

Answer this section only if you were hit from the rear.

Does your vehicle have

☐ Movable head restraints
☐ Fixed, nonmovable head restraints
☐ No head restraints

Please indicate how your head restraint was positioned at the time of crash.*

☐ At the top of the back of your head
☐ Midway height of the back of your head
☐ Lower height of the back of your head
☐ Located at the level of your neck
☐ Located at the level of your shoulder blades (upper back) below neck

*Estimate the distance between the back of your head and the front of the head restraints. _____ inches

Exhibit 2–1 (continued)

All types of collisions
Answer this section regardless of the type of crash, indicating those relevant to your case.

Yes	No	
☐	☐	Did any of the front or side structures, such as the side door, dashboard, or floor board of your car, dent inward during the crash?
☐	☐	Did the side door touch your body during the crash?
☐	☐	Were your hands on the steering wheel or dashboard during the crash?
☐	☐	Did your body slide under the seat belt?
☐	☐	Was a door of your vehicle damaged to the point where you could not open the door?

Emergency department

Yes	No	
☐	☐	Did you go to the emergency department after the accident? What is name of the emergency department? _____ When did you go (date and time)? _____
☐	☐	Did you go to the emergency department in an ambulance?
☐	☐	Did you or another person drive you to the emergency department?
☐	☐	Where you hospitalized overnight?
☐	☐	Did the emergency department doctor take X-rays? Check what was taken: ☐ Skull ☐ Neck ☐ Low back ☐ Arm or leg
☐	☐	Did the emergency department doctor give you pain medications?
☐	☐	Did the emergency department doctor give you muscle relaxants?
☐	☐	Did you have any cuts or lacerations?
☐	☐	Did you require any stitching for cuts?
☐	☐	Were you given a neck collar or back brace to wear?

When did you first notice any pain after injury?
☐ Immediately ☐ ____ Hours after injury ☐ ____ Days after injury

If you did not see a doctor for the first time within the first week, indicate why
Check all that apply
☐ No pain was noticed
☐ No transportation
☐ No appointment schedule available
☐ Work/home schedule conflicts

If you did not see a doctor for the first time within the first month after injury, indicate why
Check all that apply
☐ No pain was noticed
☐ No transportation
☐ I thought pain would go away
☐ I self-treated with over-the-counter drugs
☐ No appointment schedule available
☐ Work/home schedule conflicts
☐ I had no insurance or money
☐ I took hot showers, used ice, heat

Have you been unable to work since injury?
☐ Yes ☐ No If yes, you were off work ☐ partially or ☐ completely
Please list date off work: _____ to _____.

Management

- Patients with clinical, radiographic, or laboratory evidence of tumor, infection, fracture, or dislocation should be sent for medical evaluation and possible management.
- Patients who appear to have a mechanical cause of pain should be managed conservatively for one month; if unresponsive, further testing or referral for a second opinion is suggested.

Relevant Anatomy and Biomechanics

The cervical spine is often discussed as two separate yet interdependent sections: the upper cervical spine (the occiput and C1-C2) and the lower cervical spine (C2-C7/T1). This is due in part to a functional distinction based on the great degree of rotation available at the upper cervical spine, allowed by the unique articulation between the C2 and C1 vertebrae. The dens of C2 acts as a pivotal point for rotation. The intricate musculature support and control in this region are important in substituting for a generally more lax ligamentous system, compared with the thoracic and lumbar regions. Another important difference in the upper cervical region is the lack of intervertebral foramina and discs between the occiput (C0), C1, and C2. From a neurologic perspective, the upper cervical spinal cord has a unique connection with the CNS through the trigeminocervical nucleus, an intermingling of the spinal nucleus of the trigeminal nerve and the dorsal horn of the upper cervical spinal nerves.[9] This connection allows for interactions and misinterpretations postulated to be the cause of headaches, dizziness, and facial pain.

The vertebral arteries enter the transverse foramen at C6 and ascend through the other transverse foramina. At C2 they take sharp turns to run more laterally and horizontally to reach the transverse foramen of C1. At the transverse foramen of C1 and C2, the vertebral arteries are anchored with fibrous tissue restricting their movement. Continuing upward, the vertebral arteries travel posteromedial to run around the lateral mass of C1. Running through a groove in the posterior arch of C1, the vertebral arteries pass between the atlantooccipital membrane and capsule before entering the dura mater at the foramen magnum. These two sites—C6 and the upper cervical region—are proposed to be tethering or compressive sites leading to occlusion or intimal tearing resulting in vertebrobasilar events (vascular accidents) although studies that evaluate these effects in cadavers have not demonstrated this as likely with maneuvers that simulate cervical manipulation. Vertebrobasilar events are extremely rare and although they have been associated not only with cervical spine adjustments they also occur with common daily activities such as turning the head while driving and extending the head for a shampoo at the hairstylist as well.[10] When damage does occur it is usually due to trauma to the arterial wall leading to either vasospasm or intimal tearing. Intimal tears may occur in isolation or be complicated by embolic formation or dissection of the arterial wall.[11] The dorsolateral medullary syndrome (Wallenberg's) and the locked-in syndrome or cerebromedullospinal disconnection syndrome are two possible consequences of vertebrobasilar injury. Wallenberg's syndrome usually involves occlusion of the posterior inferior cerebellar artery with resulting problems of vertigo, diplopia, and dysarthria. Most patients regain a significant degree of neurologic function. The locked-in syndrome is much more serious, leaving the patient conscious but paralyzed.

The Discs

Like all intervertebral discs, the cervical disc is composed of a central nucleus pulposus and an outer annulus. However, by age 40 years the nucleus pulposus is essentially nonexistent, having changed to a ligamentous-like, dry material.[12] Herniation is therefore theoretically not possible in the older patient unless small hyaline pieces become free. The cervical discs have much less weight to bear than the lumbar discs for two reasons: (1) only the head plus gravity is borne and (2) the distribution of load is approximately equal among the disc and the two facet joints (i.e., each bears one-third the load). Like the other regions of the spine, the outer annulus fibrosus is innervated by the sinuvertebral nerves as are the vertebral bodies. **Exhibit 2–3** illustrates the innervations of deep spinal structures.

In a recent study[13] examining the discs of rats, researchers demonstrated that the C5/C6 disc was innervated multisegmentally from the dorsal root ganglions of C2-C8. In addition, there was innervation sympathetically from the stellate ganglion and parasympathetically from the nodose ganglion (vagus). Seventy-nine percent of the nerve fibers innervating the IVD were sensory nerves and 20.4% were autonomic nerves. Specifically,

Exhibit 2–2 Neck Disability Index

This questionnaire has been designed to give the doctor information as to how your neck pain has affected your ability to manage in everyday life. Please answer every section and mark in each section only the *one* box that applies to you. We realize you may consider that two of the statements in any one section relate to you, but please just mark the box that most closely describes your problem.

Section 1—Pain Intensity
- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

Section 2—Pesonal Care (Washing, Dressing, etc.)
- ☐ I can look after myself normally without causing extra pain.
- ☐ I can look after myself normally but it causes extra pain.
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but manage most of my personal care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

Section 3—Lifting
- ☐ I can lift heavy weights without extra pain.
- ☐ I can lift heavy weights but it gives extra pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example, on a table.
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned. I can lift very light weights.
- ☐ I cannot lift or carry anything at all.

Section 4—Reading
- ☐ I can read as much as I want to with no pain in my neck.
- ☐ I can read as much as I want to with slight pain in my neck.
- ☐ I can read as much as I want with moderate pain in my neck.
- ☐ I can't read as much as I want because of moderate pain in my neck.
- ☐ I can hardly read at all because of severe pain in my neck.
- ☐ I cannot read at all.

Section 5—Headaches
- ☐ I have no headaches at all.
- ☐ I have slight headaches that come infrequently.
- ☐ I have moderate headaches that come infrequently.
- ☐ I have moderate headaches that come frequently.
- ☐ I have severe headaches that come frequently.
- ☐ I have headaches almost all the time.

Section 6—Concentration
- ☐ I can concentrate fully when I want to with no difficulty.
- ☐ I can concentrate fully when I want to with slight difficulty.
- ☐ I have a fair degree of difficulty in concentrating when I want to.
- ☐ I have a lot of difficulty in concentrating when I want to.
- ☐ I have a great deal of difficulty in concentrating when I want to.
- ☐ I cannot concentrate at all.

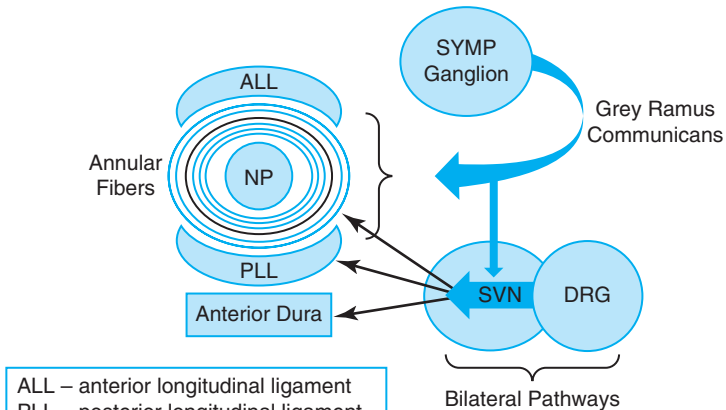
Section 7—Work
- ☐ I can do as much work as I want to.
- ☐ I can only do my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I cannot do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I can't do any work at all.

Section 8—Driving
- ☐ I can drive my car without any neck pain.
- ☐ I can drive my car as long as I want with slight pain in my neck.
- ☐ I can drive my car as long as I want with moderate pain in my neck.
- ☐ I can't drive my car as long as I want because of moderate pain in my neck.
- ☐ I can hardly drive at all because of severe pain in my neck.
- ☐ I can't drive my car at all.

Section 9—Sleeping
- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed (less than 1 hr. sleepless).
- ☐ My sleep is mildly disturbed (1–2 hrs. sleepless).
- ☐ My sleep is moderately disturbed (2–3 hrs. sleepless).
- ☐ My sleep is greatly disturbed (3–5 hrs. sleepless).
- ☐ My sleep is completely distubed (5–7 hrs. sleepless.)

Section 10—Recreation
- ☐ I am able to engage in all my recreation activities with no neck pain at all.
- ☐ I am able to engage in all my recreation activities with some pain in my neck.
- ☐ I am able to engage in most, but not all, of my usual recreation activities because of pain in my neck.
- ☐ I can hardly do any recreation activities because of pain in my neck.
- ☐ I can't do any recreation activities at all.

Exhibit 2–3 Innervation of deep spinal structures



23.9% of the nerve fibers innervating the IVD were afferent sensory pain-related nerves, 8.9% were efferent sympathetic nerves, and 11.5% were efferent parasympathetic nerves. Given the varied and unusual clinical signs and symptoms related to cervical disc injury, this finding of autonomic innervation may partially explain why. Potentiating the effect and extent of sympathetically mediated pain is a structure named "Terminal Dogiel's nests," described as bundles of sprouting sympathetic axons in the dorsal root ganglia that seem to form after injury.[14]

The Facets

The facets of the upper cervical spine are angled approximately 35° to the horizontal plane, whereas the lower cervical spine facets are oriented at approximately a 65° angle.[15] The facets (zygapophyseal) joints are surrounded by a joint capsule that is generally looser in the cervical region than in the thoracic and lumbar regions, allowing for more range of motion. The capsule is lined with synovium on the upper and lower aspects. There are often inclusions of fat-filled synovial folds and meniscoids that extend between the facets. Although they are believed primarily to be shock absorbers, these inclusions can become trapped, causing a mechanical lock.[16, 17] It is unlikely, however, that they are the primary cause of vertebral fixation given that meniscoids are not always present in fixed joints and that patients with rheumatoid arthritis have a higher incidence of meniscoids yet no higher incidence of fixation.[18] However, in children and in those who develop sudden neck pain without significant trauma that is relieved with manipulation, a synovial entrapment or extrapment (caught outside the joint) is likely the cause.

Histological studies of facet joints demonstrate the existence of substance P reactive fibers suggesting a potential role in mediating pain.[19] Facet-joint capsules contain low-threshold mechanoreceptors, mechanically sensitive nociceptors, and silent nociceptors. The speed at which mechanoreceptors are stimulated may affect their role in pain. Low stretch levels activate proprioceptors in the facet-joint capsule whereas sudden severe capsular stretch activates nociceptors, which may lead to prolonged discharge and damage to the capsule and to axons in the capsule.[20]

The facet joints are innervated by the medial branch of the posterior primary rami. Recent evidence from rat research[21] indicates that sensory nerve fibers of cervical C5-C6 facet joints are derived from the dorsal root ganglia (DRG) of multisegmental levels, from C3 to T3. This likely explains common referral patterns from the facets including neck and head pain from the C2-C3 joints and neck and shoulder pain from the C5-C6 joints. Also, this multisegmental innervation may determine more global neurological reactions to pain generated at a local segment.

The DRG themselves are at risk due to a peculiar vascular structure.[22] Primarily internal arterialization

coupled with a superficial venous drainage places the DRG at risk for ischemic damage from external pressure (e.g., degenerative osteophytes) or from internal edematous pressure leading to a form of "compartment syndrome."

Although it might be assumed that all spinal levels have contributions to the DRG, a study by Tubbs et al.[23] indicates that at the C1 level there is substantial variation with potential clinical results. The researchers found that in all specimens there were C1 and C2 spinal nerves, but only 46.6% of specimens had C1 dorsal rootlets and of these, only 28.5% had an associated dorsal root ganglion. In 50% of specimens, the spinal accessory nerve joined with dorsal rootlets of C1. When the spinal accessory nerve combined with the dorsal rootlets of C1, there was no C1 DRG.

Calcitonin gene-related peptide (CGRP) immunoreactive dorsal root ganglion neurons innervate the cervical facets and are affected by trauma. One study[24] indicated that although the number of CGRP cells decreased after trauma, there was a phenotypical switch to larger cells.

Ligaments and Muscles

The upper cervical spine has an intricate system of ligaments and muscles to stabilize and control fine head movements. In addition, the muscles serve a function of providing important proprioceptive input integrated into the reflex control of the head and neck and posture in general. Studies have demonstrated that injections into the upper cervical spine area result in various symptoms, including vertigo.[25]

Three ligaments help stabilize the dens of C2 to the anterior arch of C1. These include the alar ligament, cruciform (cruciate) ligament, and tectorial membrane. These continue down as the posterior longitudinal ligament. A prominent section of the cruciate ligament is the transverse ligament. This ligament is the primary stabilizer of the dens. Deterioration of the transverse ligament, usually through rheumatoid processes, will allow abnormal movement between C2 and C1. The posterior longitudinal ligament (PLL) is broad in the cervical spine, providing more protection against lateral disc herniation than found in the lumbar region. Also, the joints of Luschka provide some bony protection to nerve root impingement from disc herniation. The ligamentum flavum is posterior to the PLL, attaching to the laminae forming the anterior support for the facet joint capsules and protecting the spinal cord. A recent study indicates that contrary to accepted knowledge, the ligamentum flavum does not connect the posterior arch of the atlas to the laminae of the axis 15a. Bogduk[1] emphasizes that the interspinous ligament is nonexistent in the cervical region and that the sagittal and superficial component of the ligamentum nuchae are simply extensions of other structures.

The muscles of the cervical spine are often divided into posterior and anterior with subdivisions of superficial and deep sections. The more superficial muscles are involved with upper extremity movement and respiration. The deeper muscles are involved more with posture and head/neck movement. The posterior muscles, including the semispinalis, spinalis, and splenius, are essential as antigravity/postural muscles, often being called upon to fire eccentrically during flexion of the neck/head, and are chronically strained during forward head positions. The four suboccipital muscles (obliquus capitis inferior and superior and the rectus capitis posterior major and minor) plus the deep "shunt" muscles of the middle and lower cervical spine, such as the interspinales, multifidus, rotatores, intertransversarii, and longus cervicis, are important for intersegmental movement. In addition, they play a major role in providing afferent proprioceptive input to the spinal cord used both for gross postural control and spinal segmental (involuntary) positioning. This is due to the high density of muscle spindles in this region.[26]

Thoracic Outlet

The thoracic outlet is the path taken by the brachial plexus and associated vasculature into the arm from the neck. Thoracic outlet syndrome (TOS) is an overdiagnosed condition. It is purported to be caused by neurologic or neurovascular compromise of the brachial plexus and/or subclavian-axillary vessels. The potential sites of entrapment or compression include: at the cervical ribs (elongated C7 transverse processes), the scalene muscles, the costoclavicular interval, and the subcoracoid loop involving the pectoralis minor. When TOS is present it is most common to have involvement of the lower brachial plexus (C7-T1) with related medial arm and hand complaints. Factors that have been suggested as causes include trauma, posture (rounded shoulders), tight scalenes or pectoralis minor, and cervical ribs. Leffert[27] states, however, that patients who have had stabilizing surgery for the shoulder have had accompanying TOS symptoms resolved.

Biomechanics

The various motion patterns available to the cervical spine are determined by both active and passive elements. The passive elements include the facets, discs, ligaments, and bone. The various components of functional patterns that may be affected include range of motion (ROM), coupling patterns, the instantaneous axis of rotation (IAR), and the neutral zone. Many of the biomechanical studies have focused on how the various static components contribute to movement and ROM, and therefore must be considered cautiously when extrapolated to patients. Many of the manipulative maneuvers used by chiropractors and others, however, require elimination of muscular participation; therefore, the studies may have some clinical validity.

The cervical spine flexes, extends, rotates, and bends laterally. Flexion and extension occur mainly at three areas: (1) the atlantooccipital joint, (2) the C1-C2 level, and (3) between C4 and C6. Each accounts for about 20° of flexion/extension. The other segments contribute between 10° and 20°. Flexion at the atlantooccipital joint is accompanied by a coupled movement of slight anterior translation of the occiput relative to C1.

The facet orientation in the cervical spine allows for a large degree of motion. Approximately 50% to 60% of axial rotation occurs between C1 and C2.[28] It is in large part due to the pivot-shaped articulation between these segments. On the other hand, axial rotation is minimal (0° to 5°) at the atlantooccipital articulation. Lateral bending between segments increases from the upper to the lower cervical spine. In the upper cervical spine only about 5° is available; in the middle and lower cervical spine 5° to 10° is available. With lateral bending in the middle and lower cervical regions, the spinous processes rotate to the opposite side (i.e., left lateral bending causes the spinous processes to move to the right). This coupling occurs most at C2-C3 and decreases in the lower segments. With rotation, C2-C3 and segments above bend laterally in the opposite direction of rotation (i.e., right rotation causes left lateral bending). Below this level, however, the cervical spine generally bends to the same side as head rotation. Another coupled pattern with rotation is flexion and extension. Above the C4-C5 level, extension accompanies rotation; below this level, flexion occurs with rotation. These coupling patterns change with the beginning head position.[29] For example, if the head rotates while in full flexion, lateral flexion coupled with axial rotation decreases compared to neutral. These coupled patterns may be important factors for planning positioning and force application with manipulative procedures.

Because acceleration/deceleration injury to the cervical spine is a common mechanism of injury in patients seeking chiropractic care, a brief overview of the biomechanics of whiplash is presented. There is considerable research to indicate a "typical" sequence of events following a rear-end collision. They are divided into phases by Croft:[30]

- *Phase One*—When a vehicle is rear-ended, the patient's torso is forced back into the seat and at the same time moves upward. This upward movement is accompanied by straightening of the cervical spine as it is being compressed axially. The head and neck then begin to extend.
- *Phase Two*—As the head and neck are extending, the vehicle has reached its peak acceleration. Energy stored in the seat from the backward movement of the body into the seat may add more acceleration to the torso as a "diving board" effect. The upward (vertical) movement of the torso may allow ramping over the headrest, adding an element of extension. If the driver's foot is taken off the brake, acceleration may be prolonged.
- *Phase Three*—Acceleration diminishes while the head and torso are thrown forward. It may be accentuated if the driver's foot is reapplied to the brakes.
- *Phase Four*—As the body moves forward, a seat belt and shoulder harness (if applicable) will restrain the torso, allowing the head to decelerate forward.

The older model of hyperextension/hyperflexion injury associated with a "whiplash" or rear-end collision is not always the case. In fact, in recent studies the global neck motion did not extend beyond the normal range of motion.[31] Although global hyperextension does not always occur, intersegmental hyperextension does appear to occur and may be the most prominent injury mechanism. Recent evidence suggests that low-speed rear-impact collisions (LOSRIC) result in a distinct s-shaped curvature with the lower cervical segments hyperextending and the upper cervical segments flexing.[32] As a result of the injury sequence, the instantaneous axis of rotation changes in the lower cervical segments placing more compressive forces on the facet joints and discs in a rapid manner (within 100 msec), particularly at C5-C6.

Evaluation

History

The first line of business is to attempt to rule out "serious" causes of neck or neck and arm pain. It is important to consider the possibility of meningitis when there is accompanying fever and a complaint of neck stiffness. Although neck stiffness may be a common complaint with the flu, the severity of pain and the response to passive flexion of the head are usually less remarkable. When neck pain is associated with a severe headache that is "new" or worse than any headache previously experienced, a red flag should be raised for infection, tumor, or vascular causes.

When patients have a complaint of neck and arm pain, clues to the cause may be evident from the history (**Table 2–1**). If the complaint is of a strip of pain connecting the neck or shoulder to the hand and this strip overlaps several dermatomes or in the hand is rather diffuse, nerve root compression is unlikely. Patients with this presentation often have a referred pain that is unrelated to nerve root compression. These patients rarely complain of weakness in the arm (or if they do it is usually not objectifiable). Patients with nerve root compression will have complaints not only of pain (often localized to a dermatome) but also of eventual motor weakness that can be objectified on the physical examination.

Traumatic/Overuse Injury

When there is direct trauma to the head or neck, it is important to gauge the degree of injury, the mechanism of injury, and whether there was loss of consciousness. There are some classic patterns of injury with respect to specific types of fractures (**Table 2–2**). When these mechanisms are evident from the history, radiographic evaluation can be more focused. In addition to the well-known Ottawa Knee and Ankle Rules, Canadian Cervical Spine Rules[33] have been developed in an attempt to determine who does or does not need radiographic examination following trauma to rule out fracture. Developed a number of years ago, these rules have stood the test of time and comparison to other approaches, and have proven very sensitive for detecting patients in need of radiographic evaluation following trauma.[34, 35] The rules are a set of questions:

- Are there any high-risk factors involved (i.e., age greater than or equal to 65 years, work with dangerous mechanisms, or paresthesias in extremities)? If the answer is yes, then x-rays are indicated.
- Are there any low-risk factors that allow safe assessment of range of motion (i.e., simple rear-end collision, sitting in emergency department or ambulatory since injury, delayed onset neck pain, or absence of midline cervical spine tenderness)? If not, x-rays are indicated. If so, move on to the next question.
- Is the patient able to actively rotate neck 45° right and left? X-rays are indicated if the answer is no.

These rules are intended only to detect those individuals who might have a cervical spine fracture.

Similarly the National Emergency X-Radiography Utilization Study (NEXUS)[36] rules state that, for patients with neck trauma no radiographs are needed if all of the following are true:

- No posterior or central cervical spine tenderness
- No evidence of intoxication
- A normal level of alertness
- No focal neurologic deficit
- No painful distracting injuries

If the patient was involved in an MVA, it is important to acquire detail such as type of vehicle, angle of collision, and damage to the vehicle(s) (see Exhibit 2–1). Information to be elicited from the patient includes his or her position in the car, whether a seat belt and shoulder harness were worn, whether an air bag was triggered, and whether the head or other body parts made contact with the windshield, steering wheel, or dashboard.

Lateral flexion injury to the neck is common in sports and MVAs. When a patient reports having his or her neck snapped to the side, compression injury on the side of head/neck movement and stretch injury on the side opposite are likely. When the brachial plexus is stretched, the upper section is most often involved. The patient will report a sudden onset of weakness in the arm, often with a burning or tingling pain down the outside of the arm to the hand. This type of injury is often referred to in sports as a "burner" or a "stinger." Most injuries are transient; however, some cases may need further evaluation with electrodiagnostic studies. When a lateral flexion injury is reported, it is a caution to the chiropractor not to take the head/neck into the position of injury when adjusting the neck.

When forced flexion is the mechanism, in addition to fractures of the vertebral bodies, myelopathy from a stenotic spinal canal must be considered when the patient has arm or leg complaints. If the patient

Table 2–1 History Questions for Cervical Spine Injuries

Primary Question	What Are you Thinking?	Secondary Questions	What Are You Thinking?
Were you involved in an accident?	Sprain/strain, subluxation, dislocation, fracture, disc lesion	Was your head forced forward?	Sprain/strain of posterior neck muscles/ligaments, fracture of vertebral body, facet dislocation, disc lesion
		Was your head forced back?	Sprain/strain of anterior neck muscles/ligaments, facet compression, hangman's or teardrop fracture at C2-C3
		Was your head turned and flexed?	Facet subluxation or dislocation, sprain/strain
		Was your head stretched to the side?	Brachial plexus stretch lesion, facet fracture, nerve root compression on side of head flexion
		Was your head turned and extended?	Facet compression, articular pillar fracture, sprain/strain
		Did you hit the top of your head?	Possible Jefferson fracture
Does the pain radiate to your arm(s)?	Disc lesion, nerve root entrapment, referred pain, myelopathy, brachial plexus damage, double crush	Is there isolated weakness or numbness?	Nerve root involvement
		Was there associated numbness/tingling or weakness that resolved over a few minutes?	Burner or stinger if involved with a lateral flexion injury
		Is there associated difficulty with walking or urinary dysfunction?	Myelopathy possible
		Is there more numbness and tingling in a diffuse or ill-defined pattern?	Referred pain from facet or trigger points
Are you unable to move your head in a specific direction?	"Torticollis," osteoarthritis, fracture/dislocation, meningitis	Did you simply wake up with this?	Acute "pseudotorticollis" due to global muscle spasm
		Is there associated fever? Is it worse with flexion?	Possible meningitis if flexion pain is severe
		Was there a gradual onset? (in an older patient)	Likely osteoarthritis
		Did this occur after head or neck trauma?	Consider fracture or dislocation
Do you have chronic pain or stiffness?	Osteoarthritis, postural syndrome, subluxation	Does work involve a forward head posture or lateral flexion while on the phone?	Postural syndrome
		Is there local pain with specific movement?	Subluxation

has accompanying complaints of urinary dysfunction, myelopathy must be suspected and investigated further via physical examination and radiographs.

Overuse injury is in most instances postural "injury." A line of questioning regarding occupational mechanical stresses is particularly important for patients with chronic neck pain. Questions should be asked regarding workstations (i.e., height of chair, desk, and computer monitor) and how the telephone is answered and for how long during a one-day period. For those patients whose

Table 2–2 Fractures of the Cervical Spine

Mechanism	Fracture	Best Radiographic View	Stable/Unstable?
Hyperflexion	Wedge fracture of vertebral body	AP and lateral views; loss of anterior body height	Generally stable; based on neurologic signs or potential risk
	Clay shoveler's [C6-T1 spinous process]	Lateral; may need swimmer's view	Generally stable; however, may require several weeks in a hard collar or in rare cases surgical excision
	Teardrop	Lateral view	Unstable; may be associated with anterior cord injury
	Burst fracture	Lateral view	Generally stable; however, requires close monitoring for neurologic compromise
	Bilateral facet dislocation	Lateral view demonstrates instability	Unstable
Flexion/rotation	Unilateral facet dislocation	Lateral view may demonstrate anterior body translation or a dysrelationship of the normal overlap of facets	May be unstable
Hyperextension	Extension teardrop fracture of anteroinferior body of C2	Lateral view	Relatively stable in flexion; unstable in extension
	Hangman's: bilateral pedicle fracture of C2	Lateral view	Highly unstable, requiring halo traction immobilization
Hyperextension/rotation	Articular pillar	Lateral view may show a double outline; AP may show a disruption of the smooth cortical line; oblique or pillar views may be necessary; if found, CT is suggested	Generally stable; however, swelling may produce some radicular signs
Hyperextension/lateral flexion	Facet fracture	Obliques	Usually neurologically stable; however, must be assessed for stability after healing
Compression	Jefferson burst fracture of C1	Visible on AP open mouth; on lateral view increase in retropharyngeal space	Highly unstable, requiring halo traction immobilization

Key: AP, anteroposterior; CT, computed tomography.

Reproduced with permission from S.M. Foreman, Long-Term Prognosis, in *Whiplash Injuries: The Cervical Acceleration/Deceleration Syndrome*, 2nd ed., S.M. Foreman and A.C. Croft, eds., ©1995, Lippincott Williams & Wilkins.

employment requires less sitting and more lifting, it is important to determine the degree of overhead lifting, which often requires a degree of hyperextension of the neck. Dentists, mechanics, plumbers, electricians, and others represent a unique population who often work in awkward positions. It is important to have the patient give a detailed explanation of common prolonged positions or any single position that causes pain. From this description, a relationship regarding which anatomic structures are stretched and which are compressed can be appreciated.

Stiffness/Restricted Motion

For many patients, the biggest concern is stiffness or restricted ROM; they complain that looking over the shoulder is not possible. In an acute setting, the patient often will present with an insidious onset that began upon waking. He or she will complain of difficulty moving the head in any direction with accompanying pain. Often this acute "torticollis" is not a torticollis at all, because all ranges are affected and the patient's head is held in neutral and not cocked to one side. Although

there is no known cause, the global muscle-splinting effect makes this a painful but benign condition in the majority of cases.

Instability

Instability is a concern with trauma to the head or neck. The type of fracture often suggests the mechanism of injury (Table 2–2). Fracture should always be considered with compressive or distractive injury to the neck. Instability is always a concern with patients who have signs or symptoms or a previous diagnosis of rheumatoid arthritis, seronegative arthritides (i.e., ankylosis spondylitis, Reiter's syndrome, or psoriatic arthritis), or Down syndrome.

Examination

Inspection, palpation, and ROM testing are the clinical approach taken when neck pain or stiffness is the primary complaint. A recent study evaluated the intrarater and interrater reliability of visual assessment of cervical and lumbar lordosis (without the use of a measurement instrument).[37] This study included chiropractors, physical therapists, physiatrists, rheumatologists, and orthopaedic surgeons. Subjects were divided into those with back pain and those without. Raters were asked to rate photographs placed in a PowerPoint presentation. Lateral views of relaxed individuals' cervical and lumbar curves were rated as normal, increased, or decreased. Interestingly, there was no difference in rating between those with or without back pain. The intrarater reliability was statistically fair ($\kappa = 0.50$) and the interrater reliability was poor ($\kappa = 0.16$). When the complaint involves radiation into the back or extremities, specific orthopaedic and neurologic tests are added. The primary intention of orthopaedic tests is to compress or stretch pain-producing structures such as facets and nerve roots. The standard battery of orthopaedic tests includes various forms of cervical compression, cervical distraction, shoulder depression, the brachial plexus stretch test, Soto-Hall test, and Lhermitte's test. Cervical compression also referred to as Spurling's test (**Figure 2–1**) is usually axially applied with the patient's head in neutral and then in all positions of lateral flexion, flexion, extension, and rotation. Local pain felt more on extension and/or rotation indicates facet involvement, while radiating pain down the arm indicates nerve root involvement. Cervical distraction is an attempt to reduce local or radiating complaints. If the maneuver is more painful, muscle splinting is likely. There are very few orthopaedic tests for the cervical spine. Most of these tests are provocative or relief tests for cervical radiculopathy. Recently, a study evaluating the sensitivity and specificity of Spurling's test determined that although not very sensitive, Spurling's test is a specific test for cervical radiculopathy.[38] Therefore, the test is not useful in screening, but is useful in confirming a cervical radiculopathy diagnosis. Shoulder depression can cause nerve root or brachial plexus stretching on the side opposite head deviation, or nerve root compression on the side of lateral flexion; however, there is no evidence for the value of this test. Shoulder depression, in fact, is imbedded in the upper limb tension test and does not need to be performed separately. Cervical distraction too is part of the upper limb tension group of testing maneuvers and will be discussed later (**Figure 2–2**). Soto-Hall and

Figure 2–1 Spurling's test.

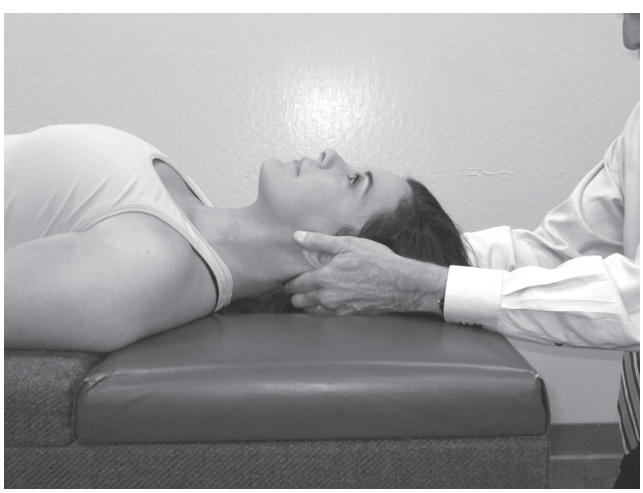


Figure 2–2 Distraction.

Lhermitte's tests involve passive flexion of the patient's neck. Electric shock sensations down the arm or arms is a positive Lhermitte's response and is occasionally found with multiple sclerosis or cervical myelopathy.

Vikari-Juntura and colleagues[39, 40] evaluated the interexaminer reliability and validity of some common clinical evaluation procedures for the cervical spine. Inspection of atrophy of small muscles of the hand, sensitivity tests for touch and pain, and the cervical compression and distraction tests were considered reliable. Muscle strength testing and an estimation of ROM were considered fairly reliable. Palpation for trigger points, the brachial plexus stretch test, and the shoulder abduction relief test (relief of arm pain when holding the arm above shoulder level), however, were considered poor. When 43 patients with known cervical disc disease were tested with cervical compression, distraction, and shoulder depression the specificity was high; however, the sensitivity was low (25% to 50%). Therefore, patients with cervical disc disease did not consistently have pain provoked or relieved by these maneuvers. When the test was positive, however, it was fairly specific to a disc lesion. Adding neurologic and radiographic information raised the sensitivity to between 40% and 64%. A recent study[41] suggests that the addition of cervical nonorganic signs to assess abnormal illness behavior may be helpful.

A more recent and high-level review by Wainner et al.[42] on the diagnostic accuracy of the clinical examination and patient self-report for cervical radiculopathy indicates that there may be some value in clusters of findings. The upper limb tension test (ULTT), sometimes referred to as the brachial plexus stretch test, was found to be a very good screening to rule out cervical radiculopathy. As with the lumbar spine examination, the neurological examination for dermatome, myotome, and deep-tendon reflex abnormalities is relatively specific but not sensitive (i.e., the patient may have nerve-root involvement and not have neurological evidence upon examination). The recommended cluster of test findings was:

- The ULTT
- Cervical rotation of less than 60°
- The distraction test (i.e., relief of radicular symptoms)
- Spurling's "A" test

Exhibit 2–4 provides a graphical example of how the likelihood of cervical radiculopathy is estimated using this approach. It was estimated that if three out of these four tests were positive, the probability of having cervical radiculopathy increased to 65%. If all four were positive, the probability increased to 90%. (For a description of how to perform these tests see **Table 2–3** and **Figure 2–3**.) The authors caution the clinician in applying the cluster in practice. They indicate that the 95% confidence intervals (CI) for diagnostic accuracy for individual examination tests, and the test cluster, were wide due to the limited sample size and low prevalence of radiculopathy in their study. Another review by Rubinstein et al.[43] concurs with this caution stating that more high-quality studies are needed.

Nordin et al.[44] have made recommendations as the Task Force on Neck Pain and Its Associated Disorders committee addressing assessment. The committee came to similar conclusions in other studies. Specifically, they found that the interexaminer reliability was quite variable for muscle strength testing and sensitivity to touch. There was better reliability for increased versus decreased sensation. For radiculopathy, they concluded that a specific portion of the ULTT was highly sensitive and potentially specific. This position was a contralateral rotation of the head and extension of the arm and fingers. For non-emergency neck pain, the evidence does not support the diagnostic validity of provocation discography, anesthetic facet or medial branch blocks, surface electromyography, dermatomal somatosensory evoked responses, or quantitative sensory testing for radiculopathy. It is important to note that facet or medial branch blocks are also used as treatment, and this group did not address this use given that their focus was on diagnosis.

Other tests with acceptable diagnostic accuracy included cervical flexion less than 55°, a decrease in biceps reflex and muscle strength, the Valsalva test, a variation of Spurling's (test A), shoulder abduction weakness, C5 dermatome involvement, and two history questions: "Where are your symptoms most bothersome?" and "Do your symptoms improve with moving or positioning of your neck?"

The standard neurologic examination attempts to differentiate the cause of associated arm pain, numbness and tingling, or weakness. This process attempts to rule in or rule out nerve root compression, peripheral nerve entrapment, referred pain, brachial plexus injury, and spinal cord injury. This is accomplished by determining whether regions specific to a nerve root or peripheral nerve have sensory or motor deficits (see **Figure 2–4**). Larger, more diffuse patterns of sensory or motor loss require a search for brachial plexus or spinal cord

involvement. Bilateral patterns suggest systemic polyneuropathies or spinal cord involvement.

It is important to note that weakness found on physical examination is actually more common than subjective weakness. Of patients with radiculopathy, 64% to 75% demonstrate weakness upon examination while only 15% to 34% complain of weakness. Deep tendon reflex involvement is found in 84% of patients with radiculopathy and dermatome sensory changes in only 33%.

The most commonly involved nerve root is C7 followed by C6. The standard muscle test for C7 is elbow extension. For C6, the standard muscle test used is wrist extension. A recent study[45] evaluated the value of adding forearm pronation to these muscle tests. Their results

Exhibit 2–4 Likelihood Patient Has a Cervical Radiculopathy Approximating Probability: The likelihood ratios (LRs) in this graphical representation represent estimates of probability based on the aggregate of multiple reviews of each test finding. They are only approximations and only reliable indicators of a change in the context of a patient having an intermediate pre-test probability of between 20% to 80%. If the pre-test probability is very high or very low, the LR has little effect on changing the probability.

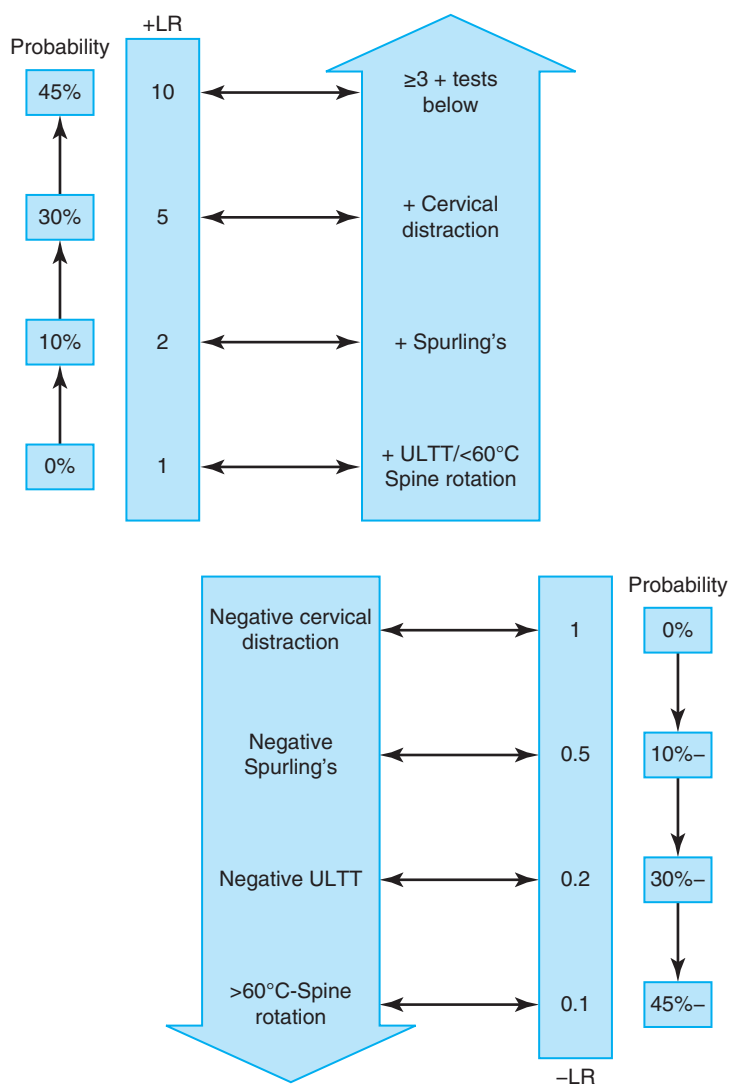


TABLE 2–3 Tests as Described and Performed in the Wainner et al.[1] Study

Name of Test	How to Perform	Positive Test Finding
Spurling's test A	With the patient seated, the neck is passively laterally bent toward the symptomatic side and the examiner applies over-pressure.	Symptom reproduction
Spurling's test B	With the patient seated, the neck is passively placed in a combination of laterally bending, coupled with rotation and extension toward the symptomatic side and the examiner applies over-pressure.	Symptom reproduction
Neck distraction	The patient is tested supine. The examiner's contact is under the chin and occiput. The patient's neck is then flexed to a position of comfort. Gradual distraction is then applied up to 14 kg.	Symptom decrease or elimination
Upper limb tension (Part A)	The patient is supine. The patient is positioned sequentially through six positions. The first five gradually increase stretch to the nerves and therefore may create a positive reproduction of arm symptoms. Scapular depression is followed by shoulder abduction (with scapular stabilization), then forearm supination coupled with wrist and finger extension. Next, shoulder external rotation, then elbow extension is added followed by contralateral cervical side-bending. The final position is movement of the head to ipsilateral cervical side-bending. This final position should provide relief of arm symptoms if positive.	In addition to reproduction of the patient's complaints with any of the first five maneuvers, or relief of symptoms with ipsilateral side-bending of the neck, side-to-side differences of >10° in elbow extension are also considered a positive.
Cervical rotation	The patient is seated and asked to perform two repetitions in each direction and then a single measure with a long-arm goniometer is performed.	Cervical rotation <60°
Cervical flexion	The patient is seated and asked to perform two repetitions. A single inclinometer is used to measure.	Cervical flexion <55°

1. Data from Wainner RS, Fritz JM, Irrgang JJ, Boninger ML, Delitto A, Alison S. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. *Spine*. 2003;28(1):52–62.

indicated that with C6 radiculopathies, forearm pronation was weak in 72% of patients, twice the number of patients demonstrating weak wrist extension. For C7, elbow extension and forearm pronation were weak in 23% of patients but in 10% of patients the only weakness found was in the forearm.

The basic approach to detecting nerve root involvement is a search for corresponding deficits in sensory, motor, and reflex function. Following is a basic pattern for spinal levels C5-T1 (patterns may vary depending on the source due to root overlap):

- C5—motor supply to the deltoid (shoulder abduction) and biceps (elbow flexion/supination), biceps reflex, and sensory supply to outer shoulder (axillary nerve)
- C6—motor supply to the biceps (elbow flexion/supination) and wrist extension, brachioradialis reflex, and sensory supply to the outer forearm
- C7—motor supply to the triceps (elbow extension), finger extensors and wrist flexors, triceps reflex, and sensory supply to the middle finger
- C8—motor supply to the finger flexors, no reflex, and sensory supply to the little and ring fingers
- T1—motor supply to the interosseous muscles of the hand (abduction/adduction of fingers), no reflex, and sensory supply to the medial arm

It is interesting to note though that in a study by Murphy et al.[46] patients with radiculopathy do not seem to indicate a dermatomal pattern to their radiating pain. Only 30.3% of patients with cervical radiculopathy reported a dermatomal pattern to their radiating pain (69.7% reported a nondermatomal pattern) with the exception of C4 where 60% of patients reported a dermatomal pattern. Given C4 is not often involved in radiculopathy, the majority of patients then describe a nondermatomal pattern.

Figure 2–3 The Upper Limb Tension Test (ULTT): (A) Step 1—scapular depression; (B) Step 2—shoulder abduction; (C) Step 3—forearm supination, wrist and finger extension; (D) Step 4—shoulder external rotation; (E) Step 5—elbow extension; (F) Step 6—contra lateral cervical side-bending (lateral bending); (G) Step 7—ipsilateral cervical side-bending (lateral).

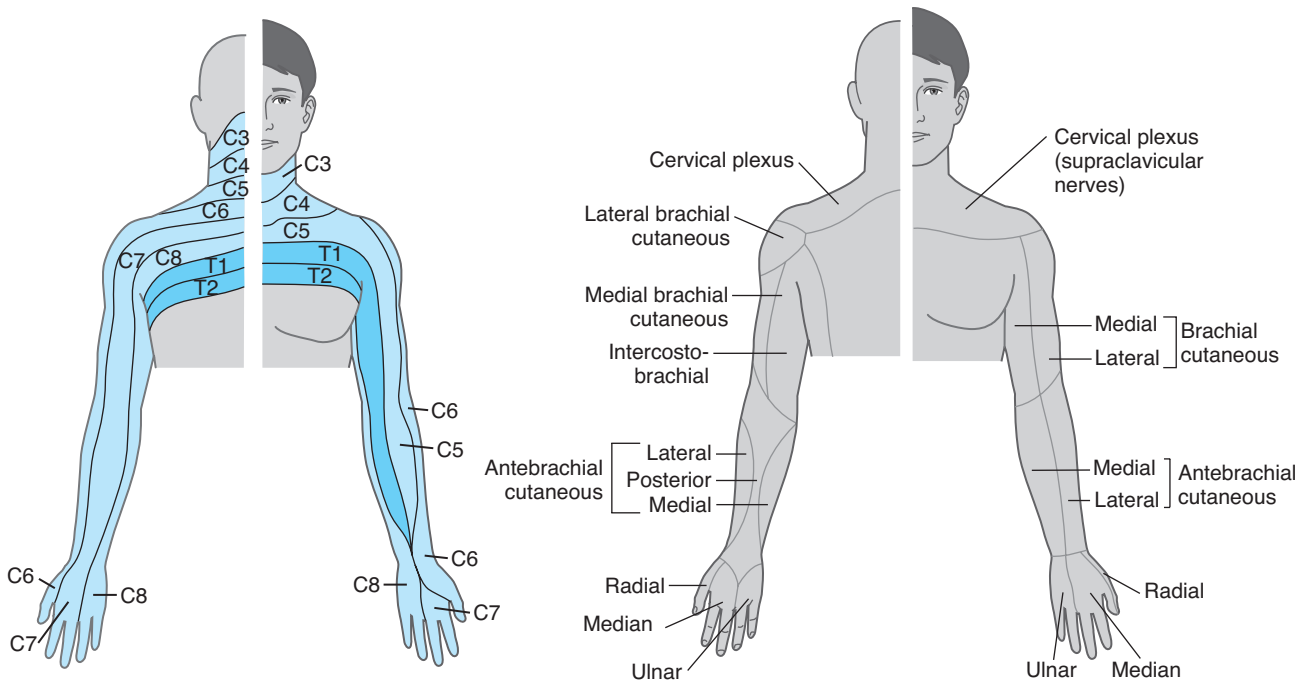


Figure 2–4 Neck complaints. Dermatomes of the upper extremity and the cutaneous innervation of the arm by the peripheral sensory nerves.

Part of the neurologic examination includes evaluation of grip strength. The most common device used is a Jamar dynamometer (Bissell Healthcare Corporation, Bolingbrook, Illinois). This device has been shown to be accurate, and the interrater reliability is high. There are, however, positional and postural effects on readings:[47]

- The wrist can be between 15° of palmar flexion and 30° of extension without an effect on strength; grip is stronger in supination, weaker in pronation; use neutral as the standard forearm position.
- The maximum readings are found with the second- and third-handle positions of a Jamar dynamometer.
- The first and second attempts are the strongest.
- Hand dominance may cause a 10% to 15% higher reading on that side.
- Test and retest reliability is best with the mean of three trials (attempts) (0.80).
- The patient should be tested in a seated position with the elbow flexed 90° at the patient's side.
- Patients test stronger in the standing position.
- If there is any question as to patient participation, it may be helpful to have the patient test with each handle position; a bell curve should appear even with neurologic weakness (i.e., strongest in the middle handle positions, weakest in the shortened and lengthened positions).

Common muscle imbalances at or affecting the cervical spine include tightness of the sternocleidomastoids (SCMs); short, deep neck extensors; upper trapezius; levator scapulae; and the pectoralis major and minor. Muscles that tend to be inhibited include the deep neck flexors and the lower stabilizers of the scapulae, including the lower and middle trapezius and the rhomboids. Taken together, these imbalances often lead to a rounded shoulder, forward head position. Functional testing as described by Janda[8] includes the spine-chin tuck test. The supine patient is instructed to tuck the chin in as much as possible and then raise the head 1 cm off the table. If the chin pokes or juts forward or if the head shifts up or down, Janda considers this an indication of substitution by the SCMs for the deep neck flexors.

TOS is often considered in the differential diagnosis of patients with arm complaints. Unfortunately, much of this testing is associated with a high level of false-positive and false-negative responses. These maneuvers are designed to compress the brachial plexus by specific structures in the hope of reproducing the patient's arm complaint. If a diminished pulse is used as a positive, however, a false-positive rate of 50% occurs.[48] Tests

include Adson's, Halstead's, Wright's, and Roos' hyperabduction test. Adson's and Halstead's tests attempt to isolate the anterior or middle scalenes, respectively, as compression sites. The patient's arm is passively abducted while the patient turns his or her head to one side and then the other. The examiner palpates the radial pulse for a decrease; however, a true positive is reproduction of the patient's arm complaints. Wright's hyperabduction test is similar; however, the arm is abducted and extended back. The Roos' test is a functional assessment. The patient is asked to hold the hand up above the head and repeatedly grip and release for 20 to 60 seconds in an attempt to reproduce the arm complaint(s).

Although numerous factors have been implicated as potential predispositions to vascular injury, none has been demonstrated to be significant for vertebrobasilar risk.[49] Analysis of the literature published before 1993 that reported vertebrobasilar artery dissection and occlusion leading to brainstem and cerebellar ischemia and infarction totaled 367 case reports.[51] Of these, 160 cases were of spontaneous onset with no association to manipulation, whereas 115 cases were of onset after spinal manipulation, 58 cases were associated with trivial trauma, and 37 cases were caused by major trauma. An analysis of possible causative head positions or specific manipulative procedures failed to identify any consistent pattern. In a review article by Haldeman et al., data from 64 cases of CVA associated with cervical spine manipulation did not reveal any inherent predictors in the history or physical examination that would assist in determining which patients are at risk.[52]

Routine radiography of the cervical spine is considered unnecessary unless it can potentially change the management of a case. Conditions that might warrant routine radiography include trauma, infection, gross instability, fracture/dislocation, and cancer. Another possible indication is radiating pain or numbness/tingling into the arm/hand. The decision is based on a thorough history and examination, however. Routine radiographs to evaluate degenerative changes are considered of limited value.[53] Radiographic examination of the cervical spine begins with a standard three-shot series including an AP, an AP open-mouth, and a lateral. Based on what is viewed on these basic films, a decision to complement the evaluation with oblique, flexion/extension, swimmer's, or pillar view can be made. Oblique views are valuable for visualizing the intervertebral foraminae (IVF) in search of foraminal encroachment due to osteophytes or dislocation. A bilateral or unilateral pillar view may be helpful when concerned about a possible hidden fracture of the posterior elements.[54] The unilateral view is safest with the patient's head turned 45° and slightly flexed. There is a 30° to 35° caudad tube tilt based on the degree of cervical lordosis. When segmental instability is suspected, the lateral view will provide sufficient evidence for the middle and lower cervical spine. The criteria that are used include the following:

- fanning of adjacent spinouses
- a kyphotic angulation greater than 11°
- greater than 3 mm anterior displacement between the inferior posterior border of the superior vertebra and the superior posterior border of the adjacent inferior vertebra

Medical evaluation of instability may involve a radiographic traction stretch test.[55]

For the upper cervical spine, instability is often the result of rheumatoid or congenital disorders, although trauma is a possible cause. In patients with rheumatoid arthritis, the seronegative arthropathies, or Down syndrome, an evaluation of the atlantodental interspace is warranted. It is measured on a lateral view; most evident in flexion on a flexion/extension series. A measurement of the distance between the posterior margin of the anterior tubercle of C1 and the anterior surface of the odontoid is referred to as the atlantodental interspace (ADI), and it is an indirect measure of the integrity of the transverse ligament of the atlas. For adults the normal ADI measurement is between 1 and 3 mm; in children, it is between 1 and 5 mm.

Intersegmental hypermobility has been suggested as a biomechanical factor worth investigating; however, examiners have not been able to establish either the criteria or the ability to detect this entity.[56] The standard approach is to use flexion/extension lateral views to observe or to mark intersegmental movement not visible on a neutral lateral view.

A measure of the spaciousness of the spinal canal can be estimated on the lateral cervical view. The distance is measured with a line drawn from the posterior surface of the vertebral body extending to the same-level spinolaminar junction. The diameter varies based on the segmental level and the age of the patient (i.e., adults versus children); however, a canal less than 12 mm is considered stenotic. Another approach is to take the ratio of the sagittal diameter (same as above) to the vertebral body sagittal diameter. A ratio of less than 0.82 is considered evidence of stenosis (Pavlov or Torg ratio).[57]

With regard to TOS, many doctors will assume that the presence of cervical ribs is diagnostic. Yet less than

1% of the population have cervical ribs; of these individuals, less than 10% will have symptoms. Also, the more common cause of TOS is fibrous bands not visible on a radiograph.[58] Three spaces can be measured if a soft tissue mass is believed to be anterior to the cervical vertebrae: the retropharyngeal (at C2-C3), retrolaryngeal (at C4-C5), and retrotracheal (at C5-C7) spaces. Normal values on the neutral are 5 mm at C2, 7 mm at C3-C4, and 20 mm at C5-C7.[59]

When ordering special studies, it is always important to consider which imaging tool best evaluates what type of tissue. It also is extremely important to correlate clinical findings with special study findings due to the significant number of abnormal findings in asymptomatic patients. CT scans and MR imaging are valuable only when radiographs fail to determine the exact cause of a complaint of radiation of symptoms into the arms or back. Even then, it is probably worth a conservative trial prior to using these expensive tools. If stenosis is suspected, a CT scan is quite valuable. If disc herniation, multiple sclerosis, tumor, infection, or cancer is suspected, MR imaging is probably more valuable in most cases.

Electrodiagnostic studies occasionally are needed in the differentiation of neck and arm pain. Electromyography (EMG) and nerve conduction velocity (NCV) tests are valuable in differentiating nerve root compression from peripheral neuropathies. Somatosensory-evoked potentials (SEPs) and dermatomal somatosensory-evoked potentials (DSEPs) may be helpful in evaluating the patient suspected of having cervical myelopathy and determining the degree of involvement.

Management

The Neck Pain Task Force (Guzman et al.[60]) recommends a triage approach. They have devised four grades with associated recommendations:

- Grade I—Neck pain with no signs of serious pathology and little or no difference with daily activities. No further work-up is necessary; reassurance and self-care should be emphasized.
- Grade II—Neck pain with no signs of serious pathology but interference with daily activities. Assess factors and advise about methods that may help decrease interference in daily activities; discuss options for short-term relief.
- Grade III—Neck pain with neurologic signs of nerve compression. Monitor if deficits are stable and minor; consider MRI and referral if deficits are major or progress; an EMG might be needed.
- Grade IV—Neck pain with signs of major structural pathology. Investigate according to the suspected condition.

Recommendations regarding options for short-term relief include exercise training and mobilization for those with neck pain after a traffic collision. For those with no trauma the task force recommends exercise training, manipulation, mobilization, acupuncture, analgesics, and low-level laser treatment. **Table 2–4** is a summary of all of the conclusions and recommendations of The Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders.

The Mercy Guidelines[61] and other sources suggest that approximately six weeks of care is usually all that is needed in most "uncomplicated" cases. Initial high-frequency treatment ranging from three to five treatments for one to two weeks is considered appropriate. Treatment past this point is gradually decreased if the patient is responding; if not, a second two-week trial using a different form of treatment is suggested. If unsuccessful, then special studies or referrals for medical consultation are suggested. It is suggested that a questionnaire such as the Neck Disability Index (Exhibit 2–2) be used as a baseline measurement of patient status. This tool has been demonstrated to be a reliable indicator of the patient's functional improvement.[62]

The Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders (Haldeman et al.[63]) provides a list of modifiable risk and protective factors, which include smoking, exposure to environmental tobacco, and participation in physical activity. Although they found insufficient evidence of the effectiveness of workplace interventions, they did find that high quantitative work demand, low social support at work, repetitive work, precision work, and sedentary work position all increased the risk of neck pain. Poor prognosis was associated with:

- poor health
- prior neck pain episodes
- poor psychological health
- worrying
- becoming angry or frustrated in response to neck pain

Indicators of a good prognosis included a coping style that involved self-assurance, optimism, and less need to socialize. Recovery appeared to be unrelated to a

Table 2–4 Conclusions and Recommendations from the Task Force on Neck Pain and Its Associated Disorders

Intervention	Recommendations
Nonsurgical Intervention[1] Whiplash-Associated Disorders	
Education or advice	• Evidence that an educational pamphlet was not associated with recovery in patients with acute WAD. • Some evidence that an educational video in combination with usual urgent or emergency care is associated with lower pain ratings at six months with acute WAD compared to usual care alone.
Exercise	• Some evidence that using an exercise component was positively associated with more favorable results in short- and long-term outcomes with acute or subacute WAD when compared to passive interventions including education. • Supervised and home exercise have marginal effects over advice but not in the long term.
Medications	• Cervical facet injections were not associated with greater pain reduction at three months. • Infusion of methylprednisolone was not associated with greater pain relief in the short term for acute WAD.
Manual therapies	• Mobilization was associated with greater pain relief in the short term for acute WAD as compared to passive modalities or general advice. • No advantage for a rigid collar for two weeks and mobilization over usual care at 12 months follow-up.
Physical modalities	• No advantage for passive modalities (TENS, ultrasound, diathermy) alone or in combination with mobilization in the short term compared to exercise and manual therapy for acute or subacute WAD.
Collars	• No advantage for soft or rigid collars compared to other approaches for acute WAD.
Combined approaches	• Evidence that multidisciplinary management was associated with quicker claim closure for WAD compared to usual care. • Evidence that fitness training or in- or outpatient rehabilitation plus usual care may increase recovery time for acute WAD.
"Nonspecific" Neck Pain	
Education or advice	• No evidence of advantage in education or advice over other interventions.
Exercise	• Evidence that a neck exercise program alone or in combination with spinal manipulation decreases pain and disability in the short term when compared to manipulation alone, TENS, or usual GP care. • Evidence that manual therapy or pulsed diathermy with neck exercise and coping advice were not associated with improvement compared to exercise and advice alone. • Compared to endurance exercise, strengthening exercise was not associated with a better outcome in the short and long term with female workers.
Medications	• No advantage to botulinum toxin A. • No advantage of piroxicam over indomethacin in the short term. • Some evidence that orphenadrine and paracetamol are associated with greater pain relief in the short term. • Some evidence that manipulation with advice and salicylates is more effective in the short term compared to salicylates with advice, massage electrical stimulation, or traction.

Table 2–4 Conclusions and Recommendations from the Task Force on Neck Pain and Its Associated Disorders (continued)

Intervention	Recommendations
Manual therapies	• Evidence that cervical spine manipulation along or with advice and home exercise was not associated with either pain or disability outcomes in the short or long term compared to mobilization with or without exercise, strengthening exercise, or instrumental manipulation. • Mobilization or exercise alone or in combination with medications was associated with better pain and functional outcomes in the short term compared with usual CP care, pain medication, or advice to stay active. • Evidence that manipulation or mobilization was not associated with better pain or disability outcome for subacute or chronic neck pain as compared to exercise alone or to exercise with massage or passive modalities.
Physical modalities	• Consistent evidence that passive modalities alone or in combination with other passive treatments or modalities have no advantage in the short or long term compared to usual CP, other modalities, or sham interventions. • Percutaneous neuromodulation therapy was associated with better intermediate post-treatment measure of pain, improved sleep, and more physical activity after three weeks with cervical disc disease causing chronic pain.
Acupuncture	• Inconsistent evidence of effectiveness. • Some evidence that acupuncture was better in the short term when compared to massage in the short term for patients with chronic pain. • Evidence that acupuncture was not better than mobilization or traction in the short term.
Laser therapy and magnetic therapy	• Evidence that low-level laser therapy was associated with improvements in pain and function in the short term for patients with subacute or chronic neck or shoulder pain. • Evidence that magnetic stimulation had better pain and disability outcome in the short term for myofascial pain compared to TENS or placebo.
Combined approaches	• Combinations of exercise, manual therapy, and advice were positively associated with decreased pain and disability and decreased time for sick leave compared to usual PCP care, surgery, cervical collar, or advice to stay active.
Workplace or employee interventions	• Evidence that any of the following were not associated with better outcomes: ergonomic interventions, relaxation or behavioral support, software-simulated work breaks which included rest or exercise, and physical training and stress management programs. • Evidence that endurance or strength training in combination with dynamic exercise involving the upper and lower extremities was associated with better one-year pain and disability outcomes in female office workers with chronic or recurrent neck pain compared to advice to perform exercises.
Invasive Interventions[2]	
Cervical injections for neck pain and radiculopathy	• There is evidence that treatment using a short course of epidural or selective root injections with corticosteroids gives short-term relief for radicular symptoms in patients involved in litigation. No evidence that multiple injections offer a benefit beyond one to three injections. • No evidence that cervical root or epidural injections in seriously symptomatic individuals reduce the need for surgery.

(*continues*)

Table 2–4 Conclusions and Recommendations from the Task Force on Neck Pain and Its Associated Disorders (continued)

Intervention	Recommendations
Cervical injection or radiofrequency neurotomy for neck pain without radiculopathy	• Evidence that intra-articular steroid injection is not effective for facet joint pain as compared to other anesthetic blockage protocols. • No evidence to support the use of radiofrequency neurotomy for facet pain.
Open surgical treatment of cervical radiculopathy	• No evidence for long-term benefit of surgery for radiculopathy; however, evidence for substantial short-term decrease of pain and impairment. • Evidence that anterior plating in one- and two-level fusions reduces kyphosis progression after surgery. • No evidence that complex approaches (fusion, case, plates, or fusion augmentation with bone) have an advantage over cervical decompression alone.
Open surgical treatment for neck pain without radiculopathy	• No support for the use of anterior cervical fusion or cervical disc arthroplasty for neck pain without radiculopathy. • No evidence to support surgical intervention for suspected upper cervical ligamentous injury following whiplash as determined by spinal change within these ligaments on MRI.
Complications with surgery	• With cervical foraminal or epidural injections—minor adverse effects in 15% to 20% of patients; serious events in < 1%. • Cervical open surgical procedures—serious complications in 4% of patients (higher in older patients and those with surgery for myelopathy); minor complications such as dysphagia, hoarseness, and donor site pain are frequently reported but resolved in most cases.

WAD = whiplash-associated disorder.
Data from: 1. Hurwitz EL, Carragee EJ, van der Velde G, et al. Treatment of neck pain: noninvasive interventions: results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Spine*. 2008;33(4 Suppl):S123–152; 2. Carragee EJ, Hurwitz EL, Cheng I, et al. Treatment of neck pain: injections and surgical interventions: results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Spine*. 2008;33(4 Suppl):S153–169.

specific workplace or physical work demands with those patients who included general exercise or sports as part of their lifestyle.

Following are a list of some of the side effects or complications with various treatment approaches (Guzman et al.[63]):

- Anti-inflammatory medication—dyspepsia (heartburn), GI bleeding in up to 2% of individuals with chronic use, heart attacks, hypertension
- Muscle relaxants or narcotics—drowsiness in one out of three individuals
- Exercise—transitory increases in pain
- Manipulation or manual medicine—transitory increase in pain in up to 30% of individuals; less common with mobilization
- Injections—transient increases in pain, numbness, and dizziness in up to 16% of individuals; major complications in less than 1%
- Surgery—transitory hoarseness and difficulty swallowing, rarely permanent hoarseness, nerve or spinal cord injury, or stroke

The recent Thiel et al.[64] prospective national survey involved more than 28,000 treatment consultations and over 50,000 cervical spine manipulations. There were no serious adverse events reported. Minor side effects with possible neurologic involvement were most common, with the highest risk occurring immediately after treatment for fainting, dizziness, or light-headedness (approximately 16 per 1,000 treatment consultations). For up to seven days post-treatment, the risks were headache

(at most approximately 4 per 100), numbness or tingling in the upper limbs (approximately 15 per 1,000), and fainting, dizziness, or light-headedness (approximately 13 per 1,000).

Rubinstein et al.,[65] in a prospective, multicenter, cohort study, have also demonstrated that although adverse effects are relatively common (56%), they are short-lived and rarely severe in intensity (13%). Patients were initially treated three times. Symptoms such as tiredness, dizziness, nausea, or ringing in the ears were uncommon (less than 8%). At 12 months, 1% of patients reported being worse. Of patients who returned for a fourth visit, about 50% reported recovery.

Ernst[66, 67] is commonly critical of cervical manipulation and its associated risk (as evident in several publications). Bronfort et al.[68] clearly point out the methodological flaws in Ernst's arguments.

The strongest study to date by Cassidy et al.[69] evaluated vertebrobasilar (VBA) stroke and chiropractic care. This very large population-based, case-control, and case-crossover study evaluated over 100 million person-years and found there were 818 VBA stroke patients who were hospitalized. Individuals younger than 45 years were three times more likely to see a chiropractor or a primary care practitioner (PCP) before their stroke as compared to controls. There was no increased association between VBA stroke and chiropractic visits in those older than 45 years. However, there was an association between VBA stroke and patients of all ages visiting a PCP prior to stroke. Those billed for headache or neck complaints were highly associated with subsequent VBA stroke. The conclusions that are drawn are:

- A VBA stroke is extremely rare.
- Given there is at least an equal association between chiropractic visits and PCP visits and stroke, it is unlikely that there is something unique to the chiropractic treatment that would contribute as a cause of the stroke.
- Given that patients who subsequently had a stroke had complaints of headache and/or neck complaints, it is likely that dissection (intimal tearing) was occurring at the time of presentation and not due to an intervention in the PCP's or chiropractor's office.

Another revealing report by Boyle et al.[70] reviewed the statistics for VBA stroke in Saskatchewan (over eleven years) and Ontario (over nine years) covering more than 100,000 person-years in each province. It appears that the incidence for VBA in Saskatchewan was 0.855 per 100,000 person-years and 0.750 per 100,000 person-years in Ontario. The study revealed that there was an increase of 300% of cases in Saskatchewan in 2000 and only a 38% increase in Ontario in the same year. Correspondingly, there was only a small increase in chiropractic utilization in Saskatchewan and an actual decrease in chiropractic utilization in Ontario during this year. This data would seem to suggest that there is no association between the increase in VBA stroke and chiropractic utilization.

Finally, a number of basic science investigations into the effect on vertebral artery blood flow by manipulation or positioning for manipulation have been conducted on cadavers and live participants. A 2014 publication[71] confirmed what other studies have found. In this study using phase-contrast magnetic resonance imaging on asymptomatic volunteers, physiologic measures of VA blood flow and velocity at the C1-C2 spinal level were obtained after three different head positions and a chiropractic upper cervical spinal manipulation. There were no significant changes in blood flow or velocity in the vertebral arteries with any positions or with manipulation.

Prior to the use of manipulation for the cervical spine, it has often been suggested that the patient be informed of the very rare yet potential risk of a vertebrobasilar accident. As mentioned earlier, there is no sensitive or reliable screening test, and it is not enough to rely on a past history of uncomplicated manipulation treatment.[49] It must be accepted that the risk is small but real, and there is no known clinical test to identify those who will have an accident. The patient should be informed of this rare complication, given the potential for neurologic compromise.

Postural advice regarding work and everyday posture is considered an important adjunct by many chiropractors. The focus should be to maintain a neutral head position. This often involves a focus on stretching of the short spinal extensors with strengthening of the deep neck flexors. Supportive to this attempt is correction of the factors contributing to a hyperlordotic lumbar spine or hyperkyphotic thoracic spine when possible. Exercises should include stretching of the upper trapezius/levator scapulae, pectorals, lumbar extensors, and hip flexors, followed by strengthening of the middle/lower trapezius, abdominals, and gluteals. Ergonomically, workstations should be oriented to provide a straight-ahead view of a computer screen,

shoulder support or a headpiece for long-term telephone usage, and arm supports on the chair.

The sequence of prescribed exercises usually begins with mild isometrics, progressing to a more functional approach. Minimal contractions into all six movement patterns of flexion, extension, lateral bending, and rotation are initiated as soon as pain restriction permits.

Mechanical Traction

Although traction is often utilized for neck pain, there are few studies to substantiate effect. One study[50] in 2009 attempted to predict improvement with mechanical traction for mechanical neck pain by evaluating the effect of several variables. A clinical prediction rule utilizing five variables was created based on patient response which included: (1) patient reported peripheralization with lower cervical spine (C4-7) mobility testing; (2) positive shoulder abduction test; (3) age > or =55; (4) positive upper limb tension test A; and (5) positive neck distraction test. The prediction for success with mechanical traction when three out of five predictors were present resulted in a +LR equal to 4.81 (95% CI = 2.17-11.4). This increased the likelihood of success with cervical traction from 44% to 79.2%. But dramatically increasing the effect was if four out of five variables were present. Then the LR was equal to 23.1 (2.5-227.9), increasing the post-test probability of having improvement with cervical traction to 94.8%. The protocol for application included:

- Intermittent traction was applied to a supine patient with 24° flexion.
- If full flexion was not possible, the angle was reduced to 15°.
- The application was one minute on; 20 seconds off. During the off-phase, 50% of the traction pull was maintained.
- Starting pull was 10–12 pounds and was increased in an attempt to reduce symptoms.
- Traction time was 15 minutes.
- There were a total of six sessions at two to three per week for three weeks.

Exercise

Most systematic reviews (including Cochrane) have concluded that exercise is an integral part of management for neck pain patients.[72–74] There is strong evidence for the incorporation of deep neck flexor strengthening either alone or in combination with mobilization or manipulation. There are several approaches to strengthening the neck flexors, yet it appears that the most commonly used are generally equal in effect.[75] The most common approaches are:

- Instruct the supine patient to lift the head and tuck the chin while maintaining the craniocervical area in neutral for a goal of three sets of 12 repetitions. The patient initially uses head weight against gravity. If unable to perform the 12 repetitions, the table is tilted to reduce the effect of gravity until the patient reaches the 12 repetitions goal. After three sets of 12 repetitions is reached, 0.5 kg are added with the goal of 12 repetitions always as the target. Eventually, over a four-week program, the goal is three sets of 20 repetitions.
- Using a pressure biofeedback device, patients are instructed to focus on the craniocervical junction to deemphasize the superficial neck flexors. The patient's head rests on a pressure-sensitive device to a level of 22–30 mm/hg and holds for 10 seconds. The goal is 10 repetitions with small rest periods in between.

An interesting study by Chiu et al.[76] randomized patients with chronic neck pain into either an infrared irradiation and neck care advice group, or a group that added an active exercise program that strengthened deep neck flexors for six weeks. There was a benefit at six weeks for those in the active exercise group; however, this appears to be lost at six-month follow-up when compared to the infrared irradiation plus neck care advice only group.

Two studies published in 2012 compared manipulation with exercise. The first study by Evans et al.[77] compared three groups: (1) supervised exercise with manipulation, (2) supervised exercise alone, and (3) home exercise. Both supervised exercise groups demonstrated similar success; better than the home exercise group. The second study by Bronfort et al.[78] was designed to compare manipulation, medication, and home exercise as a treatment approach for acute, and subacute neck pain. This randomized controlled trial compared these groups for benefit at three, six, and twelve months. There was no real difference between the manipulation and home exercise groups, although there was a significant advantage for

manipulation compared with medication, especially at the one-year follow-up.

Fitz-Ritson[79] suggests exercises that are based on reflex mechanisms similar to the work of Feldenkrais and Alexander. His study indicated a marked improvement in pain and in disability index rating compared with a group using standard (stretching/isometric/isokinetic) exercises. This approach is based on influencing the vestibulo-ocular reflex (VOR), which involves a quick (phasic) coordination of the eye, head, and neck through integration and processing of vestibular, visual, and proprioceptive input.

Manipulation

The effectiveness of chiropractic manipulation for chronic neck pain is supported in the recent literature;[80–84] however, more randomized trials must be performed. In the study by Giles and Muller,[80] a comparison of manipulation to acupuncture and a nonsteroidal anti-inflammatory drug indicated a significant improvement in pain and disability for the manipulated patients as compared with patients undergoing other treatment approaches. Hurwitz et al.[83] published a study as part of the clinical outcomes section of the UCLA Neck-Pain study. The researchers randomized patients with neck pain who were part of a health maintenance organization (HMO) into manipulation with or without heat, manipulation with or without electrical muscle stimulation, mobilization with or without heat, and mobilization with or without electrical muscle stimulation. Cervical spine manipulation and mobilization provided similar clinical outcomes with neither demonstrating an advantage at six months. Giles and Muller[84] conducted a randomized clinical trial on patients with chronic spinal pain presenting to a sports clinic in Australia. They compared treatment results using data from patients randomized to medication, acupuncture, or spinal manipulation. The results indicate greater short-term improvement with manipulation. The largest number of patients who were asymptomatic the earliest were those who were treated with manipulation (27.3%), followed next by acupuncture (9.4%), and then medication (5%). A systematic review[85] published in 2014 concluded that after review of 51 randomized controlled trials, manipulation or mobilization and exercise in combination were effective for management of adults with chronic neck pain.

The management of cervical disc herniation is controversial. An interesting study by Croft[86] demonstrated a "standard" of adjusting (manipulating) patients with known cervical disc herniation among the doctors polled. This finding is interesting given that chiropractors can be accused of causing disc herniation. The majority of chiropractors, however, would not adjust the affected level. There are published case studies[82–88] indicating that chiropractic management of cervical disc herniation may be successful.

Although controversial, manipulation under anesthesia (MUA) for chronic spinal pain has some published support. An early study by West et al.[89] for cervical spine pain indicated good results. Almost all patients were back to work after six months and use of medication dropped significantly. Since then, there have been no large studies using a control group.

Whiplash

A recent report by the Task Force on Neck Pain and Its Associated Disorders (Carroll et al.[90]) noted that approximately 50% of those with whiplash associated disorder (WAD) report neck pain symptoms one year following the initial injury. Some predictors for prolonged recovery appear to be more symptoms, greater initial pain, and greater initial disability. Also prognostic for prolonged recovery were depressed mood, fear of movement, and a passive coping style. Interestingly, factors related to the actual collision such as direction, position, headrest type, and so on, were not found to be prognostic. It is proposed, though, that the number of WAD patients has been decreased by a seat design that has been changed over the last decade. Softer seats that absorb the body's backward movement prevent some ramping, while also bringing the head/neck to the head restraint sooner.

In a study by Cassidy et al.[91] patients who were involved in a whiplash injury were divided into four groups determined by their follow-up care:

1. Fitness training at a health club
2. Outpatient rehabilitation
3. Inpatient rehabilitation
4. Standard care

Those receiving fitness training or outpatient rehabilitation had slower recovery times than patients in the other two groups. Patients in the inpatient rehabilitation group did not differ in outcome as compared to those assigned to standard care. Another study by Cassidy et al. reflects

a similar finding when a patient is returned to work too quickly following a WAD.

For massage, a systematic review published in 2007 by Ezzo et al.[92] concluded that no recommendations could be made based on the existing literature regarding the contribution, type, frequency, multimodal application, or effect on patients with mechanical neck disorders. They recommend better research designed to determine the role of massage therapy.

There have been some small studies[93, 94] with patients suffering from myofascial chronic neck pain that suggest that low-level laser treatment (830 nm or 904 nm) may be effective alone or in combination with other treatment as compared to a sham laser treatment. Although a 2009 review[95] in Lancet concluded that LLLT reduces pain immediately after treatment for acute neck pain and for patients with chronic pain up to 32 weeks after treatment with LLLT, there were limitations to the strength of these conclusions. Three of the studies quoted and utilized in the review that had the largest reported mean differences in favor of LLLT had limitations or errors.

- Two studies had significant baseline differences in favor of the active treatment
- A typing error indicated a significant mean difference when in the original study, there was no significant difference
- Pooling of data for nonspecific neck pain, myofascial pain syndrome, and cervical osteoarthritis may be inappropriate because each may represent a different set of patient types and clinical responses

A more recent study[96] published in 2011 was a small RCT that compared patients randomized to CMT, CMT with LLLT, or a group with both therapies combined concluded that the combination therapy demonstrated better results. However, this was a small group and the effect differences were minimal. More studies need to be conducted with a larger group of participants.

The Quebec Task Force on Whiplash-Associated Disorders[5] concluded that there is little or no evidence for the efficacy of soft cervical collars, corticosteroid injections of the facet joints, pulsed electromagnetic treatment, magnetic necklace, and subcutaneous sterile water injection. Use of soft collars beyond the initial 72 hours postinjury will probably prolong disability. The task force also found that the literature did not support the use of cervical pillows, postural alignment training, acupuncture, spray and stretch, heat, ice, massage, muscle relaxation techniques, epidural or intrathecal injections, psychological interventions, ultrasound, laser, or short-wave diathermy. It is important to note that lack of literature support often means that no significant research has been performed to evaluate efficacy, even though many of these approaches are commonly used. In other words, it does not mean that they are ineffective; more often they are simply untested. Often this is due to the complacent attitude of, "if it works, why question it?"

The contribution of zygapophyseal joint pain to chronic neck pain following whiplash injury was evaluated in a study by Barnsley et al.[97] Fifty consecutive patients with chronic neck pain following whiplash were studied using a double-blind controlled approach incorporating local anesthetic blocks of cervical zygapophyseal joints. Joint blockade injections provided relief to 54% of patients.

In addition to pain, it appears that other reflex abnormalities may occur and persist as a result of cervical spine afferent activation. The question is whether these "late effects" are the result of damage at the time of injury, chronic pain, or cervical afferent activation. These effects include:

- abnormal neuropsychological test results[98]
- vestibular hyperreactivity and abnormalities of the vestibulo-ocular reflex[99]
- cervicocephalic kinesthetic sensibility decreases (ability to return to a neutral cervical position after movement)[100]
- reduction of smooth pursuit ability with neck torsion (ability to smoothly track a moving object)[101]

Results from another study[102] implied a possible positive association between a history of neck injury in an MVA and headaches, disabling neck pain, and a perception of lower general health compared to those with no history of neck injury. Although interesting, it is important to realize that these results do not imply a cause-and-effect relationship between the injury and these subsequent complaints. Low-speed rear-impact collisions (LOSRIC) account for as many as 80% of rear-impact collisions. The range of speed in these LOSRICs is between 6 and 12 mph.

Recent, encouraging research[103, 104] indicates that patients with symptoms of chronic whiplash injury respond well to chiropractic management. Interestingly, one of these studies[103] identified a subgroup of patients who did not respond well to most therapies. These

patients include those with severe neck pain, yet with a full range of motion and no neurologic symptoms/signs specific to a myotome or dermatome. These patients often complained of other symptoms and signs such as blackouts, visual disturbances, nausea and vomiting, chest pain, and a nondermatomal pattern of pain.

Algorithms

Algorithms for traumatic neck pain, nontraumatic neck and arm pain, nontraumatic neck pain with no radiation, and annotations are presented in **Figures 2–5** through **2–8**.

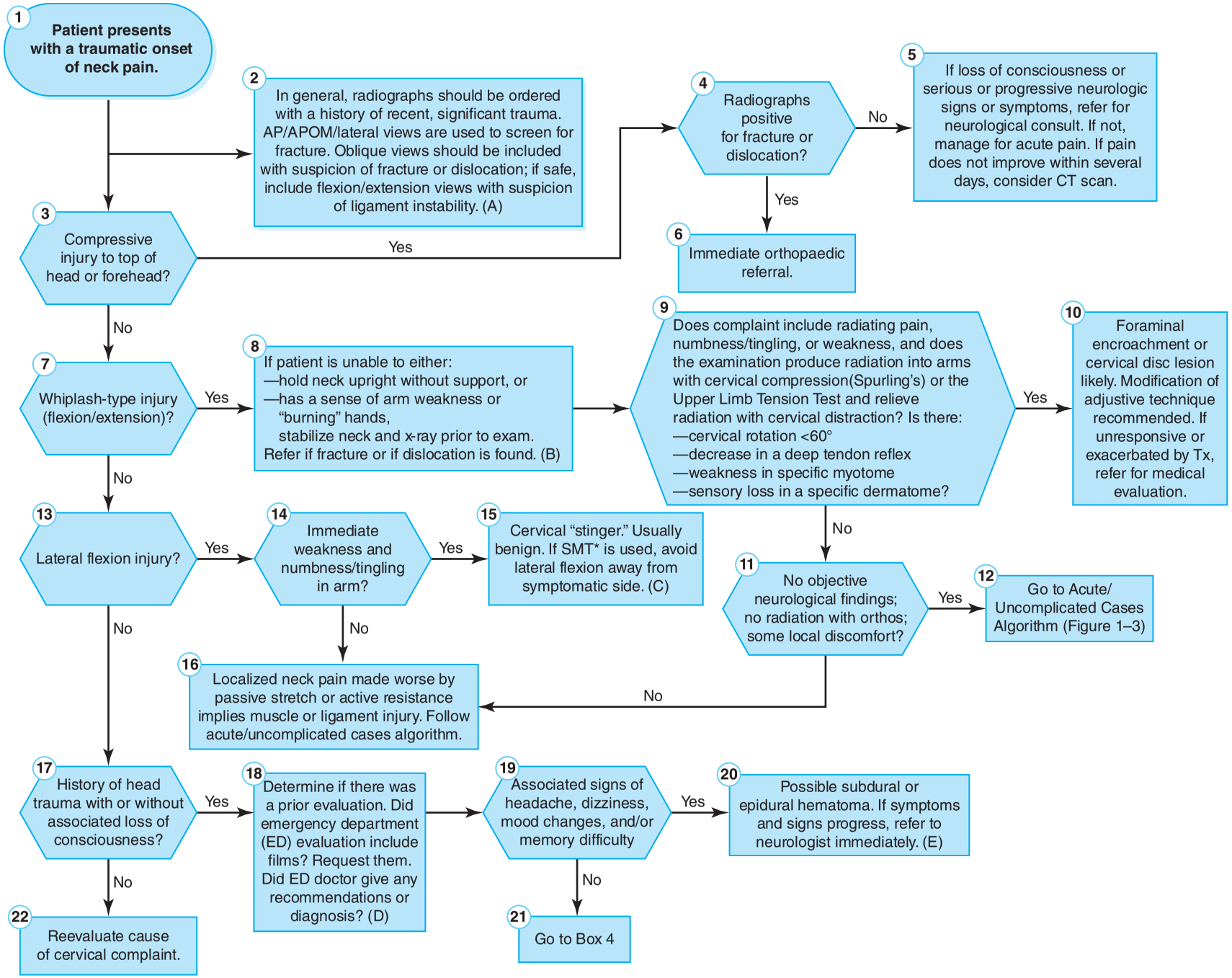


Figure 2–5 Traumatic Neck Pain—Algorithm

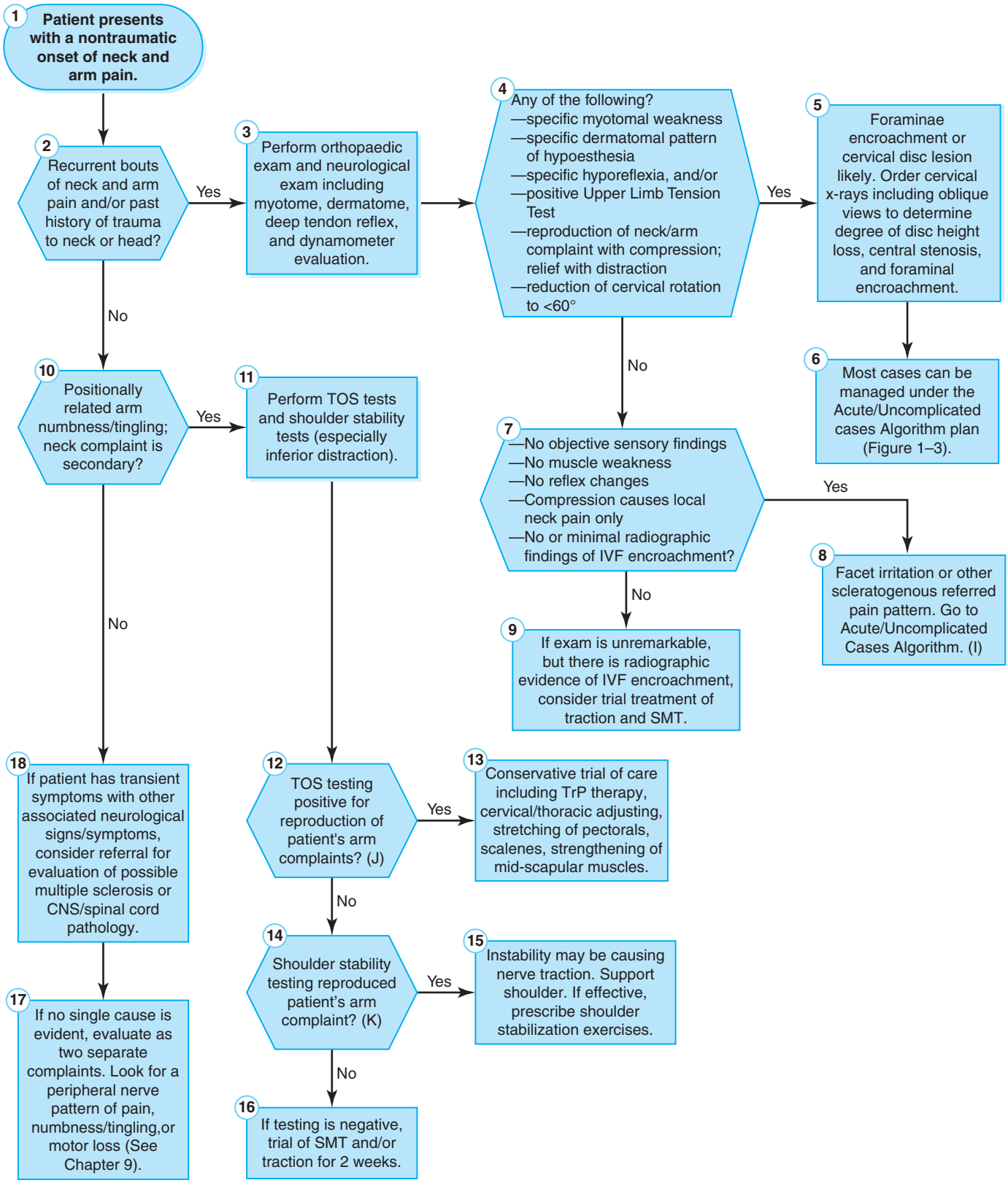


Figure 2–6 Nontraumatic Neck and Arm Pain—Algorithm

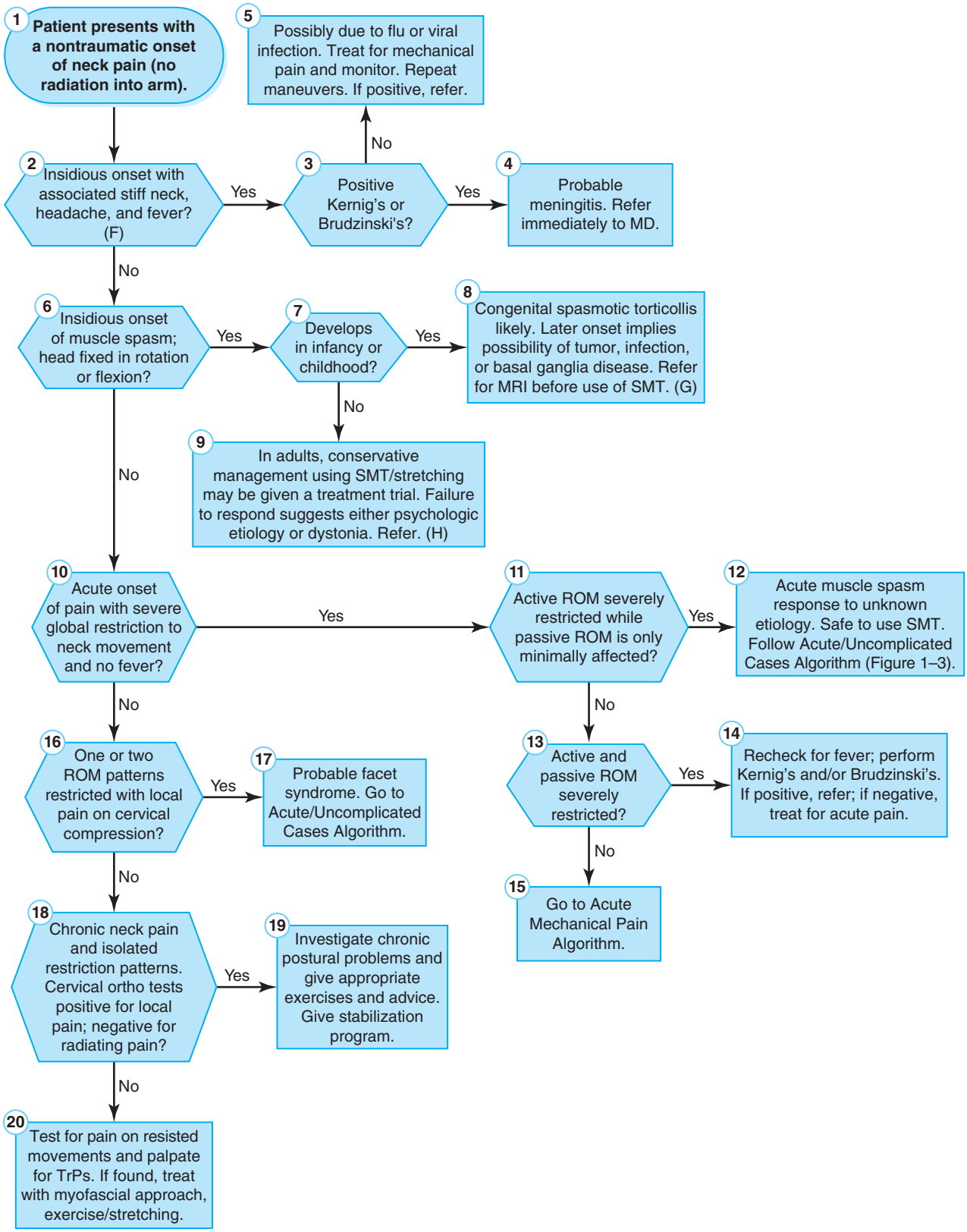


Figure 2–7 Nontraumatic Neck Pain (No Radiation)—Algorithm

A. If trauma is significant or patient is unable to move their neck without significant discomfort, stabilize neck and shoot x-rays prior to orthopaedic examination.

B. Burning-hands syndrome represents spinal cord injury due to stenosis or fracture. Radiographs to determine fracture and degree of stenosis should also include lateral flexion/extension views to determine any contributory instability. Most cases of burning-hands syndrome are self-resolving; however, prolonged recovery is not uncommon.

C. A "stinger" usually involves a traction injury of either the nerve root or plexus. Most are brief occurrences representing a neuropraxia, however, with more severe trauma an axonotmesis can occur requiring referral to a neurologist.

D. It is extremely important to get information regarding any evaluation at another facility. Often films are available and a previous diagnosis and/or patient instructions have been given including some contraindications to manipulation.

E. Any patient with a Hx of head trauma should be monitored for several weeks. Usually due to a torn vein, pressure may develop slowly resulting in very subtle neuro signs/symptoms. With patients who do not seem "quite right," referral to neurologist is warranted. Epidural hematomas usually involve a temporal bone fracture and bleeding from an artery usually resulting in a more rapid onset of neuro signs.

F. Subarachnoid hemorrhage is essentially a brain bruise. It may result from trauma or a ruptured aneurysm or AVM. With vessel rupture, the onset is sudden and there is no associated fever. This may help distinguish the presentation from meningitis. Immediate referral is necessary.

G. Spastic torticollis (wryneck) may be congenital and is self-resolving or is correctable within the first few months. Other causes may include basal ganglion disorders, infection, tumors, and psychiatric disorders. A thorough evaluation is needed prior to application of CMT. Note that the restriction is limited to one side.

H. Dystonia may first present with torticollis and an accompanying distortion of another body part such as the feet. It is rare yet progressive resulting in sustained abnormal postures.

I. Sclerotogenous pain patterns are less distinct than dermatomal or peripheral nerve patterns. Additionally, reflexes, sensory testing, and muscle strength are normal.

J. TOS tests may produce frequent false positives. It is not enough to obtain a diminished pulse. The test must reproduce the patient's complaint of arm pain/numbness/tingling.

K. Shoulder instability has been shown to produce similar symptoms as TOS due to tractioning of the plexus.

Figure 2–8 Annotations for neck pain—algorithms

Selected Causes of Cervical Spine Pain

Cervical Radiculopathy

Classic Presentation

The patient complains of neck and arm pain. Onset often follows neck injury; however, it may be insidious. There is often a past history of multiple bouts of neck pain following minor injuries. The patient also complains of some weakness in the hand. The pain is described as a deep ache. Some patients report some relief with the hand held behind the head.

Cause

Unlike the lumbar spine, herniation of the nucleus pulposus accounts for only 20% to 25% of cases in the cervical spine. The clear difference is the natural history of the intervertebral disc of the cervical spine, which dehydrates to the point of almost a ligamentous structure by the age of 40 to 50 years. In fact, the peak incidence occurs at approximately 50 to 54 years old when the disc can no longer herniate, and a history of trauma is found in only about 15% of cases. The prevalence is quite low compared to the lumbar spine: only 0.8 to 3.5 per 100,000 patients.[105] Seventy percent to seventy-five percent of cases are due to foraminal encroachment due to degeneration, including decreased disc height, uncovertebral joint arthrosis, and facet joint arthrosis.

Evaluation

The patient often will have a painful restriction in active and passive ROM, often more on one side. Orthopaedic testing with cervical compression (Figure 2–1) may reproduce the neck and arm pain. Radiation into the medial scapular area also is possible. Cervical distraction (Figure 2–2) may relieve the arm pain. All of these orthopaedic tests are relatively insensitive but moderately specific.[106] Some patients report some relief of the arm pain by putting the hand behind the head, thereby decreasing any traction effect. Neurologic testing should reveal a decreased corresponding deep tendon reflex, weakness in a related myotome, and sensory abnormality in a related dermatome. Radiographic evaluation of the neck should include oblique views to determine the degree of bony foraminal encroachment. MR imaging or CT scans are reserved for patients with severe pain or those unresponsive to nonsurgical management. Electrodiagnostic studies may be helpful three to four weeks after the onset of symptoms if a specific cause has not yet been identified or the patient is unresponsive to care.

Management

The natural history appears favorable.[107] Conservative treatment is used for approximately 74% of cases. Ninety percent of patients fully recover or have only mild residual dysfunction. A small prospective study[108] published in 2013 evaluated the short-term effectiveness of manipulation for patients with MRI-confirmed radiculopathy caused by disc herniation. There was no comparative group for natural history or other treatment approach, yet, the improvement rates were, at two weeks 55.3%, at one month 68.9%, and at three months 85.7%. Given there was no comparative control group, it is important to note that for subacute and chronic patients, 76.2% were improved at three months. No adverse events related to manipulation were reported in this previously-assumed high-risk group of patients.

A prospective study[109] published in *Spine* in 2013 compared the results of a structured physiotherapy approach versus anterior decompression surgery and physiotherapy for patients with cervical radiculopathy and followed patients over two years. At a one-year follow-up, 87% of the patients in the surgical group rated their symptoms as "better/much better" versus 62% in the nonsurgical group. At two years, the percentage for improvement using the above rating was 81% in the surgical group versus 69% in the structured physiotherapy group. Improvement was more rapid in the surgical group; however, at two years, there were significant reductions in the Neck Disability Index, in neck pain, and with arm pain compared with baseline in both groups.

Cervical manipulation at sites other than the herniation is used by many chiropractors.[86] If osseous adjusting is to be used, it should be applied with a trial of mild mobilization impulses at the involved level to determine patient response. The degree of force application should be the least possible. It should always be kept in mind that if the patient has hard neurologic evidence of nerve root compression, the chiropractor is at risk of irritating the nerve and being accused of causing the herniation. Nonosseous techniques may be attempted for a short course to determine therapeutic effect.

A first-time randomized controlled trial[87] examined the management of cervical radiculopathy with either a semihard cervical collar or physiotherapist-direct exercise versus rest during the first six weeks of onset. Although the use of a cervical collar for neck pain has decreased significantly based on evidence that it does not seem to make a difference for whiplash patients, there was no evidence for or against the use of a cervical collar for patients with cervical radiculopathy.

Reduction in arm pain at six weeks in the wait-and-see group was approximately 19 points on a 100-point scale. Comparatively, the semirigid collar group experienced on average a reduction of 31 points on a 100-point scale at six weeks. Reduction in neck pain at six weeks in the wait-and-see group was only 5 points, whereas the reduction in the semirigid collar group was an additional 9–12 points.

Consider using a semihard cervical collar for patients with recent onset cervical radiculopathy, in particular, if there is concern by you or the patient regarding manipulation. Instruct the patient to wear the brace during the day. To avoid complications, wean the patient off of the brace over a period of six weeks. The results of this study also support the opposite approach; have patients perform mild exercising and stretching of the neck during the first six weeks of onset with caution if symptoms are increased by the exercise.

Cervical traction and physical therapy may also be incorporated. Home traction for 15 minutes twice a day will be of benefit to some patients. The response is usually evident within a few days.[110] Patients who are unresponsive or are simply in too much pain should be referred for medical comanagement.

Myelopathy

Classic Presentation

Patient presentation may differ depending on the type and degree of compression. Classically, a patient presents with complaints of bilateral symptoms of clumsiness of the hands, difficulty walking, possible urinary dysfunction, and possible shooting pains into the arms.

Cause

Cervical spine myelopathy is present in 90% of individuals older than 70 years of age and is the most common cause of spinal cord dysfunction in individuals older than 55 years of age. It is more common in males and in Asians.

There are numerous causes of spinal cord compression (myelopathy), including tumor, herniated disc, and spondylotic sources. Depending on which portion of the spinal cord or whether nerve roots are also involved, the signs and symptoms will vary. Direct pressure on the posterior columns often occurs with spondylotic myelopathy, causing disturbances in vibration perception and proprioception. If compression of nerve roots also occurs, signs of a lower motor neuron problem will surface.

Evaluation

If the anterior cord is involved, then pain, pathological reflexes and/or hyperactive deep tendon reflexes or motor weakness may be evident. If the posterior cord is involved, then loss of dexterity, gait abnormalities, poor coordination, clumsiness, or sensory loss may the dominant signs and symptoms. Overlap may occur so that headache, neck stiffness, shoulder pain, paresthesia in one or both arms or hands, or other radiculopathic signs may also be present.

Long tract signs, such as Hoffmann's, Babinski sign, clonus, the crossed-abductor sign, the inverted supinator sign, or hand withdrawal reflex testing, reflect the disinhibition of the primitive afferent or efferent (pyramidal) spinal cord pathways that are normally suppressed or modulated in the adult. Mixed findings of UMNL and LMNL signs may occur. At the level of involvement, LMNL signs may be present and below the level of involvement, UMNL signs. Mixed findings may be found including LMNL signs in the upper extremity with UMNL signs in the lower extremity. Sensory loss may include both numbness and vibration loss bilaterally, or if unilateral involvement is present it may cause contralateral numbness with unilateral vibration loss. There is a dynamic component where extension of the cervical spine may add compression through buckling of the ligamentum flavum or with flexion compression from the posterior longitudinal ligament, especially if calcified.

Cook et al.[111] conducted a systematic review and through classifying exam findings into gait abnormalities, pathological signs, and deep tendon reflex changes, they determined the following:

- Gait or balance—Both abnormal gait (ataxia, wide-based gait, or spastic gait) and a positive static or dynamic Romberg sign were very specific but not sensitive for cervical spine myelopathy.
- Pathological signs—Hoffmann sign, Babinski sign, and clonus were very specific but not very sensitive for cervical spine myelopathy.
- DTR changes—Hyperreflexia was very specific but not very sensitive for cervical myelopathy.

In other words, most tests for cervical myelopathy are specific but not sensitive, meaning that finding a positive is relatively good at ruling-in myelopathy but not finding positive tests is not very good at ruling-out myelopathy. The inverted supinator sign is probably the most sensitive test. It is similar to the brachioradialis reflex test with the patient's forearm placed in slight pronation on the examiner's knee. A few quick strikes with a percussion hammer near the radial styloid process with a pathological response of slight finger flexion or elbow extension.

The researchers combined the following to develop a clinical prediction rule.[112] The Babinski sign, inverted supinator sign, Hoffmann sign, and gait dysfunction (spastic, wide-based gait, or ataxia) and age older than 45 years. If only 1 of 5 tests was positive (4 tests are negative) the sensitivity was 0.94 with a −LR of 0.18 (rule-out). If there were 3 of 5 positive tests, the +LR was 30.9 (rule-in) (95% CI = 5.5-181.8) with a posttest probability of 94%.

The most common finding in patients with myelopathy identified on MRI is gait abnormality found in 91% of patients. Babinski's was found positive in only about 44% of myelopathic patients.[113] Hyperreflexia was more common in the lower extremity (81%) compared to the upper extremity (67%). Eighty-four percent of patients had a positive clinical examination.

Radiographic measurement of spinal canal diameter may be accomplished on the lateral view of the cervical spine. The width is measured from the posterior vertebral body to the lamina-pedicle junction. Anything less than 13 mm should warrant concern. Anything less than 10 to 11 mm is an indication of absolute stenosis. The Torg (or Pavlov) ratio uses the spinal canal width over the anterior to posterior width of the vertebral body. A ratio less than 0.82 is considered stenotic.[114] If there are myelopathic findings on exam or absolute stenosis evident on radiographs, order MRI (or CT). Evidence of myelopathy is primarily seen on sagittal images. Evidence of spinal cord compression on MRI is indicated by an indentation on the spinal cord parenchyma. More significant involvement is indicated by a T2 signal abnormality in the spinal cord, which is indicated by the presence of a hyperintense signal within the spinal cord parenchyma.[115] This finding should be confirmed on axial images to avoid an artifact effect causing a false positive.

MRI has been shown to be 79–95% sensitive and 82–88% specific with a positive likelihood ratio (LR) of 4.39–7.92 and a negative likelihood ratio (LR) of 0.06–0.27 for identifying selected abnormalities such as space-occupying tumors, disk herniation, and ligamentous ossification. Although special imaging is the "gold standard," in some individuals the presence of radiographic spinal cord compression is seen without clinical symptoms or physical signs of cervical myelopathy. Findings are seen in 16% of asymptomatic patients younger than 64 years of age, increasing to 26% of those older than 64 years of age.

Electrodiagnostic studies may be helpful in estimating the degree of involvement and perhaps the level. The most valuable tests are SEPs and DSEPs because they may determine latency of signal transmission through the spinal cord.[116]

Management

Surgery is often recommended in cases where there are "hard" lesions such as spondylosis or ossification of the posterior longitudinal ligament because of the possibility of permanent neurologic damage. "Soft" lesions such as disc lesions may resolve over time. Decompression surgery for spondylotic myelopathy has variable results between 33% and 74%.[117] In 2002, a Cochrane review of surgery for cervical spondylotic radiculomyelopathy determined that although the short-term effects of surgery were superior to conservative management for pain, weakness, or sensory loss, the effect was lost at one year where there was no significant difference between the two groups.[118] For those with a mild functional deficit associated with cervical myelopathy, there were no significant differences two years following treatment. A follow-up Cochrane review[119] in 2010 still maintained that there was lack of evidence for surgery's having a superior long-term effect. Recommendations should be based on the severity of functional impairment and failure of conservative management.

Murphy et al.[120] published a case-series report on patients with early and mild myelopathy managed chiropractically. Seventy percent of patients, on average, improved although there was a wide range of 0–100%. No neurological signs developed and no major complications occurred. A management approach to the patient with cervical myelopathy based on this study is:

- If there are mild myelopathic signs/symptoms or MRI evidence of compression with *no* T2 changes, consider an initial trial of HVLA adjusting using premanipulative positioning (i.e., setting up without thrusting) to determine if peripheralization occurs or not. It is important to find a position that does not peripheralize prior to adjusting. Make this clinical decision for treatment with patient education, input, and approval.
- If there are advanced or severe clinical findings of myelopathy or T2 hyperintense signal changes on MRI, surgical consult or a trial of nonmanipulative approaches is suggested.

Comanagement is recommended for patients who show no improvement after one to two weeks.

Burner/Stinger

Classic Presentation

The patient reports a sudden onset of burning pain and/or numbness along the lateral arm with associated arm weakness following a lateral flexion injury of the neck/head (e.g., lateral "whiplash"). The symptoms usually last only a couple of minutes.

Cause

"Burner" or "stinger" are the names given to injury of the brachial plexus or nerve roots caused by a lateral flexion injury. This is a common injury in sports and has a high percentage of underreporting (70%) because of the transient symptoms.[121] In general, lateral flexion of the head away from the involved side with accompanying shoulder distraction (depression) on the involved side causes a

brachial plexopathy. Compression on the side with lateral flexion is more likely to result in nerve root compression. When the brachial plexus is involved, the upper trunk (C5-C6) is most often affected. Varying degrees of injury may occur; however, the majority of injuries are mild, with transient symptoms.

Evaluation

The most common physical finding is weakness of shoulder abduction, external rotation, and arm flexion. Both muscle weakness and sensory findings may be delayed; therefore, it is important to reexamine patients within about one week postinjury. Persistent symptoms require a radiographic evaluation for instability, including flexion and extension views. If arm weakness is persistent after three weeks, an EMG study may be helpful.[122] If a nerve root problem is suspected, an MRI may be of help. Otherwise, most cases require no special testing evaluation.

Management

It is important to avoid reproduction of the injury with a lateral-flexion type of adjustment. Given that recurrence of the injury is common in sports, athletes are encouraged to strengthen their neck muscles and wear protective gear when appropriate. Repeated episodes may lead to more damage requiring neurologic consultation.

Thoracic Outlet Syndrome

Classic Presentation

The patient presents with diffuse arm symptoms, including numbness and tingling. Often the patient will describe a path down the inside of his or her arm to the little and ring fingers. This is often made worse by overhead activity.

Cause

The brachial plexus and/or subclavian/axillary arteries can be compressed at various sites as they travel downward into the arm. Several common sites are possible, including an elongated C7 transverse process (cervical rib), the scalene muscles, the costoclavicular area, and the subcoracoid area (between the coracoid and the pectoralis minor). Muscular compression at the scalenes or with the pectoralis minor is believed to be due to tight muscles and/or posturally induced (forward head and rounded shoulder habit). Leffert[123] reports that in 40% of cases there is a report of inciting trauma. It is important to recognize that only 1% of the population has cervical ribs, and only 10% of those individuals have symptoms.[124] A fibrous band connecting the cervical rib to the first rib also may be the culprit in some cases.

Evaluation

Although a number of provocative tests are used, there are often false positives and false negatives. The intent of the tests is to reproduce symptoms in the arm. If the positive is based on simply a reduction of the radial pulse, many false positives will be found. When the scalenes are being tested, the patient is asked to look either toward (Adson's test) or away (Halstead's test) from the involved side with the arm held in slight abduction. When the pectoralis minor is tested, the arm is lifted into abduction and horizontal abduction (Wright's test). A functional test is to have the patient raise the arms above head level and repeatedly grip and release the hands for 20 to 60 seconds (Roos' test) in an attempt to reproduce arm symptoms or weakness. It is always important to perform a neurologic evaluation in an attempt to differentiate TOS from lower brachial plexus, nerve root, or peripheral entrapment problems.

Management

Generally, management is conservative with an approach based on postural correction, stretching of tightened muscles, and strengthening of weakened muscles. This includes strengthening of the middle and lower trapezius and rhomboids, and stretching of the pectorals and scalenes. Trigger-point therapy is also advocated by Travell and Simons.[125] Taping or bracing may help with a proprioceptive training program for postural correction. There is also a belief that a first rib subluxation may cause the signs and symptoms of TOS. Several investigators have suggested manipulation of the first rib in an attempt to correct this problem.[126–128] Surgery is suggested for a minority of patients (approximately 24%) who do not respond to conservative management.[129]

Facet/Referred

Classic Presentation

The patient often will report a minor (e.g., sudden turning of the head) to moderate (e.g., motor vehicle accident) traumatic onset of neck and arm pain. In some patients the onset can be insidious with no recent trauma. The patient often will draw a line of pain down the outer arm to the hand. The arm and hand pain do not often fit a specific dermatome.

Cause

Irritation of the facet joints or deep cervical muscles causes a referred pain down the arm. The most common location is down the outer arm to the hand. This location often implicates segmentally related facet joints of C5-C7.

Evaluation

It is assumed that what chiropractors affect are facet joints, yet there have been no studies to correlate findings of facet involvement with facet injections for pain relief. A recent study by King et al.[130] evaluated patients who were diagnosed by physical therapists as having facet joint dysfunction. The patients who were willing to participate then had controlled diagnostic blocks performed to determine which facets, in fact, were involved. The manual examination was sensitive, but not specific, for facet involvement.

A standard orthopaedic and neurologic examination of the neck and upper extremity should be performed. With referred pain, there is rarely any hard neurologic evidence. Deep tendon reflexes are normal, muscle strength is normal or weakness does not fit a specific myotome, and numbness is often subjective with no objective sensory findings. Local pain may be reproduced with cervical compression (Figure 2–1) with the neck in extension and rotation to the involved side. A search for trigger-point referral should be made, including supraspinatus or infraspinatus involvement. Radiographic evaluation may be performed to detect any foraminal encroachment on the oblique views. Patients with mild foraminal encroachment, however, may still have referred pain as opposed to nerve root impingement if the neurologic examination is normal.

Management

Manipulation of the neck is the treatment of choice. If unsuccessful, cervical traction may be of benefit. Any myofascial contribution may be addressed with stretch-and-spray techniques, trigger-point therapy, or myofascial release.

Torticollis

Classic Presentation

There may be several presentations of torticollis based on age and cause. In congenital torticollis, the infant will have a fixed asymmetry of the head that is seen within hours (or sometimes weeks) of delivery. In the adult version, a patient presents with painful spasm of the SCM, causing the head to be held in rotation and sometimes slight flexion. In pseudotorticollis, the patient presents with the inability to move the head in any direction without pain. The patient reports having awakened with the condition; there is no trauma or obvious cause. The head is held in neutral.

Cause

The congenital cause of torticollis is probably birth trauma, often breech delivery. Damage to the SCM causes it to become fibrous. The adult version may be due to a number of causes, including CNS infection, tumor, basal ganglion disease, or psychiatric disease. Pseudotorticollis has no known cause. It differs from classic torticollis in that all movements are painful and there is no deviation of the head.

Evaluation

It is important to determine whether there is a moderate to high fever, which would be suggestive of meningitis. Kernig's or Brudzinski's signs would be positive, causing severe pain and/or flexion of the lower limbs on passive flexion of the neck. Palpation of the SCMs and the anterior neck for masses is important. Patients with pseudotorticollis often have markedly increased passive ROM when examined carefully in the supine position. The amount of passive ROM is used as the gauge as to whether or not manipulation is appropriate. A neurologic check for upper motor and lower motor neuron dysfunction will reveal any medically referable causes. Radiographs are usually not necessary. MR imaging or CT scans may be needed when CNS disease is suspected.

Management

The congenital type of torticollis may respond to physical therapy attempts to lengthen the SCM; however, the therapy must be consistent and often takes up to one year. For the adult who has no known cause, attempts at neck manipulation and physical therapy may help, or the condition may self-resolve. With pseudotorticollis, manipulation should be applied cautiously as soon as possible in an attempt to decrease the global muscle spasm. Failure to resolve warrants a referral for medical evaluation.

The Evidence—Cervical Spine

Translation into Practice Summary (TIPS)

Directed by the patient presentation, the evaluation for cervical spine fracture, instability, and radiculopathy are important specific focuses of the examination. The history and examination together are good at determining the need for radiography in the evaluation of fracture and instability. The history is poor but the examination good at ruling-in cervical radiculopathy. There is no evidence for the value of the clinical examination to screen for risk of vertebrobasilar accidents.

The Literature-Based Clinical Core

- The clinical examination together with specific historical indicators is sensitive for cervical spine fracture. Both the NEXUS and Canadian Spine Rule are very good at ruling-out (but not ruling-in) fracture of the cervical spine.
- The Sharp-Purser test may be valuable in ruling-in cervical spine instability.
- The patient history is not helpful in ruling-in or ruling-out cervical radiculopathy.
- The biceps and brachioradialis DTRs are good at ruling-in (but not ruling-out) C5 and C6 nerve root involvement. However, the triceps DTR is only fair at ruling-in, but bad at ruling-out C7 nerve root involvement.
- Although the specificity for myotome and dermatome testing for radiculopathy is good, the overall performance based on LRs is poor. Adding resisted pronation testing may increase the sensitivity of detecting a C6 or C7 nerve root involvement.
- Patients are less likely to report weakness compared to the finding of weakness by the examiner so that strength testing should always be performed with patients complaining of radiating pain.
- It is less common for patients to describe a dermatomal pattern when a radiculopathy is present; therefore, any radiation warrants the application of the clinical prediction rule stated below.
- The combination of the upper limb tension test (ULTT), Spurling's, cervical distraction, and ROM less than 60° together are very good at ruling-in cervical radiculopathy
- The ICCs are good for ROM testing and cervical strength and endurance testing.
- The kappa values are poor for assessing pain with palpation and intervertebral motion testing. Palpation of cervical facets posteriorly has a good –LR and a fair +LR.
- With the exception of a forward flexed head, the kappa values for postural assessment and muscle length assessment of the cervical spine area are good.
- There is no evidence for the reliability or validity of any tests for thoracic outlet syndrome (TOS) when evaluating for the medically defined entity of TOS.

The Expert-Opinion-Based Clinical Core

- When all neurological findings are negative including the upper limb tension test, it is likely that a patient's radiating pain is not, in fact, radicular and more likely scleratogenous with the main sources coming from internal disc disruption and cervical facet joints.
- Mapping of a patient's description of radiation should always include a scleratogenous and trigger point comparison.
- Use of TOS testing may have some value when determining a myofascial component of radiating complaints of numbness, tingling, or pain.
- Screening tests for vertebrobasilar accidents (ischemia) are of no value and may introduce false positives that compromise clinical decision making. None of the tests from George's or deKleyn's are of value in screening for VBA.
- Older patients should always be screened for myelopathy especially with gait problems or with neurological symptoms or radiating complaints (especially bilaterally).
- Older patients with diffuse symptoms in both arms/hands should also be evaluated for T4 syndrome.

APPENDIX 2–1

References

1. Bogduk N. The anatomical basis for spinal pain syndromes. Conference proceedings of the Chiropractic Centennial Foundation. Presented at the Chiropractic Centennial; July 6–8, 1995; Washington, DC.

2. National Board of Chiropractic Examiners. *Job Analysis of Chiropractic: A Project Report, Survey Analysis, and Summary of the Practice of Chiropractic Within the United States.* Greeley, CO: National Board of Chiropractic Examiners (NBCE); 2010.
3. Cote P, Cassidy JD, Carroll L. The Saskatchewan Health and Back Pain Survey. The prevalence of neck pain and related disability in Saskatchewan adults. *Spine.* 1998;23(15):1689–1698.
4. Riddle DL, Schappert SM. Volume and characteristics of inpatient and ambulatory medical care for neck pain in the United States: data from three national surveys. *Spine.* 2007;32(1):132–140;discussion 141.
5. Spitzer WO, Skovron ML, Salmi LR, et al. Redefining "whiplash" and its management. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders. *Spine.* 1995;20(85):1S–73S.
6. Coulter ID, Hurwitz EL, Adams AH, et al. *The Appropriateness of Manipulation and Mobilization of the Cervical Spine.* Santa Monica, CA: Rand Corporation; 1996.
7. Haldeman S, Carroll L, Cassidy JD, Schubert J, Nygren A. The Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders: executive summary. *Spine.* 2008;33(4 Suppl):S5–7.
8. Janda V. Muscles and cervicogenic pain syndromes. In: Grant R, ed. *Physical Therapy of the Cervical and Thoracic Spine.* New York: Churchill Livingstone; 1988:153–166.
9. Bogduk N. A neurological approach to neck pain. In: Glasgow EF, Twomey IV, Seall ER, et al., eds. *Aspects of Manipulative Therapy.* New York: Churchill Livingstone; 1985.
10. Weintraub M. Beauty parlor stroke syndrome: a report of 5 cases. *JAMA.* 1993;269(16):2085–2086.
11. Terrett AGJ, Kleynhans AM. Cerebrovascular complications of manipulation. In: Haldeman S, ed. *Modern Developments in the Principles and Practice of Chiropractic.* New York: Appleton-Century-Crofts; 1994:579–598.
12. Bland JH. Cervical and thoracic pain. *Curr Opin Rheumatol.* 1991;3:218–225.
13. Fujimoto K, Miyagi M, Ishikawa T, et al. Sensory and autonomic innervation of the cervical intervertebral disc in rats: the pathomechanics of chronic discogenic neck pain. *Spine (Phila Pa 1976).* 2012;37(16):1357–1362.
14. Garcia-Poblete E, Fernandez-Garcia H, Moro-Rodriguez E, et al. Sympathetic sprouting in dorsal root ganglia (DRG): a recent histological finding? *Histol Histopathol.* 2003;18(2):575–586.
15. Panjabi M, Oxland T, Parks E. Quantitative anatomy of cervical spine ligaments, part II: middle and lower cervical spine. *J Spinal Disord.* 1991;4:277–285.
16. Webb AL, Collins P, Rassoulian H, Mitchell BS. Synovial folds—a pain in the neck? *Man Ther.* 2011;16(2):118–124.
17. Webb AL, Rassoulian H, Mitchell BS. Morphometry of the synovial folds of the lateral atlanto-axial joints: the anatomical basis for understanding their potential role in neck pain. *Surg Radiol Anat.* 2012;34(2):115–124.
18. Mootz RD. Theoretic models of chiropractic subluxation. In: Gatterman MI, ed. *Foundations of Chiropractic: Subluxation.* St. Louis, MO: Mosby-Year Book; 1995:176–189.
19. Kallakuri S, Li Y, Chen C, Cavanaugh JM. Innervation of cervical ventral facet joint capsule: Histological evidence. *World J Orthop.* 2012;3(2):10–14.
20. Cavanaugh JM, Lu Y, Chen C, Kallakuri S. Pain generation in lumbar and cervical facet joints. *J Bone Joint Surg Am.* 2006;88 Suppl 2:63–67.
21. Ohtori S, Takahashi K, Chiba T, Yamagata M, Sameda H, Moriya H. Sensory innervation of the cervical facet joints in rats. *Spine (Phila Pa 1976).* 2001;26(2):147–150.
22. Parke WW, Whalen JL. The vascular pattern of the human dorsal root ganglion and its probable bearing on a compartment syndrome. *Spine (Phila Pa 1976).* 2002;27(4):347–352.
23. Tubbs RS, Loukas M, Slappey JB, Shoja MM, Oakes WJ, Salter EG. Clinical anatomy of the C1 dorsal root, ganglion, and ramus: a review and anatomical study. *Clin Anat.* 2007;20(6):624–627.
24. Ohtori S, Takahashi K, Moriya H. Calcitonin gene-related peptide immunoreactive DRG neurons innervating the cervical facet joints show phenotypic switch in cervical facet injury in rats. *Eur Spine J.* 2003;12(2):211–215.
25. DeJong PTVN, DeJong JMBV, Cohen B, Jongkees LBV. Ataxia and nystagmus induced by injection of local anesthesia in the neck. *Ann Neurol.* 1977;1:240–246.
26. Richmond FJR, Vidal PP. The motor system: joints and muscles of the neck. In: Peterson BW, Richmond F, eds. *Control of Head Movement.* New York: Oxford University Press; 1988.
27. Leffert RD. Thoracic outlet syndrome and the shoulder. *Clin Sports Med.* 1983;2:439.

28. Panjabi MM, Vasavada A, White AA III. Cervical spine biomechanics. *Semin Spine Surg.* 1993;5:10–16.
29. Panjabi MM, Oda T, Crisco J J III, et al. Posture affects motion coupling patterns of the upper cervical spine. *J Orthop Res.* 1993;11:525–536.
30. Croft AC. Advances in the clinical understanding of acceleration/deceleration injuries to the cervical spine. In: Lawrence DJ, Cassidy JD, McGregor M, et al., eds. *Advances in Chiropractic.* St. Louis, MO: Mosby-Year Book; 1995;2:1–37.
31. Otto K, Kaneoka K, Wittek A, Kajzer J. Cervical injury mechanism based on the analysis of human cervical vertebral motion and head-neck torso kinematics during low speed rear impacts. 41st Stapp Car Crash Conference Proceedings. SAE paper 973340, 1997; 339–356.
32. Grauer JN, Panjabi MM, Chelewicki J, et al. Whiplash produces an s-shaped curvature of the neck with hyperextension at lower levels. *Spine* 1997;22:2489–2494.
33. Stiell IG, Wells GA, Vandemheen KL, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. *JAMA.* 2001;286(15):1841–1848.
34. Bandiera G, Stiell IG, Wells GA, et al. The Canadian C-spine rule performs better than unstructured physician judgment. *Ann Emerg Med.* 2003;42(3):395–402.
35. Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *N Engl J Med.* 2003;349(26):2510–2518.
36. Panacek EA, Mower WR, Holmes JF, Hoffman JR. Test performance of the individual NEXUS low-risk clinical screening criteria for cervical spine injury. *Ann Emerg Med.* 2001;38(1):22–25.
37. Fedorak C, Ashworth N, Marshall J, Paul H. Reliability of the visual assessment of cervical and lumbar lordosis: how good are we? *Spine.* 2003;28(16):1857–1859.
38. Torg HC, Haig AJ, Yamakawa K. The Spurling test and cervical radiculopathy. *Spine.* 2002;27(2):156–159.
39. Vikari-Juntura E. Interexaminer reliability of observations in physical examinations of the neck. *Phys Ther.* 1987; 67:1526–1532.
40. Vikari-Juntura E, Porros M, Lassomen EM. Validity of clinical tests in the diagnosis of root compression in cervical disc disease. *Spine.* 1989;14:253–257.
41. Sobel JB, Sollenberger P, Robinson R, et al., Cervical Nonorganic Signs: A New Clinical Tool to Assess Abnormal Illness Behavior in Neck Pain Patients: A Pilot Study. *Arch Phys Med Rehabil.* 2000;81:170–175.
42. Wainner RS, Fritz JM, Irrgang JJ, Boninger ML, Delitto A, Allison S. Reliability and diagnostic accuracy of the clinical examination and patient self-report measures for cervical radiculopathy. *Spine.* 2003;28(1):52–62.
43. Rubinstein SM, Pool JJ, van Tulder MW, Riphagen, II, de Vet HC. A systematic review of the diagnostic accuracy of provocative tests of the neck for diagnosing cervical radiculopathy. *Eur Spine J.* 2007;16(3):307–319.
44. Nordin M, Carragee EJ, Hogg-Johnson S, et al. Assessment of neck pain and its associated disorders: results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Spine.* 2008;33(4 Suppl):S101–122.
45. Rainville J, Noto DJ, Jouve C, Jenis L. Assessment of forearm pronation strength in C6 and C7 radiculopathies. *Spine.* 2007;32(1):72–75.
46. Murphy DR, Hurwitz EL, Gerrard JK, Clary R. Pain patterns and descriptions in patients with radicular pain: does the pain necessarily follow a specific dermatome? *Chiropr Osteopat.* 2009;17:9.
47. Souza TA. Which orthopedic tests are really necessary? In: Lawrence DJ, Cassidy JD, McGregor M, et al., eds. *Advances in Chiropractic.* St. Louis, MO: Mosby-Year Book; 1994;1:101–158.
48. Sieke FW, Kelly TR. Thoracic outlet syndrome. *Am J Surg.* 1988;156:54–57.
49. Ferezy JS. Neurovascular assessment for risk management in chiropractic practice. In: Lawrence DJ, Cassidy JD, McGregor M, et al., eds. *Advances in Chiropractic.* St. Louis, MO: Mosby-Year Book; 1994:455–475.
50. Raney NH, Petersen EJ, Smith TA, et al. Development of a clinical prediction rule to identify patients with neck pain likely to benefit from cervical traction and exercise. *Eur Spine J.* 2009;18(3):382–391.
51. Haldeman S, Kohlbeck FJ, McGregor M. Risk factors and precipitating neck movements causing vertebrobasilar artery dissection after cervical trauma and spinal manipulation. *Spine.* 1999;24(8):785–794.
52. Haldeman S, Kohlbeck FJ, McGregor M. Unpredictability of cerebrovascular ischemia associated with cervical spine manipulation therapy: a review of sixty-four cases after cervical spine manipulation. *Spine.* 2002;27(1):49–55.
53. Helfet CA, Stanley P, Lewis Jones B, Heller RF. Value of X-ray examinations of the cervical spine. *Br Med J.* 1983;287:1276–1278.
54. Jaeger SA, Baum CA, Linquist GR. The many faces of the facets. In: Lawrence DJ, Cassidy JD, McGregor

M, et al., eds. *Advances in Chiropractic.* St. Louis, MO: Mosby-Year Book; 1995;2:331–372.

55. White AA, Panjabi MM, eds. *Clinical Biomechanics of the Spine.* Philadelphia: J B Lippincott; 1978:229.
56. McGregor M, Mior S, Shannon H, Hagino C, Schut B. The clinical usefulness of flexion-extension radiographs in the cervical spine. *Top Clin Chiro.* 1995;2(3):19–28.
57. Torg JS. Cervical spine stenosis with cord neuropraxia and transient quadriplegia. *Curr Opin Orthop.* 1994;5(11):97.
58. Karas SE. Thoracic outlet syndrome. *Clin Sports Med.* 1990;9:297–310.
59. Sistrom CL, Southall EP, Peddada SD, et al. Factors affecting the thickness of the cervical prevertebral soft tissues. *Skeletal Radiol.* 1993;22:167.
60. Guzman J, Hurwitz EL, Carroll LJ, et al. A new conceptual model of neck pain: linking onset, course, and care; the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Spine.* 2008;33(4 Suppl):S14–23.
61. Haldeman S, Chapman-Smith D, Petersen DM, Jr. *Guidelines for Chiropractic Quality Assurance and Practice Parameters: Proceedings of the Mercy Center Consensus Conference.* Gaithersburg, MD: Aspen Publishers, Inc; 1993.
62. Vernon H, Mior S. The neck disability index: a study of reliability and validity. *J Manipulative Physiol Ther.* 1991; 14:409–415.
63. Guzman J, Haldeman S, Carroll LJ, et al. Clinical practice implications of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders: from concepts and findings to recommendations. *Spine.* 2008;33(4 Suppl):S199–213.
64. Thiel HW, Bolton JE, Docherty S, Portlock JC. Safety of chiropractic manipulation of the cervical spine: a prospective national survey. *Spine.* 2007;32(21):2375–2378; discussion 2379.
65. Rubinstein SM, Leboeuf-Yde C, Knol DL, de Koekkoek TE, Pfeifle CE, van Tulder MW. The benefits outweigh the risks for patients undergoing chiropractic care for neck pain: a prospective, multicenter, cohort study. *J Manipulative Physiol Ther.* 2007;30(6):408–418.
66. Ernst E. Adverse effects of spinal manipulation: a systematic review. *J R Soc Med.* 2007;100(7):330–338.
67. Ernst E, Canter PH. A systematic review of systematic reviews of spinal manipulation. *J R Soc Med.* 2006; 99(4):192–196.
68. Bronfort G, Haas M, Moher D, et al. Review conclusions by Ernst and Canter regarding spinal manipulation refuted. *Chiropr Osteopat.* 2006;14:14.
69. Cassidy JD, Boyle E, Cote P, et al. Risk of vertebrobasilar stroke and chiropractic care: results of a population-based, case-control, and case-crossover study. *Spine.* 2008;33(4 Suppl):S176–183.
70. Boyle E, Cote P, Grier AR, Cassidy JD. Examining vertebrobasilar artery stroke in two Canadian provinces. *Spine.* 2008;33(4 Suppl):S170–175.
71. Quesnele JJ, Triano JJ, Noseworthy MD, Wells GD. Changes in vertebral artery blood flow following various head positions and cervical spine manipulation. *J Manipulative Physiol Ther.* 2014;37(1):22–31.
72. Gross AR, Goldsmith C, Hoving JL, et al. Conservative management of mechanical neck disorders: a systematic review. *J Rheumatol.* 2007;34(5):1083–1102.
73. Gross AR, Hoving JL, Haines TA, et al. A Cochrane review of manipulation and mobilization for mechanical neck disorders. *Spine.* 2004;29(14):1541–1548.
74. Kay TM, Gross A, Goldsmith C, Santaguida PL, Hoving J, Bronfort G. Exercises for mechanical neck disorders. *Cochrane Database Syst Rev.* 2005(3):CD004250.
75. O'Leary S, Jull G, Kim M, Vicenzino B. Specificity in retraining craniocervical flexor muscle performance. *J Orthop Sports Phys Ther.* 2007;37(1):3–9.
76. Chiu TT, Lam TH, Hedley AJ. A randomized controlled trial on the efficacy of exercise for patients with chronic neck pain. *Spine.* 2005;30(1):E1–7.
77. Evans R, Bronfort G, Schulz C, et al. Supervised exercise with and without spinal manipulation performs similarly and better than home exercise for chronic neck pain: a randomized controlled trial. *Spine (Phila Pa 1976).* May 15, 2012;37(11):903–914.
78. Bronfort G, Evans R, Anderson AV, Svendsen KH, Bracha Y, Grimm RH. Spinal manipulation, medication, or home exercise with advice for acute and subacute neck pain: a randomized trial. *Ann Intern Med.* 2012;156(1 Pt 1):1–10.
79. Fitz-Ritson D. Phasic exercises for cervical rehabilitation after "whiplash" trauma. *J Manipulative Physiol Ther.* 1995;18:21–24.
80. Giles LG, Muller R. Chronic spinal pain syndromes: a clinical pilot trial comparing acupuncture, a nonsteroidal anti-inflammatory drug, and spinal manipulation. *J Manipulative Physiol Ther.* 1999;22(6):376–381.

81. Aker PD, Gross AR, Goldsmith CH, Peloso RS. Conservative management of mechanical neck pain: systematic overview and metaanalysis. *Br Med J.* 1996;313:1291–1296.
82. Hurwitz EL, Aker PD. Manipulation and mobilization of the cervical spine. *Spine.* 1996;21(15):1746–1760.
83. Hurwitz EL, Morgenstern H, Harber P, et al. A randomized trial of chiropractic manipulation and mobilization for patients with neck pain: clinical outcomes from the UCLA Neck Pain study. *Am J Public Health* 2002; 92:1634–1641.
84. Giles LG, Muller R. Chronic spinal pain: a randomized clinical trial comparing medication, acupuncture, and spinal manipulation. *Spine.* 2003;28(14):1490–1503.
85. Bryans R, Decina P, Descarreaux M, et al. Evidence-based guidelines for the chiropractic treatment of adults with neck pain. *J Manipulative Physiol Ther.* 2014;37(1):42–63.
86. Croft AC. Standards of care in cervical disk herniation: results from our nationwide survey of 3500 DCs. *SRISD Fact Sheet.* 1995;3:1–2.
87. Kuijper B, Tans JT, Beelen A, Nollet F, de Visser M. Cervical collar or physiotherapy versus wait and see policy for recent onset cervical radiculopathy: randomised trial. *BMJ.* 2009;339:b3883.
88. Ben-Eliyahu D. Magnetic resonance imaging follow-up study of 27 patients receiving chiropractic treatment for cervical and lumbar disc herniations. Conference proceedings of the Chiropractic Centennial Foundation. Presented at the Chiropractic Centennial; July 6–8, 1995; Washington, DC.
89. West DT, Mathews RS, Miller MR, Kent GM. Effective management of spinal pain in one hundred seventy-seven patients evaluated for manipulation under anesthesia. *J Manipulative Physiol Ther.* 1999;22(5):299–308.
90. Carroll LJ, Holm LW, Hogg-Johnson S, et al. Course and prognostic factors for neck pain in whiplash-associated disorders (WAD): results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. *Spine.* 2008;33(4 Suppl):S83–92.
91. Cassidy JD, Carroll LJ, Cote P, Frank J. Does multidisciplinary rehabilitation benefit whiplash recovery? Results of a population-based incidence cohort study. *Spine.* 2007;32(1):126–131.
92. Ezzo J, Haraldsson BG, Gross AR, et al. Massage for mechanical neck disorders: a systematic review. *Spine.* 2007;32(3):353–362.
93. Gur A, Sarac AJ, Cevik R, Altindag O, Sarac S. Efficacy of 904 nm gallium arsenide low-level laser therapy in the management of chronic myofascial pain in the neck: a double-blind and randomized-controlled trial. *Lasers Surg Med.* 2004;35(3):229–235.
94. Chow RT, Heller GZ, Barnsley L. The effect of 300 mW, 830 nm laser on chronic neck pain: a double-blind, randomized, placebo-controlled study. *Pain.* 2006;124(1–2): 201–210.
95. Chow RT, Johnson MI, Lopes-Martins RA, Bjordal JM. Efficacy of low-level laser therapy in the management of neck pain: a systematic review and meta-analysis of randomised placebo or active-treatment controlled trials. *Lancet.* 2009;374(9705):1897–1908.
96. Saayman L, Hay C, Abrahamse H. Chiropractic manipulative therapy and low-level laser therapy in the management of cervical facet dysfunction: a randomized controlled study. *J Manipulative Physiol Ther.* 2011;34(3):153–163.
97. Barnsley L, Lord SM, Wallis BJ, Bogduk N. The prevalence of chronic cervical zygapophyseal joint pain after whiplash. *Spine.* 1995;20(1):20–26.
98. Otte A, Ettlin TM, Mitsche EU, et al. PET and SPECT in whiplash syndrome: a new approach to a forgotten brain? *J Neuro Neurosurg Psychiat.* 1997;63:368–372.
99. Fischer AJEM, Verhagen WIM, Huygen PLM. Whiplash injury. A clinical review with emphasis on neurotological aspects. *Clin Otolaryngol* 1997;22:192–201.
100. Heikkila HV, Wenngren BI. Cervicocephalic kinesthetic sensibility, active range of cervical motion, and occulo-motor function in patients with whiplash injury. *Arch Phys Med Rehab* 1998;79:1089–1094.
101. Tjell C, Rosenhall U. Smooth pursuit neck torsion test—a specific test for cervical dizziness. *Am J Otol.* 1988; 19:76–81.
102. Cote P, Cassidy JD, Carroll L. Is a lifetime history of neck injury in a traffic collision associated with prevalent neck pain, headache, and depressive symptomatology? *Accident Analysis and Prevention.* 2000;32:151–159.
103. Khan S, Cook JCH, Gargan M, Bannister GC. A symptomatic classification of whiplash injury and the implications for treatment. *J Orthop Med.* 1999;21(1):22–25.
104. Woodward MN, Cook JCH, Gargan ME, Bannister GC. Chiropractic treatment of chronic whiplash injury. *Injury.* 1996;27:643–645.
105. Radhakrishnan K, Litchy WJ, O'Fallon WM, Kurland LT. Epidemiology of cervical radiculopathy. A

population-based study from Rochester, Minnesota, 1976 through 1990. *Brain.* 1994;117(Pt 2):325–335.

106. Vikari-Juntura E, Porros M, Lassomen EM. Validity of clinical tests in the diagnosis of root compression in cervical disc disease. *Spine.* 1989;14:253–257.

107. Carette S, Fehlings MG. Clinical practice. Cervical radiculopathy. *N Engl J Med.* 2005;353(4):392–399.

108. Peterson CK, Schmid C, Leemann S, Anklin B, Humphreys BK. Outcomes From Magnetic Resonance Imaging-Confirmed Symptomatic Cervical Disk Herniation Patients Treated With High-Velocity, Low-Amplitude Spinal Manipulative Therapy: A Prospective Cohort Study With 3-Month Follow-Up. *J Manipulative Physiol Ther.* 2013;36:461–467.

109. Engquist M, Lofgren H, Oberg B, et al. Surgery Versus Nonsurgical Treatment of Cervical Radiculopathy: A Prospective, Randomized Study Comparing Surgery Plus Physiotherapy With Physiotherapy Alone With a 2-Year Follow-up. *Spine. (Phila Pa 1976).* 2013;38(20):1715–1722.

110. Venditti PP, Rosner AL, Kettner N, Sanders G. Cervical traction device study: a basic evaluation of home-use supine cervical traction devices. *J Neuromusculoskeletal Sys.* 1995;3:82–91.

111. Cook CE, Wilhelm M, Cook AE, Petrosino C, Isaacs R. Clinical tests for screening and diagnosis of cervical spine myelopathy: a systematic review. *J Manipulative Physiol Ther.* 2011;34(8):539–546.

112. Cook C, Brown C, Isaacs R, Roman M, Davis S, Richardson W. Clustered clinical findings for diagnosis of cervical spine myelopathy. *J Man Manip Ther.* 2010;18(4):175–180.

113. Harrop JS, Naroji S, Maltenfort M, et al. Cervical Myelopathy: A Clinical and Radiographic Evaluation and Correlation to Cervical Spondylotic Myelopathy. *Spine (Phila Pa 1976).* 2010. Feb 10. [Epub ahead of print].

114. Torg JS, Pavlov H, Genuario S, et al. Neuropraxia of the cervical spine cord with transient quadriplegia. *J Bone Joint Surg Am.* 1986;68:1354–1370.

115. Bell GR, Ross J. Diagnosis of nerve root compression. *Orthop Clin North Am.* 1992;23:405–415.

116. Swenson R. Dermatomal somatosensory evoked potentials: a review of literature. *J Neuromusculoskeletal Sys.* 1994;2(2):45–51.

117. Yone K, Sakov T, Yanese M, Ijuri K. Preoperative and postoperative magnetic resonance image evaluation of the spinal cord in cervical myelopathy. *Spine.* 1994;17(10S):390–392.

118. Fouyas IP, Statham FX, Sandercock P A G. Cochrane review on the role of surgery in cervical spondylotic radiculomyelopathy. *Spine.* 2002;27:736–747.

119. Nikolaidis I, Fouyas IP, Sandercock PA, Statham PF. Surgery for cervical radiculopathy or myelopathy. *Cochrane Database Syst Rev.* 2010(1):CD001466.

120. Murphy DR, Hurwitz EL, Gregory AA. Manipulation in the presence of cervical spinal cord compression: a case series. *J Manipulative Physiol Ther.* 2006;29(3):236–244.

121. Hershman EB. Brachial plexus injuries. *Clin Sports Med.* 1990;9(2):311–329.

122. Sallis RE, Jones K, Knopp W. Burners: offensive strategy for an underreported injury. *Physician Sportsmed.* 1992; 20:47–55.

123. Leffert RD. Thoracic outlet syndrome: a correspondence newsletter to the American Society of Surgery of the Hand, December 12, 1988.

124. Brown SCW, Charlesworth D. Results of excision of a cervical rib in patients with thoracic outlet syndrome. *Br J Surg.* 1988;75:431.

125. Travell J, Simons DG. *Myofascial Dysfunction: The Trigger Point Manual.* Baltimore: Williams & Wilkins; 1983.

126. Grice AC. Scalenus anticus syndrome: diagnosis and chiropractic adjustive procedure. *J Canad Chiro Ass.* 1977; 5:35–37.

127. Lee R, Farquarson T, Domleo S. Subluxation and blockierung der ersten rippe: eine ursache fur das "thoracic outlet syndrome." *Manuelle Medizin.* 1993;31:126–127.

128. Lindgren KA, Leino E. Subluxation of the first rib: a possible thoracic outlet syndrome mechanism. *Arch Phys Med Rehabil.* 1988;69:692–695.

129. Swaraz ZT. The thoracic outlet syndrome: first rib subluxation syndrome. In: Gatterman MI, ed. *Foundations of Chiropractic: Subluxation.* St. Louis, MO: Mosby-Year Book; 1995:360–377.

130. King W, Lau P, Lees R, Bogduk N. The validity of manual examination in assessing patients with neck pain. *Spine J.* 2007;7(1):22–26.

APPENDIX 2–2

Neck Diagnosis Table

Diagnosis	Comments	History Findings	Positive Examination Findings	Radiography/Special Studies	Treatment Options
Segmental Dysfunction of Cervical Spine Joints	• Should be used when chiropractic manipulation is used as Tx for any cervical spine problem/Dx. • Can be primary Dx if patient is asymptomatic or patient has tenderness and no pain. • Must indicate chiropractic exam findings to support Dx.	*Nonspecific*	*Palpation*—Local tenderness or other signs of subluxation *Ortho*—None *Neuro*—None *Active ROM*—Variable restriction *Passive ROM*—Endrange restriction *Motion palpation*—Specific vertebral segmental restriction or symptoms produced on endrange	• Radiography not required for the diagnosis of subluxation. • Radiographic biomechanical analysis may assist in treatment decisions. • For specifics see radiographic guidelines.	• Chiropractic adjustive technique. • Decisions regarding specifically which technique(s) is/are applied and modifications to the given approach will be directed by the primary Dx and patient's ability to tolerate pre-adjustment stresses.
Cervical Sprain/Strain	• Should be reserved for acute traumatic sprain/strain.	*Trauma*—Overstretch or overcontraction Hx as acute event *Radiation of pain*—Possible (referred) *Pain radiation with Valsalva-type activities*—No *Worse with Specific ROM*—Contraction of muscle or stretch of muscle or joint	*Ortho*—None *Neuro*—None *Active ROM*—Pain on active ROM that contracts involved muscles *Passive ROM*—Pain on endrange stretch of involved muscle or ligament	• Radiography not required for diagnosis. • With significant trauma or for med/legal purposes, radiographs may be required. • For specifics see radiographic guidelines.	• Myofascial therapy. • Limited orthotic support. • Ergonomic advice. • Preventive exercises and stretches (e.g., spinal stabilization exercises).
Neuritis or Radiculitis Due to Disc	• Requires hard neurological evidence of nerve root dysfunction. • Requires special imaging confirmation.	*Trauma*—Often Hx of similar events with resolution; major or minor trauma possible *Radiation of pain*—Often into arm/hand *Pain radiation with Valsalva-type activities*—Possible *Worse with Specific ROM*—Variable; may be related to disc protrusion	*Ortho*—Nerve compression or stretch tests positive (e.g., upper limb tension test) *Neuro*—Deficit in corresponding dermatome, myotome, and DTR *Active ROM*—Variable; weakness more in related upper limb muscle(s) *Passive ROM*—Variable	• Radiography may help initially in differentiating stenosis and disc. • MRI or electrodiagnostic studies may be needed after one month without resolution or if progressive.	• Emphasis may be placed more on "soft" techniques such as activator or traction. • Limited orthotic support. • When subacute, begin spinal stabilization.

(*continues*)

Neck Diagnosis Table (continued)

Diagnosis	Comments	History Findings	Positive Examination Findings	Radiography/Special Studies	Treatment Options
Non-Specific Cervical Spine Pain	• Used for patients with evidence of a myofascial cause. • Also used for patients without Hx of recent trauma. • May be used for unspecified neck pain.	*Trauma*—Not recent *Radiation of pain*—May radiate into shoulder or arm to hand *Pain radiation with Valsalva-type activities*—No *Worse with Specific ROM*—Variable	*Ortho*—None positive, however, may reproduce local symptoms *Neuro*—None (although patient may have neurological complaints such as numbness) *Active ROM*—Variable *Passive ROM*—Variable	• Radiography not necessary. • May be used to access biomechanical status or predisposition. • See PCCW Radiographic Guidelines.	• Myofascial therapy • Limited orthotic support • Ergonomic advice • Preventive exercises and stretches (e.g., spinal stabilization exercises)
Neuritis or Radiculitis Unspecified	• Used in cases where there are radicular signs/symptoms. However, not enough evidence to pinpoint disc vs other causes. • Used with radicular signs/symptoms where no specific nerve root is clearly involved.	*Trauma*—Variable presentation *Radiation of pain*—May radiate down shoulder and arm *Pain radiation with Valsalva-type activities*—Possible *Worse with specific ROM*—Variable	*Ortho*—Nerve compression or stretch tests positive (e.g., upper limb tension test) *Neuro*—Deficit in corresponding dermatome, myotome, and DTR *Active ROM*—Variable weakness *Passive ROM*—Variable	• Radiography may help in differentiating stenosis and disc. • MRI or electrodiagnostic studies may be needed after one month without resolution or if progressive.	• Limited orthotic support • Myofascial therapy • When subacute, begin deep flexor strengthening
Cervicobrachial Syndrome	• Used when neck pain with radiation is not radicular but referred.	*Trauma*—Variable presentation *Radiation of pain*—May radiate down shoulder and arm *Pain radiation with Valsalva-type activities*—No *Worse with specific ROM*—Variable	*Ortho*—Nerve compression or stretch tests negative *Neuro*—None *Active ROM*—Variable *Passive ROM*—Variable	• None needed initially.	• Limited orthotic support • Myofascial therapy • When subacute, begin deep flexor strengthening
Facet Syndrome	• Should be reserved for neck pain increased with hyperextension posture or movement (acute or chronic) with local pain.	*Trauma*—Variable *Radiation of pain*—Often into shoulder, arm to hand, or upper back *Pain radiation with Valsalva-type activities*—May be painful *Worse with Specific ROM*—hyperextension and rotation increases local or radiating pain	*Ortho*—Positions of rotation and/or hyperextension maneuvers may increase symptoms *Neuro*—None *Active ROM*—Variable *Passive ROM*—Variable *Motion palpation*—Endrange restriction to side of involved facet	• Radiography may be useful for determining biomechanical predispositions.	• Myofascial therapy • Limited orthotic support • Ergonomic advice • Preventive exercises and stretches • Avoid hyperextension/rotation
Thoracic Outlet Syndrome (TOS)	• Should be used only when TOS testing reproduces patient's complaint.	*Onset*—Traumatic onset in 40% of cases *Radiation of Pain/Neuro Symptoms*—Generally on medial aspect of arm (lower brachial plexus)	*Ortho*—Several provocative positions may reproduce symptoms: Adson's, Halstead's, Wright's, and Roos' tests	• Cervical spine films may reveal cervical ribs, however, this is not pathognomonic for TOS.	• Myofascial therapy • Preventive exercises and stretches • Postural training