CHAPTER 1

Cervical Spine

John J. Monahan, M.D., and Richard J. Waite, M.D.

Essential Anatomy

FUNCTIONAL UNITS OF THE CERVICAL SPINE (Fig. 1.1)

A functional unit of the spine consists of any two adjacent vertebrae and their articulations with one another. The cervical spine (C-spine) contains eight functional units, five of which are alike, and three of which (the first, second, and last) are unique.

The first functional unit is the articulation between the occiput and the first cervical vertebra (the atlantooccipital joint, Fig. 1.2). This unit is controlled primarily by short, deep muscles anteriorly and posteriorly that extend only the width of the segment. Its movement allows for about one-third of full flexion and extension and for about 50% of lateral bending of the head and neck.

The second functional unit is the articulation between the first and second cervical vertebrae (the atlantoaxial joint, Fig. 1.3). It too is controlled primarily by short, deep muscles anteriorly and posteriorly that extend across only the second unit and the first two units. The movement of the second unit allows for 50% of the rotational range of motion of the head and neck.

Weight is borne across each of the first two units of the spine on the broad surfaces of the facet joints.

The next five functional units are the articulations between the second through the seventh cervical vertebrae (Fig. 1.4). These units are controlled by long and short deep muscles anteriorly and posteriorly, the scalenus muscles at middle depth, and the sternocleidomastoid and trapezius muscles superficially. Their movement allows for approximately two-thirds of full flexion and extension, approximately 50% of rotation, and approximately 50% of lateral bending. In contrast to the first two units, these five units bear weight on three broad surfaces—the two facets and the vertebral bodies. The facet articulations are synovial joints, and the body articulations are fibrocartilaginous joints (the intervertebral discs). The facet articulations are in the same plane as the intervertebral disc. The posterolateral margins of the bodies project slightly beyond the disc to form bony pseudoarthroses, the uncovertebral joints, across each functional unit. The uncovertebral joints are vulnerable to wear and tear and frequently develop degenerative osteophytes.

The cervical nerve roots exit through the foramen formed by the uncovertebral joint anteriorly and the facet joint posteriorly. Thus, the roots are vulnerable to acute impingement during subluxation of any of the units and to compression caused by posterolateral herniation of disc material or protrusion of bony spurs from the uncovertebral and facet joints (Fig. 1.4). The movements of the cervical spine allow for the most severe injuries and greatest wear and tear across the units between C-4 and C-7. The nerve roots passing through the intervertebral foramina of these units are the fifth, sixth, and seventh respectively.

The last functional unit is the articulation between C-7 and T-1 (Fig. 1.5). The C-7 vertebra is unique in two respects: its upward-directed facets are cervical-like, its downward-directed facets are thoracic-like, and its body is nearly of thoracic dimension. (The body of each lower cervical vertebra from C-3 to C-7

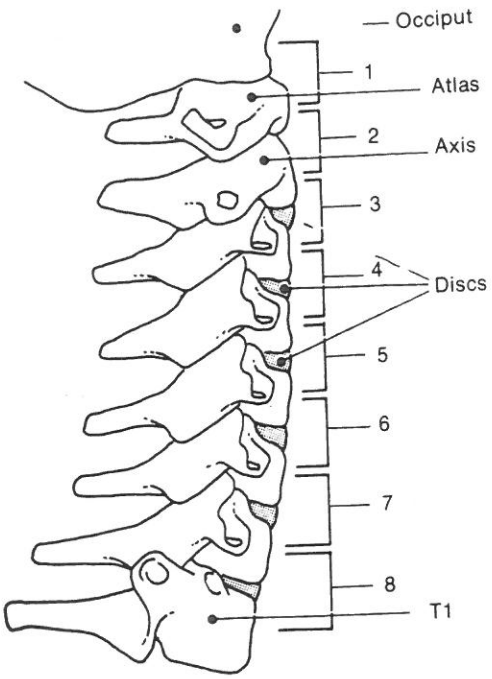

Figure 1.1. The eight functional units.

is slightly larger than its superior neighbor.) These unique characteristics make the last functional unit of the cervical spine similar to a thoracic unit, in that the larger vertebral bodies of C-7 and T-1 bear the bulk of the weight across the unit, and the facet articulations are nearly at right angles to the intervertebral disc. These near-perpendicular articular surfaces allow the unit limited movement in flexion, extension, and rotation. Severe injury or wear and tear across this unit is unusual.

SOFT TISSUES OF THE CERVICAL SPINE

The soft tissues of the cervical spine include the deep fascia, many layers of muscle, the thick ligaments, the synovia of the facet joints, and the intervertebral disc.

Deep Fascia (Fig. 1.6)

The deep fascia consists of three layers of dense connective tissue that separate the neck into compartments. The superficial layer lies beneath the platysma and surrounds all the deeper structures of the neck. The superficial layer splits to invest the sternocleidomastoid and strap muscles anteriorly and the trapezius posteriorly. The prevertebral layer surrounds the cervical spine and the deep muscles that cling to the spine anteriorly and posteriorly. The pretracheal layer surrounds the trachea, esophagus, thyroid, and parathyroid. All three layers fuse to form the carotid sheath that surrounds the carotid artery, the internal jugular vein, and the vagus nerve.

Muscles (Fig. 1.7)

The muscles of the neck accessible to physical examination anteriorly are the accessory muscles of the pharynx and larynx, which in aggregate are often called the strap muscles and the sternocleidomastoid muscle. Muscles that are accessible posteriorly and laterally are the trapezius and parts of the splenius capitis and cervicis, the levator scapulae, and the scalene muscles. The diagnosis of muscular injury depends on the discovery of tenderness in these muscles. Although deeper muscles that surround and lie on the cervical spine are affected in painful processes, the effect cannot be isolated by physical examination.

Ligaments (Fig. 1.8)

The ligamentum nuchae is the most superficial ligament. It represents a thin extension of the supraspinous and interspinous ligaments outward between the trapezius muscles. The supraspinous and interspinous ligaments are distinct entities in the dorsal and lumbar spine; however, in the neck they merge and lose their identities in the ligamentum nuchae. With the neck in full flexion, the ligamentum nuchae can be palpated distinctly as it extends from the spine of the seventh cervical vertebra to the prominence of the occiput. The ligamentum nuchae is the only ligament that can be distinguished as such by palpation.

The capsular ligaments of the facet joints surround each facet joint, extending between the margins of the two articular surfaces. Palpation through the scalene and splenius muscles allows the examiner to detect the facet column. The joints cannot be distinguished

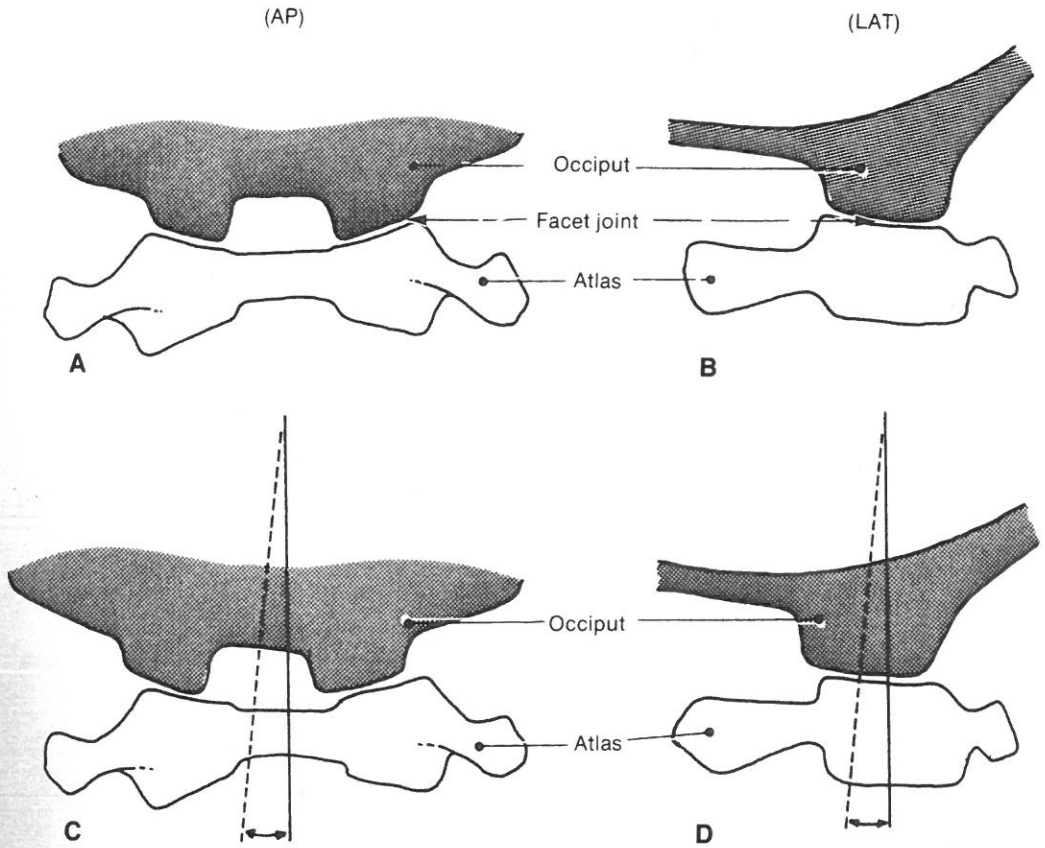

Figure 1.2. The first functional unit: the atlanto-occipital joint. *A* and *B*, neutral. *C*, lateral bending. *D*, nodding.

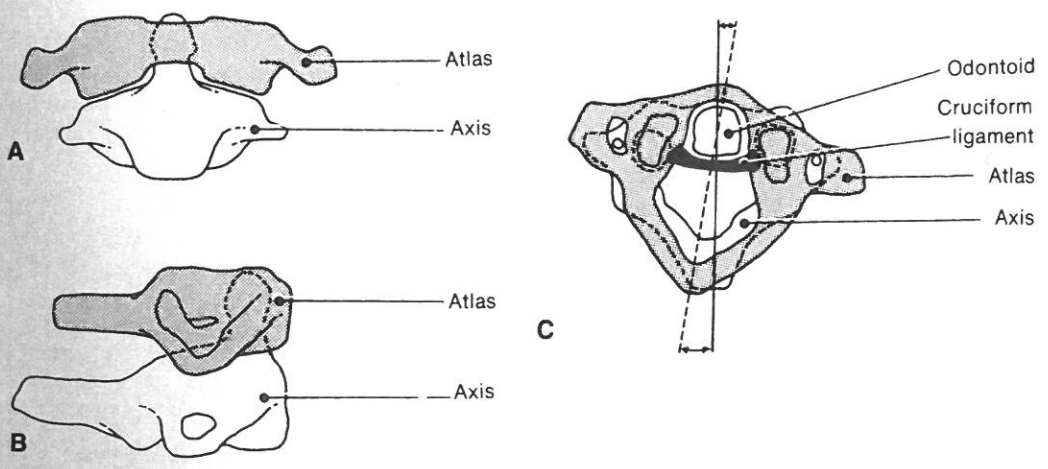

Figure 1.3. The second functional unit: the atlanto-axial joint. *A*, anteroposterior, neutral. *B*, lateral. *C*, superior, rotated.

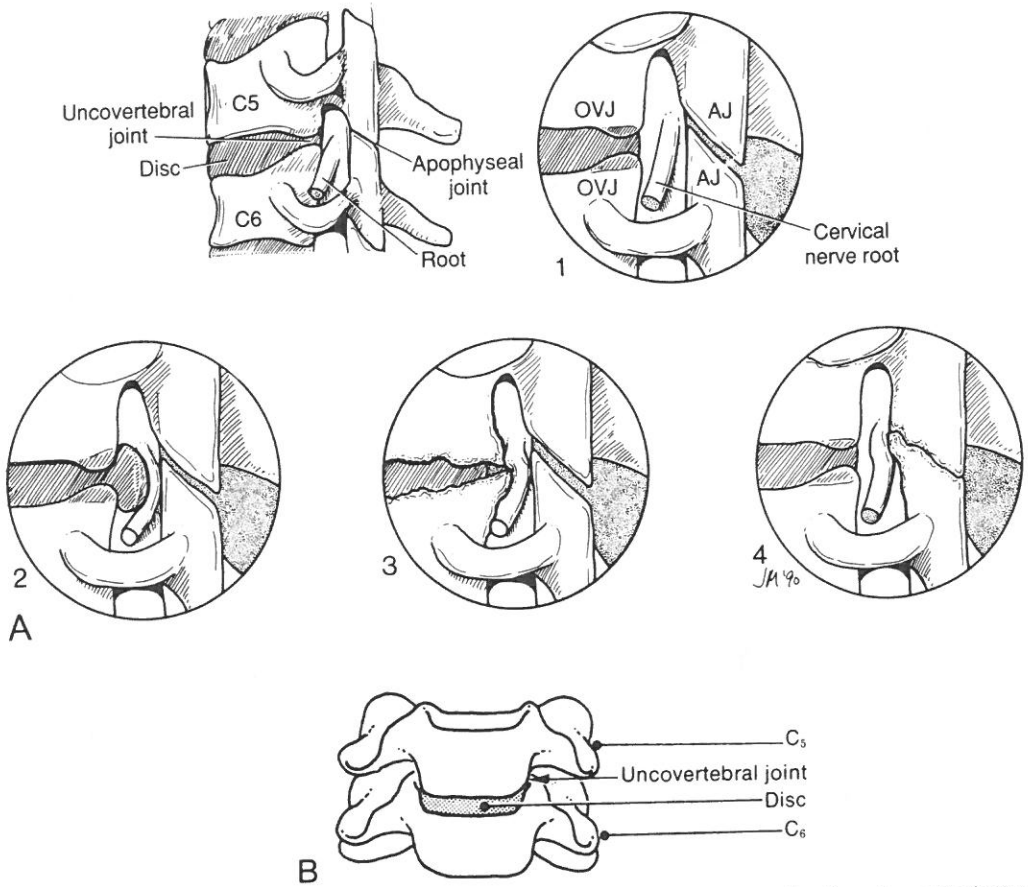

Figure 1.4. *A*, normal and abnormal relationships of a cervical nerve root passing from the spinal canal through the foramen. *1*, normal. *2*, disc protrusion. *3*, uncovertebral osteophyte. *4*, apophyseal osteophyte. *B*, the five similar functional units: articulations between the 2nd and 7th cervical vertebrae.

by palpation, and tenderness of the ligaments cannot be distinguished from tenderness of the overlying muscles. Localized tenderness does, however, indicate a potential injury of the superficial or deep soft tissues.

The posterior longitudinal ligament passes the length of the spinal column, lying against the posterior walls of the vertebral bodies and discs. The anterior longitudinal ligament passes the length of the spinal column, lying against the anterior walls of the vertebral bodies and discs. The ligamenta flava are a series of short ligaments that pass between the lamina of the posterior arches of each functional unit along the length of the spine.

All of these ligaments are pain sensitive.

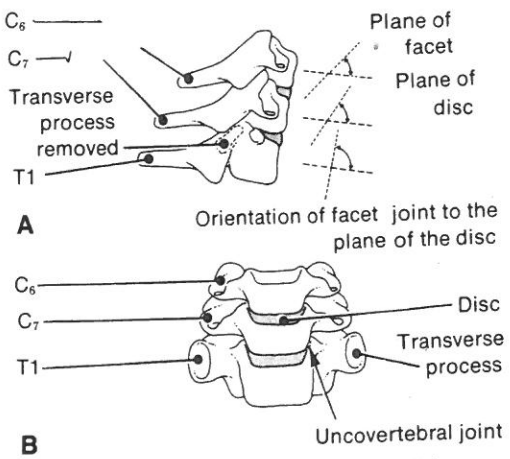

Figure 1.5. The unique structure of the 7th cervical vertebra.

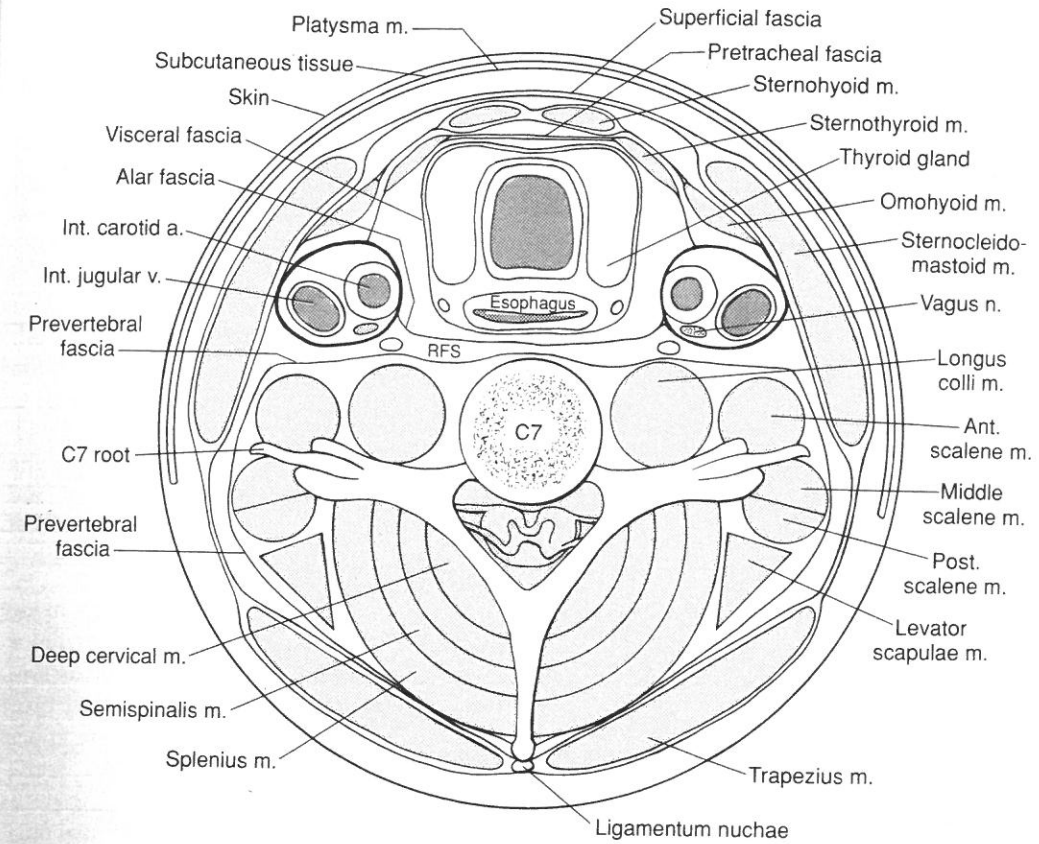

Figure 1.6. Cross section of the cervical spine at C-7.

Figure 1.7. The muscles accessible to physical examination.

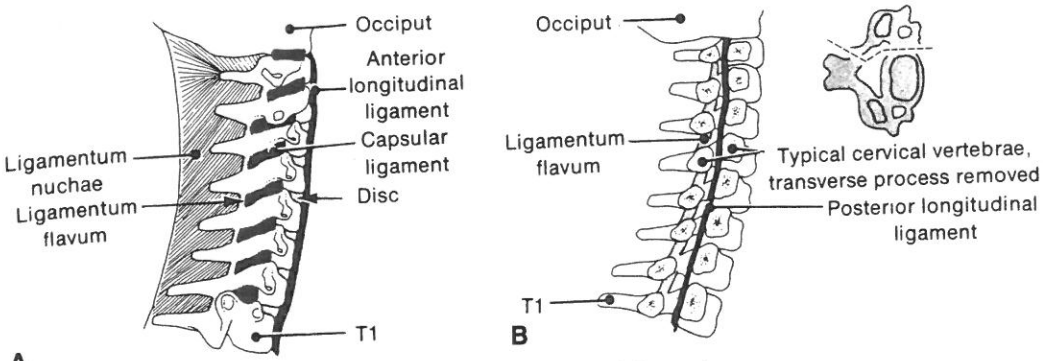

Figure 1.8. The ligaments of the neck.

Synovia of the Facet Joints (Fig. 1.8)

A synovial membrane lies beneath the capsular ligaments and invests and lubricates the articulations of the facets. It may be stretched along with the capsule when the facet joints are subluxed, and it has been postulated that it may be pinched between facet surfaces when they move on one another in slight malalignment. As may be true of all synovial joints, local degenerative and various "systemic" events may cause an inflammation within the synovium. All these processes result in a painful synovitis.

Intervertebral Disc (Fig. 1.8)

The disc consists of two parts, a springy outer ring of interwoven fibrocartilaginous bands called the anulus, and a "hydroelastic," gelatinous inner core called the nucleus pulposus. Young discs are thick, malleable, and elastic, whereas old discs are thin, rigid, and brittle. Thus, greater forces are required to injure young discs than old. The forces that injure discs may injure the anterior and/or posterior longitudinal ligaments as well. Disc material displaced against the posterior longitudinal ligament also may protrude far enough to compress the adjacent nerve root, producing radicular pain and dysfunction. The disc anulus also contains pain-sensitive nerve endings. Therefore, the pain directly attributable to a disc injury is the pain from the disc, injured nerve root (radiculopathy), injured spinal cord (myelopathy), and/or injured anterior or posterior longitudinal ligament.

EVALUATION OF THE PATIENT WITH NECK SYMPTOMS

HISTORY

Since the neck is a complex structure made up of multiple organ systems, a meticulous history is necessary to define the specific system or systems involved. The pathologic process may be local or referred from the upper abdomen, thorax, upper extremities, scalp, temporomandibular joint, or teeth. The clinical characteristics include pain, abnormal posture or range of motion, and neurologic or vascular dysfunction. The history of the present illness should include the how, what, when, and where of the onset of symptoms; details of possible congenital, infectious, inflammatory, traumatic, endocrine, metabolic, or tumor processes; description of pain pattern; description of any deformity; and description of muscle weakness and/or associated disturbance of sensory function or bowel and bladder sphincter control.

PHYSICAL EXAMINATION

The techniques and emphasis of the physical examination of the neck vary with the etiology of neck symptoms: nontraumatic or traumatic.

Inspection

The patient with a traumatic C-spine injury should have been immobilized in a neck brace at the scene of the injury. In addition, the

patient should be attached to a spine board. The neck should be in the neutral or least deformed position possible without using undue force or causing pain. Inspection of the patient with a suspected spinal injury must be carried out in the brace with the patient's neck in a neutral or near-neutral position. The primary physician should look for obvious swelling, asymmetry, discoloration, tracheal deviation, respiratory distress, or malalignment of the cervical spine. The patient's neck should not be moved until fracture, dislocation, or unstable ligament injury has been ruled out. The patient with complete cord injury is usually able to identify pain at the site of injury, but the observer notes anesthesia below this level. The sensory loss may mask visceral injuries involving the chest or the abdominal cavity. Suspicion of injury above C-5 should trigger concern for possible respiratory compromise (the diaphragm is innervated by C-3 through C-5).

In the nontraumatic case, the patient is inspected as he or she walks into the examining room and undresses to the waist. The examiner notes abnormal posture or motion (splinting or guarding) and diminished range of motion. Local or diffuse swelling, rashes, discoloration, or scars of the neck and upper extremities are observed. The chest, upper abdomen, scalp, temporomandibular joint, and teeth may need to be inspected.

Palpation

In both traumatic and nontraumatic cases, palpation may reveal areas of tenderness, swelling, induration, asymmetry, or malalignment in the bony and soft tissues of the neck. Anterior bony landmarks include the hyoid bone at the C-3 level, thyroid cartilage at the C-4/C-5 level, and first cricoid ring at the C-6 level. Posteriorly, the occiput, inion, superior nuchal line, mastoid process, spinous processes, and apophyseal joints are examined. The examination of the anterior soft tissues includes the sternocleidomastoid muscles, strap muscles, scalenus muscles, lymph nodes, thyroid gland, carotid pulses, and supraclavicular fossa (e.g., clavicle fractures, cervical ribs, or superior sulcus tumors). Posteriorly, the trapezius and paraspinous muscles, lymph nodes, greater occipital nerve, and superior nuchal ligament (which extends from the occiput to the C-7 spinous process) are examined.

In traumatic cases, active or passive range of motion should not be tested until appropriate radiographic studies rule out fracture or dislocation.

Range of Motion

The range of motion of the C-spine is age dependent, in that it tends to diminish with aging. The normal painless range of motion of the cervical spine in a young adult is approximately 45° of flexion (the patient is able to touch chin to chest), approximately 45 to 60° of extension, and approximately 90° of rotation (the patient is able to rotate the head from side to side so that the chin is almost in line with the shoulder). Lateral bending, in which the patient tries to touch the ear to the shoulder, should be approximately 45° toward each shoulder.

NEUROLOGIC EXAMINATION

Neurologic Anatomy

There are eight cervical nerves. The individual spinal cord segments correspond to the vertebral segments. One through seven exit on top of their respective vertebrae; the eighth exits between C-7 and T-1. T-1 exits below the T-1 vertebra. The brachial plexus is composed of nerves emanating from C-5 to T-1. As the individual roots travel from the spine to the upper extremity, they form specific trunks, divisions, cords, and peripheral nerves at specific anatomic levels. Impingement of these specific structures produces characteristic signs and symptoms.

Sensory Distribution

From C-2 to T-1, each root supplies sensation to a portion of the extremity in a succession of dermatomes around the extremity. These dermatomal distributions are variable, but the following autonomous zones for each root are useful, though approximate, clinical

indices. C-2 supplies the area 2 inches below the tip of the ear; C-3, the base of the neck; C-4, the top of the shoulder; C-5, the lateral arm at the shoulder; C-6, the lateral aspect of the forearm and tip of the thumb; C-7, the tip of the middle finger; C-8, the medial border of the hand; and T-1, the medial aspect of the lower arm.

Motor Distribution and Deep Tendon Reflexes

Roots C-3/C-5 via the phrenic nerve innervate the diaphragm; respiratory paralysis may be present and assisted ventilation necessary with injuries proximal to C-4. C-5 innervates the deltoid and biceps muscles and is responsible for the biceps deep tendon reflex. C-6 supplies the wrist extensors (extensor carpi radialis longus and brevis) and abductor and extensors of the thumb and is responsible for the brachioradialis reflex. C-7 innervates the triceps, wrist flexors, and finger extensors and controls the triceps reflex. C-8 supplies innervation to the finger flexors and has no deep tendon reflex. T-1 innervates the intrinsic muscles of the hand, which include the dorsal interossei and the abductor digiti quinti; there is no definable reflex.

The examiner should also test the function of the intrinsic neck muscles in flexion, extension, lateral rotation, and lateral bending. The primary flexor is the sternocleidomastoid, innervated by the spinal accessory or the 11th cranial nerve. Secondary flexors are the scalenus and paravertebral muscles. Primary extensors are the splenius, semispinalis, capitis (paravertebral extensor mass), and trapezius, innervated by the spinal accessory or the 11th cranial nerve. The sternocleidomastoid muscle is responsible for lateral rotation. Primary muscles acting in lateral bending are the scalenus anticus, medius, and posticus, innervated by the anterior primary divisions of the lower cervical nerves.

Special Tests

Distraction Test

The distraction test is performed by cupping the patient's chin and occiput and gently lifting the head. Distraction opens up the foramen, intervertebral space, and apophyseal and uncovertebral joints. This relieves pressure on the nerve root exiting through the foramen and sensitive para-articular tissues, protruding discs, inflamed synovia, or degenerative osteophytes of the adjacent synovial joints. A positive test (i.e., pain relief) indicates a disorder within the vertebral complex.

Compression Test

The compression test is the opposite of the distraction test. It is performed by gently pushing directly down on the patient's head. The axial loading precipitates or aggravates the pain when the foramen and its contained nerve root, intervertebral space, and degenerated synovial joints are compressed.

Valsalva Test

The patient bears down as if moving the bowels. The examiner notes aggravation of pain as the intrathecal pressure increases. Space-occupying lesions in the cervical canal, such as herniated discs or tumors, cause local and/or radicular pain corresponding to the level of C-spine pathology.

Swallowing Test

Dysphagia or pain on swallowing may be caused by a cervical spine disorder, such as bony protuberances, osteophytes, or soft tissue swelling.

Adson's Test

(See section on "Thoracic Outlet Syndrome.") The Adson's test is used to determine compression of the brachial plexus and/or subclavian artery.

RADIOLOGIC EXAMINATION

Diagnostic Studies

In trauma cases, a lateral cervical spine x-ray should be taken early in the course of the examination, usually during the primary survey immediately after the life-threatening problems are identified and controlled. The

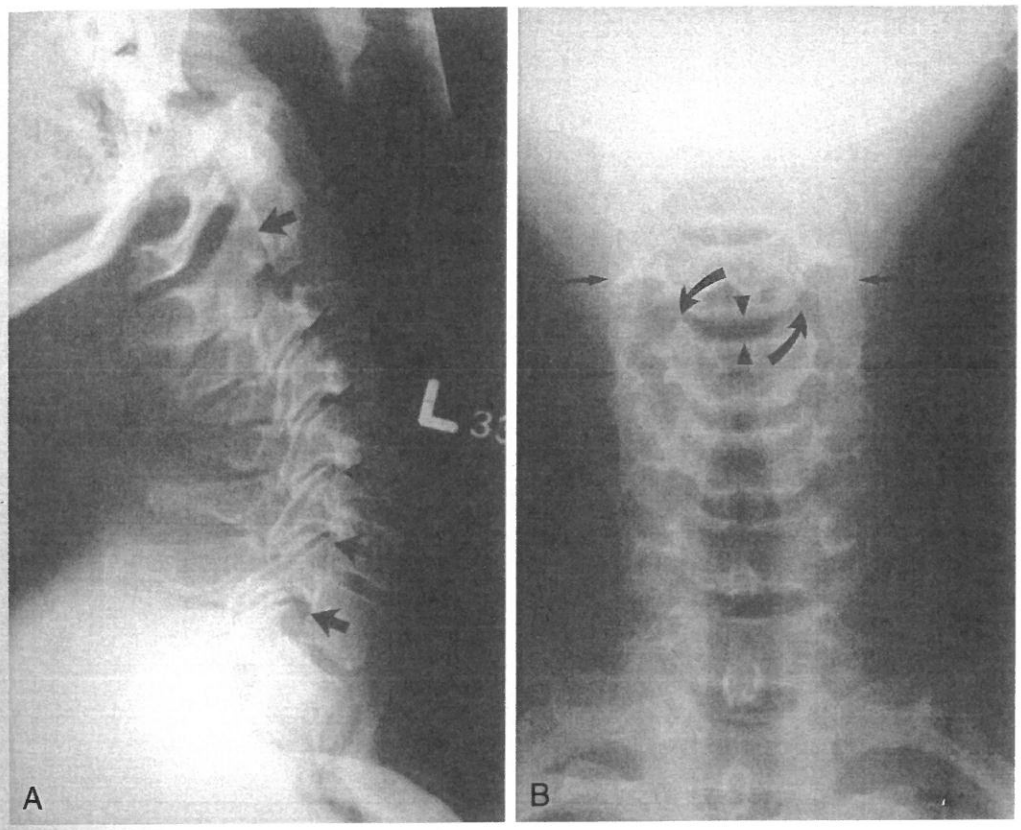

Figure 1.9. Normal: *A,* lateral; *B,* AP; *C,* oblique; and *D,* odontoid views of the cervical spine. *A,* normal lateral shows smooth cervical lordosis with maintained body heights (arrow heads), disk spaces (curved arrows), and vertebral body alignment (arrows) reflected by the posterior longitudinal line. *B,* AP view of the cervical spine shows orthogonal projection relative to *A.* Shown are disk spaces (arrow heads), lateral margins of the lateral masses (arrows), and uncovertebral joints (curved arrows). The central portion of each spinous process forms a vertical column (small arrows).

lateral x-ray (Fig. 1.9A) should be taken with the neck in a neutral position in a nonradiopaque cervical brace. All seven cervical vertebrae must be identified. If C-7 and T-1 cannot be seen, the attending physician should pull the patient's shoulders down gently while the x-ray is being taken. If C-7 and T-1 cannot be seen in the routine lateral view, a lateral swimmer's view, which is a slightly oblique lateral view of the cervical spine, is obtained. This allows the physician to assess spinal injuries and determine the need for further spine x-rays. Once the patient is stable, the full C-spine x-ray series is completed, including anteroposterior (AP) (Fig. 1.9B), oblique cervical (Fig. 1.9C), and open-mouth odontoid views (Fig. 1.9D). Tomography and/or computed tomography (CT) may be necessary to make a radiologic diagnosis. After studies have ruled out fracture or dislocation, stress films should be taken if stability of the C-spine is in question. The study should be performed with caution and supervised by the physician. It includes two lateral x-rays of the cervical spine with the neck moved actively with guidance into the maximum flexed and maximum extended positions within the limits of pain.

X-ray Review

In trauma cases, x-rays should be examined for the alignment of the vertebral bodies and any displacement of bone fragments into the

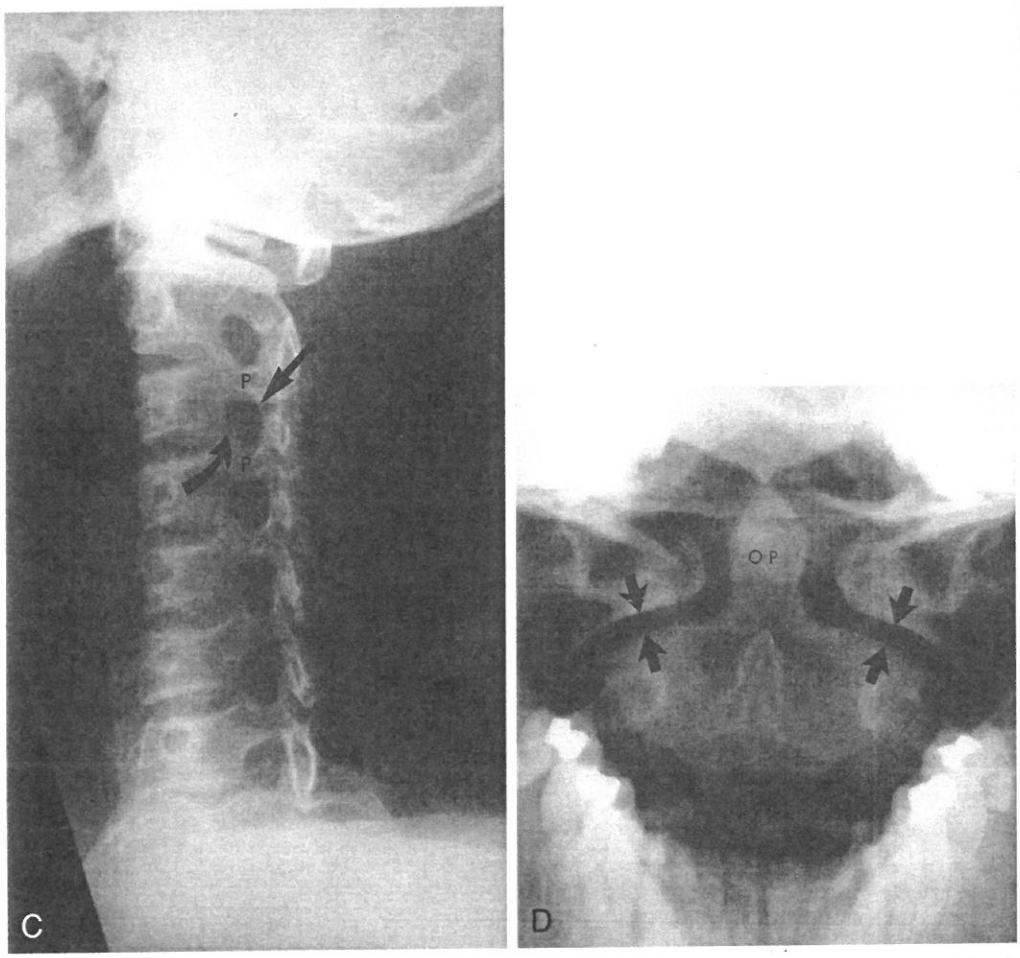

Figure 1.9. (*continued*) *C,* oblique view demonstrates well the intervertebral foramina demarcated by the pedicles superiorly and inferiorly (P), the uncovertebral articulation anteroinferiorly (curved arrow), and the facet joint posterosuperiorly (arrow). *D,* open mouth odontoid view shows the atlanto-occipital joint between C1 and C2 (arrows) pivoting about the odontoid process (OP).

spinal canal. The segments of the vertebral complex involved in the fractures (Fig. 1.10) should be identified. For the evaluation of stability, the spine may be divided into three segments. The first segment includes the anterior longitudinal ligament and anterior two-thirds of the vertebral body; the second segment is composed of the posterior third of the vertebral body, including the posterior longitudinal ligament; and the third segment is composed of the posterior elements (facet joints, neural arch and processes) of the vertebral complex (Fig. 1.10). If a fracture or ligamentous disruption involves two or more of the three segments of the vertebral complex, the injury is considered unstable. When assessing the lateral spine, the distance between the pharynx and the anterior-inferior border of C-3 is measured. The prevertebral soft tissue thickness at this level should be less than or equal to 5 mm. An increase in this area of density suggests a vertebral fracture because it could represent a hematoma secondary to the fracture. Any angulation of two adjacent vertebrae greater than 11° more than the angulation between each of those vertebrae and

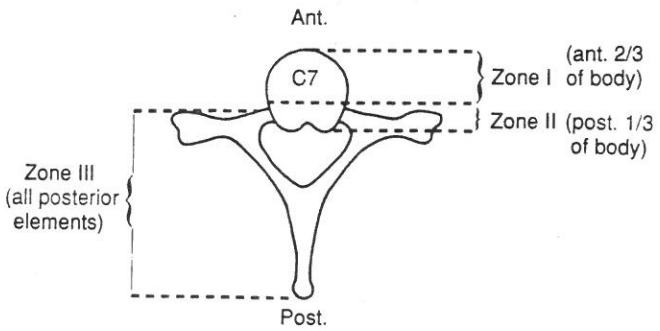

Figure 1.10. Structural segments of a cervical vertebra. Fractures involving more than one segment are usually unstable.

their adjacent normal vertebrae indicates instability of the cervical spine. Translation of one vertebra upon another, either anterior, posterior, lateral, or combinations thereof, greater than 3.5 mm also indicates instability. Any evidence of instability requires orthopaedic and/or neurosurgical referral. While waiting for the consultant, the cervical spine should continue to be immobilized.

In nontraumatic cases of neck pain, routine C-spine x-rays may be taken when indicated, (i.e., AP, lateral, both obliques, and odontoid views). In addition to the interpretive criteria described for traumatic cases, evidence of destruction (lytic lesion) or increased bone production (blastic lesion) are sought, as well as narrowing or hypertrophic changes of the disc or apophyseal joints, calcific deposition within the disc space, and associated soft tissue changes. Additional studies, such as tomography, CT scan, magnetic resonance imaging (MRI), and bone scan, are often indicated for further evaluation, but this is usually a decision made after orthopaedic referral.

NONTRAUMATIC CONDITIONS IN ADULTHOOD

DEGENERATIVE DISEASE

As in the thoracic and lumbosacral spine, a theoretical scheme of spinal degeneration provides a good perspective for the primary care physician in evaluating patients with degenerative conditions of the cervical spine. This theory proposes that facet joint synovitis, hypermobility, and progressive degeneration are "natural" consequences of aging and the repetitive trauma of "normal" activity. The facet joint changes occur along with degenerative changes in the intervertebral disc, which begin with marginal tears of the anulus and progress to radial tears and disc herniation. Subluxation of the facet joints with enlargement of the articular processes occur in parallel with disc resorption and spinal osteophyte formation. In the cervical spine, the uncovertebral joints may be severely involved in this process. In the early phases of this degenerative process, patients may be identified as having "facet joint syndrome," or after relatively minor trauma, the patient may develop an "acute disc herniation." It is important to recognize that the facet joint and the discs are each one part of the motion segment, and it is unlikely that there is isolated trauma or inflammation in one part of the spinal unit without associated abnormalities in the complementary parts.

Acute Disc Herniation

Acute disc herniation in the cervical spine is less common than in the lumbar region. The syndrome may be triggered by an acute injury to the disc, with or without underlying degenerative changes. It may also present with little or no remembered trauma and is frequently associated with degenerative changes of the intervertebral disc. With herniation of the disc, there may be irritation of an associated nerve root or other nerve endings in the disc complex, i.e., anulus fibrosus or posterior longitudinal ligament. A disc herniation,

consequently, may cause true radicular pain or nonradicular referred pain felt in the upper extremity. In true radicular pain, the signs and symptoms vary with the level of nerve root irritation.

Clinical Characteristics

C-4/C-5 (fifth root) causes neck, shoulder, and lateral arm pain and motor weakness of the deltoid and biceps. Sensation is diminished over the lateral upper arm, with an autonomous zone over the lateral deltoid. The biceps reflex may be diminished.

C-5/C-6 (sixth root) causes neck pain, with variable radiation into the occiput and/or interscapular area, posterolateral aspect of the shoulder, lateral aspect of the upper arm and forearm, and the thumb and index finger. Sensory dysfunction in the lateral forearm, thumb, and index finger may be noted. There may be weakness of the biceps, long abductor and extensor of the thumb, and wrist extensors. The brachioradialis reflex is usually diminished.

C-6/C-7 (seventh root) causes neck pain, with variable radiation into the occiput and shoulder or interscapular region, lateral aspect of the upper arm and forearm, and, occasionally, the volar aspect of the forearm, ulnar aspect of the hand, and fourth and fifth fingers. Sensory loss involves the fourth and fifth fingers. Muscle weakness is evident in the triceps, wrist flexors, and finger extensors. The triceps reflex is usually diminished.

C-7/T-1 (eighth root) causes neck pain, with variable radiation into the occiput, interscapular region, medial aspect of the upper arm, and forearm. Motor weakness involves the deep and superficial finger flexors. Sensory dysfunction occurs along the C-8 dermatome on the ulnar aspect of the distal forearm and hand.

T-1/T-2 (T-1 root) pain involves the neck, with variable referral to the occiput and interscapular region. Usually, pain is felt in the medial aspect of the arm. Sensory deficits are noted in the medial side of the proximal half of the forearm and distal half of the upper arm. Motor weakness involves the finger abductors. No deep tendon reflex is associated with the T-1 root.

Pain from an acute disc herniation is usually aggravated by coughing, sneezing, straining, and activities involving prolonged abnormal positioning, especially fixed flexion or extension with rotation. Lifting, pushing, and pulling may trigger pain. There is tenderness to palpation over the posterior elements of the spinous process of the involved root or over the facet joints. Gentle manual traction tends to relieve pain, while compression of the spine increases pain. Further physical findings include pain on active or passive motion of the C-spine, with an overall diminished range of motion. There may be abnormal posture of the C-spine, with flattening of lordosis or development of torticollis. The pain is relieved somewhat by bringing the patient's ipsilateral hand up behind the neck. Pain is aggravated by hyperextension and rotation of the neck to the involved side. There is usually associated muscle spasm of the paravertebral muscles and, occasionally, the more anterior muscle groups. Trigger points may be in the interscapular region.

X-ray studies may be normal or may reveal degenerative changes or disc space narrowing. If there is no response to initial conservative treatment, orthopaedic referral is indicated. CT scan, MRI studies (Fig. 1.11), myelogram, or bone scan may be indicated to further evaluate the patient. Electromyography (EMG) and nerve conduction studies are useful in delineating a specific radiculopathy.

Treatment

Conservative treatment is recommended for acute disc herniation. The keystone is rest. Rest may be defined as limiting the patient's activities of daily living to a point where he or she is comfortable. If the patient is having severe pain, especially when associated with neurologic dysfunction, strict bedrest is indicated (bathroom privileges are allowed). A position of comfort, utilizing soft (not foam rubber) pillows, elevation of the head of the bed, and a soft cervical collar (Fig. 1.12) when

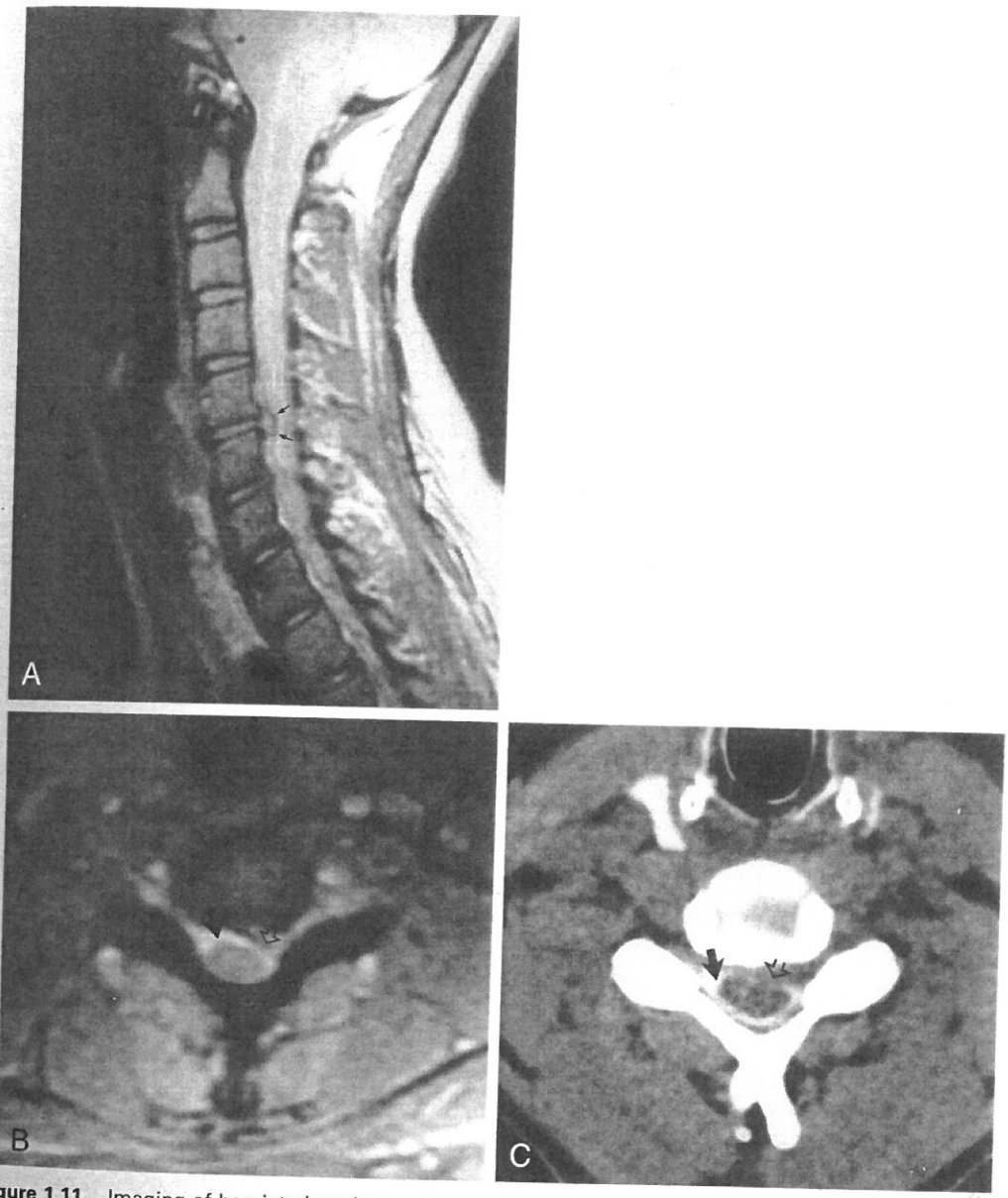

Figure 1.11. Imaging of herniated nucleus pulposus. *A,* sagittal MR proton density scan (TR 2118, TE 30) demonstrates posterior extrusion of disk material at C4-C5 (arrows). *B,* axial gradient echo image (TR 733, TE 18, flip angle = 13°) demonstrates high signal (white) to the normal cerebrospinal fluid (CSF) (solid arrow). Extruded disk material anterolaterally on the left (open arrow) effaces the CSF in this area and noninvasively clarifies the patient's cervical radiculopathy. *C,* axial CT-myelogram in a different patient with a similar herniated disc. The CSF shows high density (white) reflecting the instilled contrast material (solid arrow). This somewhat invasive study (myelogram) shows a similar pattern of anterior CSF effacement and cord distortion (arrows) compared with B.

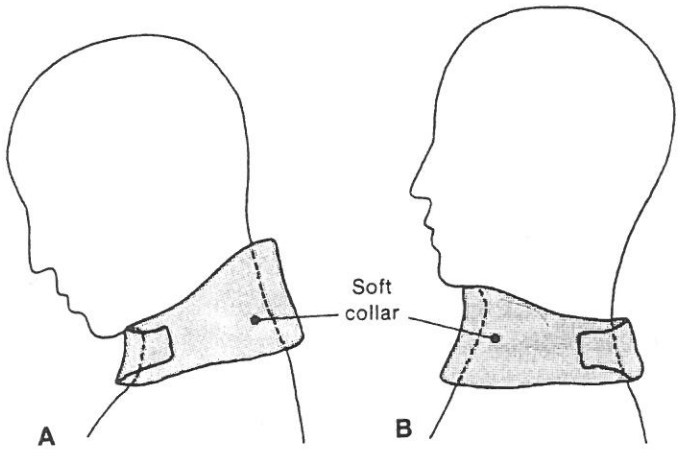

Figure 1.12. Applications of the soft collar. *A*, flexion. *B*, extension.

necessary, is recommended. Bedrest is continued, with the neck protected in a cervical collar until the patient can sit, stand, and walk comfortably in the collar. At this point, ambulatory activity is allowed as tolerated. The period of bedrest is usually 2 to 10 days. While on bedrest, the patient may maintain muscle tone in the trunk and lower extremities by an isometric exercise regimen.

If the signs and symptoms are moderate, relative rest is indicated, utilizing a firm or soft cervical collar to provide comfort and support to the cervical spine. Limited activities are permitted as tolerated, using pain as the limiting factor.

The rest regimen may be supplemented by intermittent cervical traction, unless this makes the patient more uncomfortable. Careful positioning for traction is essential (Fig. 1.13). Traction should begin with the neck in a comfortable position, usually slight flexion. The neck should be well supported, with the halter applying a distractive force posteriorly below the occiput. Traction for 20 minutes four times a day should begin with light weight, i.e., 5 to 7 pounds, with the patient supine in bed, or 10 to 12 pounds, with the patient sitting. Weight should be increased gradually as tolerated for as long as the traction affords relief, up to a maximum of 10 to 15 pounds, with the patient supine in bed, or 20 to 25 pounds, with the patient sitting. Before traction, moist heat should be applied to the neck for 15 to 20 minutes, with gentle massage of the area as tolerated.

Medications may include nonsteroidal anti-inflammatory drugs, muscle relaxants, and analgesics.

If the patient does not respond to these conservative measures within 2 to 3 weeks, additional studies as well as orthopaedic or neurosurgical consultation are indicated. If the patient demonstrates progressive weakness, sensory loss, or loss of bowel or bladder control at any point in the program, immediate consultations should be obtained.

If the patient has improved on the conservative program (i.e., the patient is comfortable under rest conditions, and range of motion and motor strength of the neck are improving without precipitating pain), rehabilitative measures are indicated. These measures involve a physical therapy program to gain full functional range of motion and strength of the C-spine and the affected extremity. The program begins with active range of motion exercises and isometric exercises and progresses to isotonic exercises of the neck and involved upper extremity, while maintaining a mobilizing and strengthening program for the trunk and lower extremities. During the rehabilitation period, patients should be encouraged to perform activities of daily living as tolerated to lessen the

overall period of disability and hasten full recovery.

Rehabilitation also involves weaning the patient from the restrictions imposed during the acute phase. The patient should be weaned from bedrest by initiating progressive periods of ambulation over the day. Initially, the neck is protected by a cervical collar. The three or four periods out of bed each day are gradually lengthened. The patient is taught to avoid pain, or better, to recognize the warnings that precede pain (e.g., fatigue, dull burning ache) and indicate that the patient is proceeding too quickly.

The cervical collar is gradually discontinued. The progressive isometric and isotonic exercises are continued three to five times a day for 5 to 7 minutes each session, while the periods out of the collar are gradually extended in 20- to 30-minute increments, beginning with 15 to 20 minutes every 2 to 3 hours. Pain should be avoided while reducing time in the collar.

The author suggests that the weaning process be carefully monitored over 2 to 3 weeks to avoid prolonged immobilization and its attendant chronic pain syndrome with persistent pain, muscle atrophy, stiffness, depression, and disability.

The patient should be guided back to full activity when he or she is out of the collar and comfortable with the physical therapy program. A general aerobic exercise program should be prescribed. Walking is excellent. Swimming is equally beneficial, but occasionally causes recurrent pain and spasm with specific strokes that stress the neck improperly.

The patient should avoid lifting, pushing, pulling, or using the hands above shoulder level. Malpositioning should be discouraged, i.e., prolonged neck flexion while typing or the

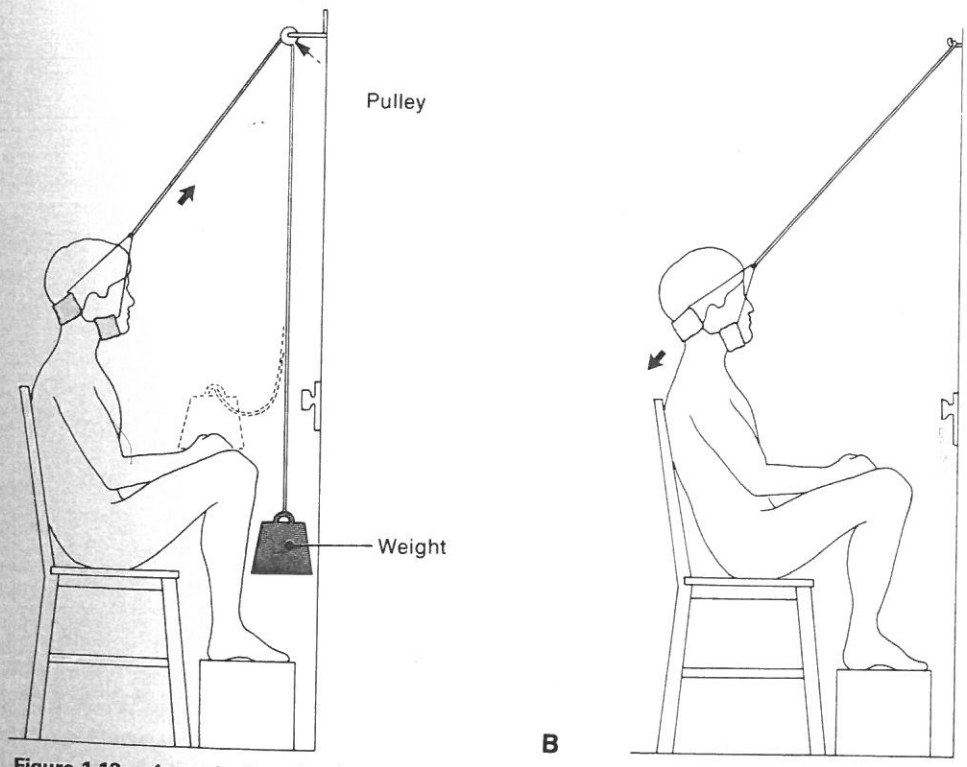

Figure 1.13. *A*, cervical traction by counterweight. *B*, cervical traction by body weight.

extension/rotation that occurs when falling asleep while sitting with the head unsupported. An early return to rigorous sports is discouraged, and contact sports are contraindicated. Most patients can return to sedentary occupations in 2 to 4 weeks, whereas manual laborers may require 6 to 8 weeks or longer.

Chronic Degenerative Disease of the Cervical Spine, Cervical Spondylosis, Osteoarthritis

The constellation of symptoms grouped under these diagnostic categories occur in an older population, usually over age 45. The underlying pathology of the intervertebral disc, facet and uncovertebral joints, and ligaments has been described. While these conditions are often more benign in their clinical presentation than an acute cervical disc syndrome, they are frequently associated with true radiculopathy because of the relationship of the nerve root to the surrounding structures, as demonstrated in Figure 1.4A.

Clinical Characteristics

Pain may be limited to the involved facet joints but is more often a generalized ache in the cervical spine without a radicular component. Referred, nonradicular shoulder and arm pain may occur. If the nerve root is involved, true radiculitis or radiculopathy may be noted with sensory and motor dysfunction. The pattern of symptoms depends on the nerve root involved, as discussed above. Symptoms may occur because of the loss of mobility in the cervical spine from minor trauma (see Fig. 1.14).

Treatment

Symptoms usually respond to the traction program as described previously. Further treatment is the same as that described under "Acute Disc Herniation." A more recent alternative to relieving root pain is "epidural steroids" (Fig. 1.15), and an alternative for lessening facet joint pain is with facet joint injection with steroids (Fig. 1.16).

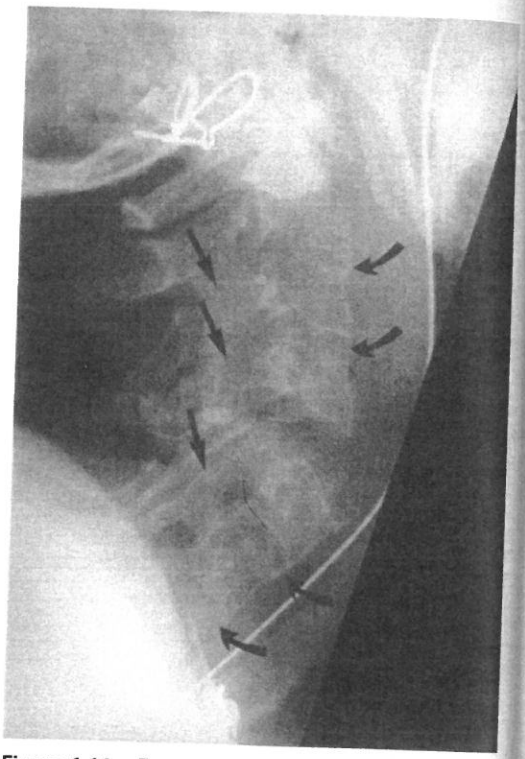

Figure 1.14. Fracture-dislocation of the cervical spine in a 32-year-old male with ankylosing spondylitis. There is disruption of the C4-C5 disk space extending posteriorly through the ankylosed posterior elements with diastasis, retrolisthesis, and acute kyphosis. Syndesmophytes (curved arrows) and ankylosed facet joints (arrows) are seen. This patient suffered this severe cervical spine injury with resultant paraplegia after relatively minimal trauma, highlighting the increased risk in a spine with limited mobility (Courtesy of Dr. Richard Waite, Department of Radiology, University of Massachusetts Medical Center, Worcester, MA).

Acute Cervical Myalgia (Muscular Wryneck)

Wryneck is a symptom complex; its etiology is unclear. It appears to be some type of soft tissue inflammation or irritation, either in the muscles, ligaments, or facet joints (synovia).

Clinical Characteristics

Onset is gradual, usually without history of significant trauma. Onset may be associated with exposure to cold, tension or anxiety, or repetitive motion or prolonged positioning of

the C-spine. Pain is felt in one of the posterior cervical triangles. Occasionally, pain may be referred into the ipsilateral shoulder, interscapular region, and occiput. Range of motion is usually diminished. The greatest restriction is in those directions that stretch the affected muscle groups. A tender focus is often discovered by careful palpation of the trapezius, splenius capitis, and levator scapulae on the painful side (Fig. 1.7). This area is often indurated and exhibits crepitus on deep palpation. Palpation over the spinous processes has no effect on pain. X-rays are within normal limits.

Treatment

Acute cervical myalgia is treated as a mild cervical sprain (see section on "Cervical Sprains and Strains"), except that the exercise regimen is initiated as early as possible and emphasizes movements that stretch the tender muscle. The condition tends to clear spontaneously in 7 to 10 days, with no significant sequelae.

Rheumatoid Arthritis

Rheumatoid arthritis may involve the cervical spine, as it does other parts of the axial and appendicular synovial joints. (Refer to Chapter 12 for a discussion of the underlying pathology.) Cervical instability is the most serious and potentially life-threatening sequela of rheumatoid arthritis of the cervical spine.

Clinical Characteristics

The history and physical findings include neck pain with occipital and lower cervical

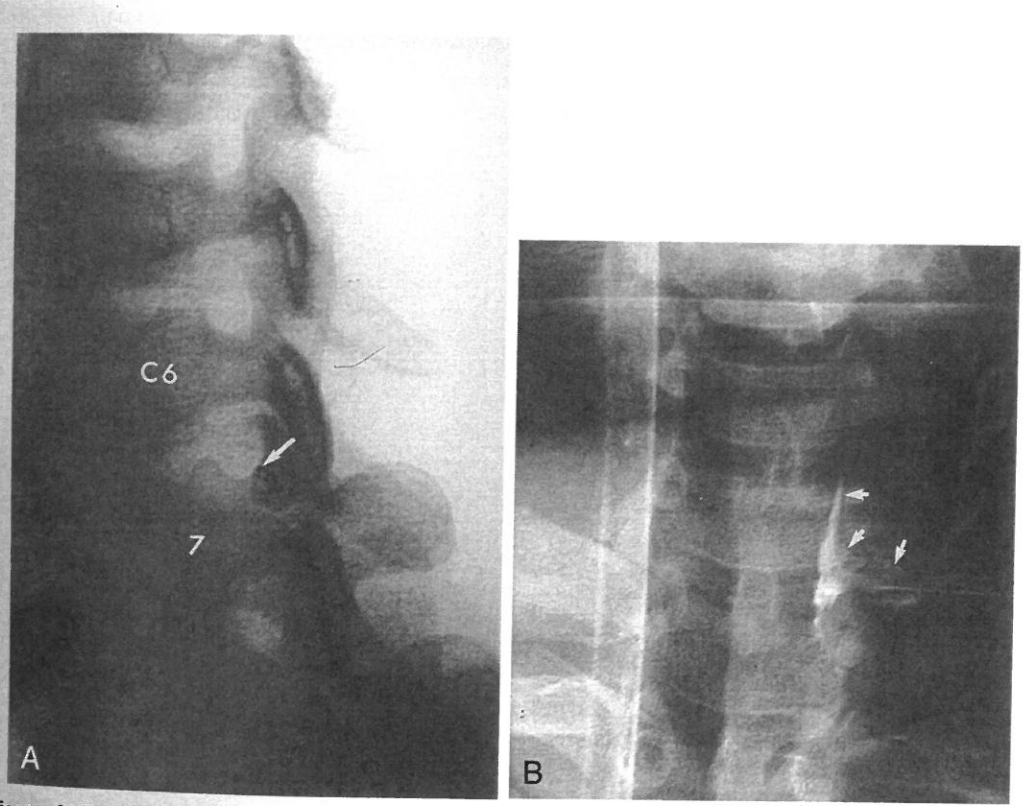

Figure 1.15. Fluoroscopic-guided transforaminal perineural and local epidural Medrol injection at the left C7 level. *A,* oblique view demonstrates needle advancement along the posterior margin of the C6-C7 neural foramen. *B,* AP view of lower cervical spine after the injection of 0.5 mL of nonionic contrast demonstrates central perineural flow with extension into the local epidural space, confirming positioning for therapeutic cortisone injection.

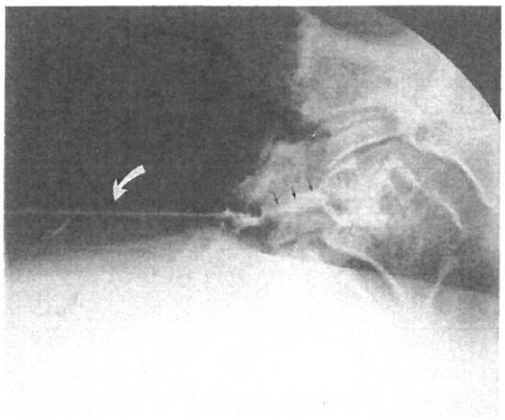

Figure 1.16. Fluoroscopic-guided C3-C4 facet injection using a posterior approach in a patient with symptomatic degenerative facet arthropathy for instillation of local anesthetic and corticosteroids. Needle (curved arrow) extends to the posterior margin of the facet joint, which is opacified by high-density contrast, confirming intra-articular location (arrows).

radiculopathy, neck crepitus, variable signs of cervical myelopathy, and generalized signs and symptoms of the disease process. Significant laboratory abnormalities include elevated erythrocyte sedimentation rate and the presence of rheumatoid factors. X-rays (Fig. 1.17 reveal osteopenia, joint space narrowing, soft tissue swelling around involved joints, bone erosions near the capsular attachments of involved joints, and joint malalignment and subluxation.

Treatment

General treatment of C-spine rheumatoid arthritis consists of rest, gentle massage, a soft cervical collar, isometric neck exercises within pain tolerance, and intermittent heat, i.e., 15 minutes three times a day (a hot shower in the morning to "loosen up" is an excellent technique). Medications begin with salicylates. If these do not provide adequate pain control, nonsteroidal anti-inflammatory drugs are used. Diagnostic and therapeutic epidural or facet injections can be useful (Figs. 1.15 and 1.16). Rheumatologic consultation determines the role of further pharmacologic therapy.

Surgical treatment must be considered in instances in which the disease has progressed to produce joint instability. There are three basic types of instability: atlantoaxial impaction (platybasia), C-1/C-2 subluxation, and subluxations of the lower cervical vertebrae, which is most common at the C-3/C-4 level. The reported incidence of instability in rheumatoid arthritis ranges from 43 to 86%. These lesions are expected to progress. Lateral cervical spine films in neutral, flexion, and extension are useful for evaluating the degree of instability and platybasia. Initially, cervical bracing is a reasonable treatment. If neurologic signs of cord or root entrapment are present or if there is evidence of instability on x-ray, orthopaedic referral is indicated for possible decompression and/or stabilization. An incidence of neurologic deficits of 7 to

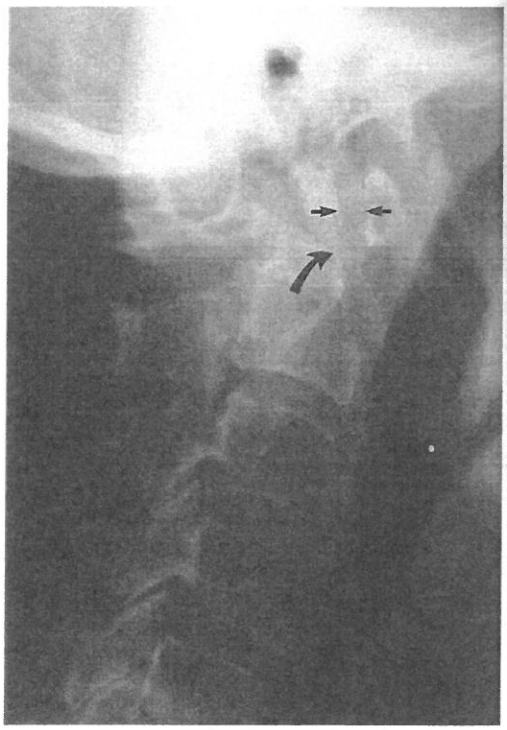

Figure 1.17. Ligamentous laxity and erosive disease in a 71-year-old male with rheumatoid arthritis. There is widening of the atlanto-dens interval (arrows) with areas of erosion to the odontoid (curved arrow).

34% and sudden death of 10% have been reported.

FIBROMYALGIA (MYOFASCIAL PAIN SYNDROME, EXTRA-ARTICULAR RHEUMATISM, FIBROSITIS)

Fibromyalgia affects musculoskeletal tissues other than joints, including muscle, tendon, fascia, bursa, ligament, and synovial sheath. There may be a psychologic overlay.

Clinical Characteristics

These entities present a spectrum of signs and symptoms. A common form is characterized by multiple localized sites of deep tenderness in the trapezius, rhomboids, and levator scapulae. These are considered trigger points. Diffuse aching of more than 3 months duration and sleep disturbances in a patient of less than 50 years of age are characteristic of this disorder. Physical findings include normal C-spine range of motion, normal motor strength, and exquisitely tender "trigger points" in the above-mentioned muscle groups. The EEG is usually abnormal and indicative of sleep disturbance. X-rays are within normal limits.

Treatment

Treatment should include reassurance, psychotherapy, and physical therapy, i.e., intermittent heat, massage, gentle active range of motion exercises, and isometric programs. Vacation or rest is recommended to relieve stress. Medications include amitriptyline, salicylates, nonsteroidal anti-inflammatory drugs, and occasional local injection of trigger points with lidocaine with or without corticosteroids. Addictive drugs should be avoided. Prognosis is poor with chronic relapses.

OSTEOPOROSIS

This generalized disease of bone affects the cervical spine as it does other parts of the axial and appendicular skeleton (see Chapter 14 for full discussion).

THORACIC OUTLET SYNDROME

The thoracic outlet syndrome presents as neck and shoulder pain with radicular or nonradicular referred pain into the upper extremity with variable neurovascular signs and symptoms. It results from compression of the brachial plexus and the subclavian vessels, usually at one of three sites as they pass through the neck and superior thoracic outlet toward the axilla: (*a*) supraclavicular, (*b*) costoclavicular, and (*c*) infraclavicular (Fig. 1.18). These anatomic zones define the three subgroups that comprise the thoracic outlet syndrome.

Essential Anatomy and Pathomechanics

As the plexus descends toward the first rib (Fig. 1.18), it passes through the first zone of potential entrapment (supraclavicular), which is a triangular area bounded by the anterior scalene muscle, the middle scalene muscle, and the first rib. Distally in this zone, the plexus is joined by the subclavian artery and vein from below. This segment of the neurovascular bundle may be compressed by (*a*) an enlargement of the transverse process of C-7 (cervical rib); (*b*) a fibrous band that extends from the C-7 transverse process of C-7 to the first rib (pseudocervical rib); (*c*) degenerative arthritis of the first costovertebral joint; (*d*) hypertrophy or spasm of the anterior and/or medial scalene muscles; or (*e*) any process that causes traction on the neurovascular bundle as it crosses the first rib, such as poor posture, kyphosis, muscle weakness, heavy breasts, or obesity.

The second point of potential compression is the costoclavicular area (Fig. 1.18), which involves impingement of the neurovascular bundle as it exits the subclavicular zone and enters a rigid narrow space formed by the clavicle superiorly and the first rib inferiorly. This space may be further narrowed by abnormal configuration of the first rib or clavicle caused by trauma, tumor, or inflammation; elevation of the first rib; or drooping of the shoulder girdle from backpacking or weightlifting.

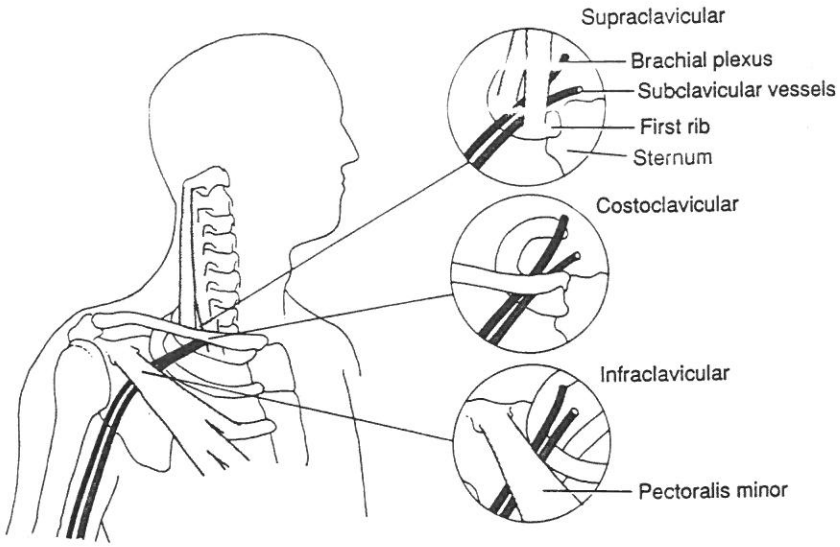

Figure 1.18. Point of neurovascular compression in the thoracic outlet.

The third point of compression is at the coracoid process (subcoracoid zone) (Fig. 1.18). The neurovascular bundle is trapped between the pectoralis minor and the rib cage, where the bundle is sharply angulated during hyperabduction and extension of the shoulders. Symptoms develop when patients work for prolonged periods with the arms stretched overhead or sleep with the shoulders hyperabducted.

Clinical Characteristics

The essential picture of the thoracic outlet syndrome, whether supraclavicular, costoclavicular, or infraclavicular, is similar since it usually involves compression of the inferior trunk of the brachial plexus, which makes up the ulnar nerve. The pain pattern usually extends from the neck or shoulders into the ulnar aspect of the arm, forearm, and ring and little fingers. Occasionally, it involves the entire hand. Depending on the relative involvement of the neurovascular elements, there is a spectrum of either nonradicular referred pain associated with deep, diffuse, ill-defined aching, heaviness, weakness, burning, edema, discoloration, temperature changes, and painful throbbing of the fingers; or a more defined radicular referred pain pattern with associated specific motor, sensory, and deep tendon reflex aberrations. A positive Adson maneuver (Fig. 1.19) (producing a diminished radial pulse and/or precipitation or aggravation of the patient's symptoms in the involved extremity) is often a useful confirmatory test for the syndrome. X-rays of the neck, chest, and shoulder should be obtained. Other studies may be deferred to the time of referral if symptoms do not respond to treatment.

Differential Diagnosis

The thoracic outlet syndrome must be differentiated from the subclavian steal syndrome, in which blood is diverted from the cerebral circulation, causing CNS neurologic symptoms and signs with the upper extremity symptoms of the thoracic outlet syndrome. Subclavian steal syndrome is not usually precipitated by the Adson maneuver and is differentiated by a subclavian arteriogram (Fig. 1.20), which shows blockage of the subclavian artery proximal to the origin of the vertebral artery.

Other entities to be included in differential diagnosis are cervical disc syndrome, cervical spondylosis, Pancoast tumor, carpal tunnel

syndrome, or entrapment of the ulnar nerve at the elbow or wrist. Conditions to be excluded are reflex sympathetic dystrophy, occlusions of the axillary and brachial artery or vein, and brachial neuritis.

Treatment

The first choice in management is a conservative program. Treatment goals for the three types of thoracic outlet syndrome are the same, i.e., increase the space of the thoracic outlet and lessen pressure on the neurovascular elements. The program includes correction of faulty posture and body mechanics; manual stretching to increase mobility of the neck, shoulder girdle, and first and second ribs; and a specific home program. At home, the patient performs deep diaphragmatic breathing for relaxation, cervical-dorsal glide to stretch the neck, and strengthening

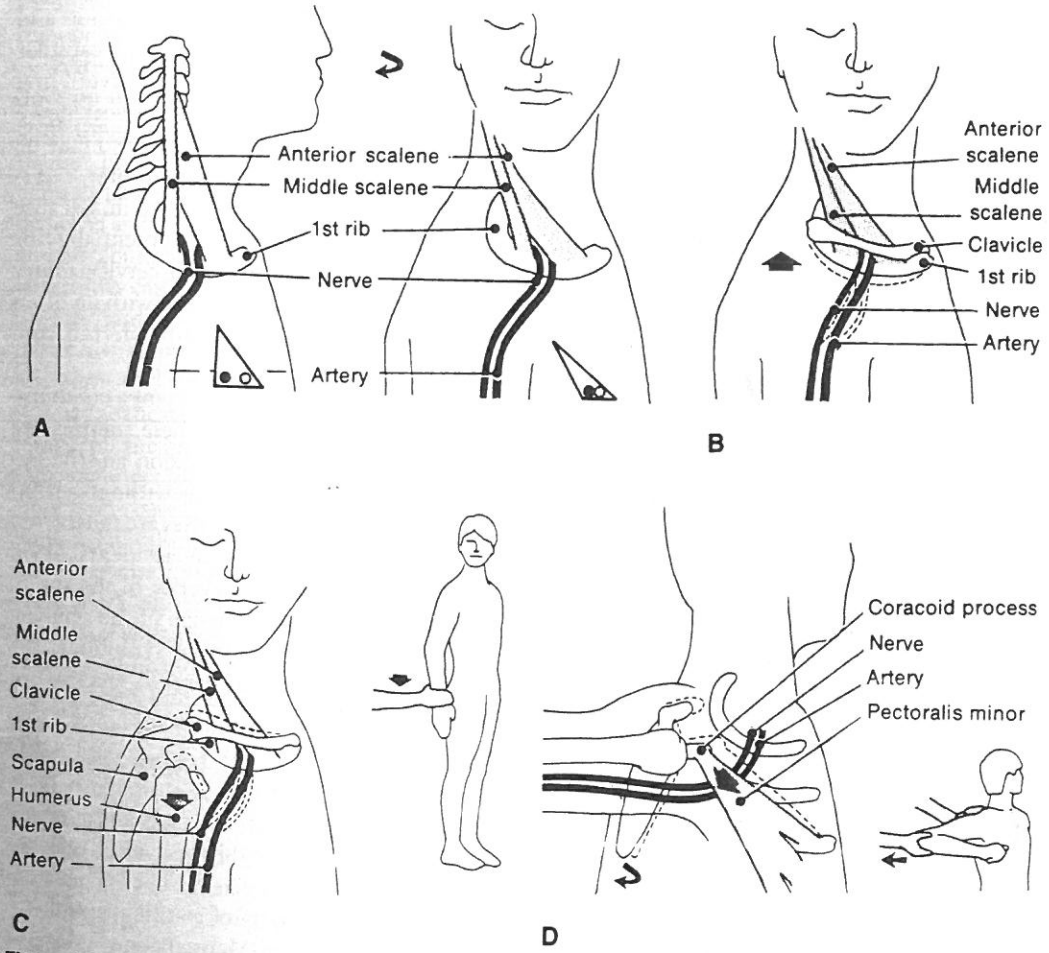

Figure 1.19. Mechanisms of the Adson maneuvers. *A*, rotation of the head and neck toward the affected side compresses the neurovascular structures between the anterior and middle scalene muscles. *B*, a full inspiration elevates the first rib, which thus stretches out the neurovascular structures and also further narrows their passage between the first rib and the middle and anterior scalene muscles. *C*, downward traction on the arm stretches out the neurovascular structures and also narrows their passage between the first rib and the clavicle. *D*, abduction and extension of the shoulder stretches out the neurovascular structures and retracts the scapula, thereby stretching the pectoralis minor tightly over the ribs, narrowing the neurovascular passage between the pectoralis minor and the ribs.

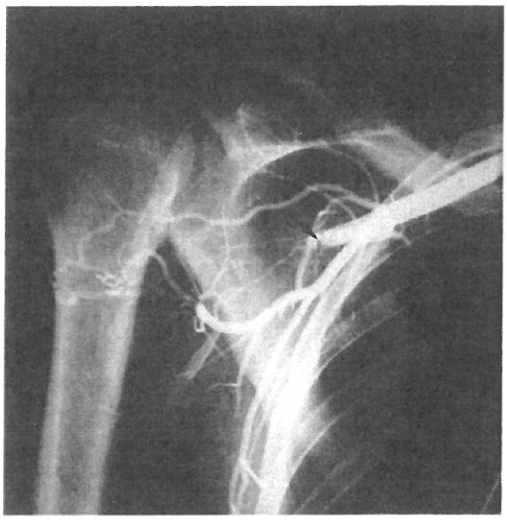

Figure 1.20. Selective subclavian arteriogram centered at the right shoulder in a 29-year-old professional baseball pitcher, demonstrating acute thrombosis of the axillary artery. Abrupt termination is seen at the proximal axillary artery (arrow) related to intimal injury created by repetitive trauma secondary to compression caused by throwing-related thoracic outlet syndrome.

exercises for the neck and shoulder girdle. The patient also must work to correct faulty sleeping or occupational habits. Patients must avoid slumped positions, round shoulders, and carrying heavy objects in the hands or over the shoulders. Patients must minimize over-head activity and support their arms when sitting. They are instructed to avoid over-exertion. Patients must avoid prone sleeping with the head rotated and extended and shoulders hyperextended or hyperabducted. Having a physical therapist manage the exercise and postural program may be beneficial.

Continuing conservative treatment is reasonable as long as the patient responds. If the signs and symptoms do not improve or if they increase, the patient should be referred to a surgeon for further evaluation and possible surgical intervention. This may involve resecting the constricting structure, e.g., the cervical rib and its fibrous attachments, a portion of the scalenus anterior and medius muscles, or the first rib.

TRAUMATIC CONDITIONS IN ADULTHOOD

CERVICAL SPRAINS AND STRAINS

The exact nature of injury to the cervical spine depends on many variables. The intensity of the injuring force, the degree of protective muscle tone at the time of impact, the underlying strength of the bone and soft tissue, the position of the head and neck at the time of impact, and the presence of a protective support are all significant. Injury may involve the muscular tissue, the anterior and posterior longitudinal ligaments, the capsular ligaments of the facet joints, the intervertebral disc, the bony elements, the cervical nerve roots, and the spinal cord. There also may be injury to the temporomandibular joint, cervical sympathetic chain, and brain stem. Because of the numerous structures potentially involved, the symptoms following cervical injury may be numerous and complex, with an often confusing pattern of localized, referred, and radicular pain.

Most cervical injuries represent a combination of sprain and strain. These injuries are usually the result of hyperflexion and/or hyperextension injuries with or without a rotational component. The injuries are most often sustained in motor vehicle accidents or in sporting activities. The severity of the sprain is determined by a knowledge of the injuring force applied, the severity of symptoms, the physical findings, and careful analysis of x-rays.

Clinical Characteristics

Most patients recall the mechanism of injury, describing it variably as hyperextension, hyperflexion, rotation, or a combination. There may be a history of transient confusion or unconsciousness. Many patients do not note immediate pain, but after several minutes or hours they begin to develop pain and a sense of tightness in the neck. Some patients also complain of nausea.

With mild injuries, initial physical examination usually reveals little in the way of

abnormal findings. There may be some tenderness or mild restriction of motion, but often there is no tenderness or significant limitation of motion. After several hours or days, however, findings are usually more significant. Muscle tenderness, swelling, and spasm may develop. The symptom complex may include pain referred to the interscapular area, shoulders, or upper extremities. The patient may sense vague numbness, tingling, or heaviness in a nonradicular pattern, or there may be true radicular numbness and muscle weakness. Headaches, dizziness, and visual disturbances may be noted.

With moderate injuries, radicular pain may develop into one or both extremities. Spinal cord injury produces a myelopathy, and the patient may complain of a deep, aching, ill-defined pain about the shoulder girdle and/or pelvis associated with a feeling of weakness and instability in the lower extremities. Nerve root injury causes a radicular pattern of motor, sensory, and reflex signs and symptoms. Injury to the disc complex may cause local and radicular signs and symptoms.

Diagnostic work-up should include routine x-rays of the cervical spine. Normal static x-rays support the diagnosis of a mild to moderate soft tissue injury without instability. Plain x-rays also rule out fracture or dislocation. It is important to evaluate the plain films carefully. X-ray demonstration of prevertebral soft tissue widening, particularly in the upper cervical spine, indicates significant injury with hemorrhage and edema. The prevertebral space anterior to C-1 in the normal adult should not exceed 10 mm; at the C-2/C-3 level it should not exceed 5 to 7 mm. The relationship between vertebral bodies must also be assessed. Any anterior or posterior translation greater than 3.5 mm indicates potentially significant soft tissue injury and instability. Any angulation between two vertebrae that is 11° greater than the angulation between adjacent vertebrae also indicates possible instability. It is also important to be aware of any sharp reversal in the normal cervical curve. For the patient who has had a significant injury, stress views (flexion, extension, and possibly traction) should be obtained if stability is at all uncertain.

Treatment of the Stable Cervical Sprain-Strain

The patient who has a neurologic deficit or evidence of an unstable cervical spine injury should be referred promptly for orthopaedic evaluation and treatment. Fortunately, most patients do not have an unstable injury. These patients are treated with rest in a position of comfort, which is maintained by a soft cervical collar, for 1 to 2 days. For patients with moderate or severe symptoms, bedrest may be necessary. After 3 to 5 days, pain usually lessens, and by 2 weeks, most patients have improved significantly. The soft cervical collar should be used symptomatically in the initial days after the injury. Subsequently, as symptoms resolve and healing occurs, the patient should be encouraged to wean out of the collar to avoid habitual use. Application of cold packs is usually more effective initially than heat. Cold packs are applied for 15 minutes, four to six times daily for the first 2 days. After this, moist heat may be used if symptomatically helpful. Analgesics and muscle relaxants may be used on a symptomatic basis and are helpful, particularly for nighttime pain and spasm that interfere with sleep.

As symptoms subside and healing occurs, exercises to gently stretch muscles and increase motion are encouraged within the limits of comfort. Early motion of a stable C-spine injury (proved by negative stress films) brings about a better result than prolonged immobilization. Gentle active range of motion and isometric exercises are recommended (Fig. 1.21). Isometric neck exercises are simple to perform and can be done independently. Exercises are first performed in the collar, which limits the range of motion. As long as the patient is pain free, the exercises should be performed for 5 minutes, three times a day. Should pain occur, the duration but not frequency of the exercises should be decreased. A physical therapist may be helpful in guiding the patient.

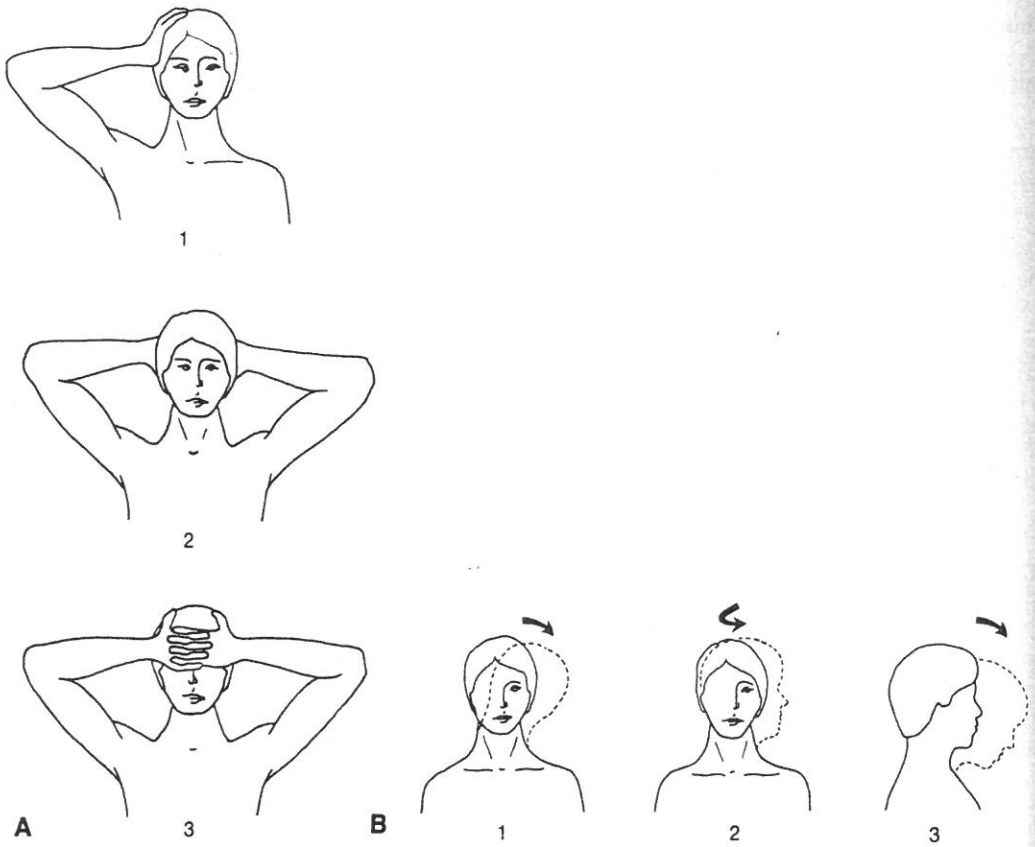

Figure 1.21. Exercises for cervical pain syndromes. *A*, isometric exercises. *1*, press head sideways against the heel of the hand (place the heel of the hand just above the ear), tense, relax, repeat. *2*, clasp hands behind head (over large bony prominence), tense head backward with chin tucked in, relax, repeat. *3*, press forehead against clasped hands, tense muscles without moving head, relax, repeat. *B*, range of motion exercises. Sit in a comfortable chair and take a moment to relax. Shrug shoulders in all directions, both together and alternately, until you relax. Shrug shoulders between exercises if you need to relax more. *1*, tip ear toward shoulder, turn to midposition, relax, tip to opposite side, relax, repeat. *2*, turn head and chin toward shoulder, return to midposition, relax, turn toward opposite shoulder, return to midposition, relax, repeat. *3*, tip head forward, return to erect position, relax, repeat.

After 2 to 3 weeks of gradual mobilization of the neck, the patient is weaned from the collar and the exercise program is expanded appropriately to include isotonic exercises. Once again, care is taken to avoid pain by not overtaxing the healing tissues.

Manipulative treatment is contraindicated in the acute phase of moderate sprain-strains since it may cause additional injury. Cervical halter traction (steady or intermittent) (Fig. 1.13), as described under "Acute Disc Herniation," may assist in mobilizing the spine in patients with stable injuries in the subacute or chronic phase who present with persistent cervical pain, stiffness, tenderness, and muscle atrophy. If traction produces more discomfort, it should be discontinued immediately.

If severe pain persists or symptoms progress after 1 week, the patient should be reevaluated, and repeat x-ray should be considered. If the patient does not improve, orthopaedic referral should be made.

Many patients with stable soft tissue neck injuries recover satisfactorily over a 4- to 6-week period, whereas a significant percentage continue to have varying degrees of symptoms several months or years after injury. As would be expected, patients with more severe

symptoms initially, x-ray abnormalities (including degenerative disease and sharp cervical curve reversal), and neurologic involvement have a poorer prognosis.

Treatment of the Unstable Cervical Sprain-Strain

These patients should be promptly placed under the care of an orthopaedic and/or neurosurgeon. The injuries frequently require surgical stabilization or prolonged bracing with a halo brace or halo cast apparatus. In the acute phase, the patient's cervical spine must be immobilized as described earlier in this chapter.

Burner's Syndrome

Burner's syndrome is a variant of the sprain-strain syndrome that occurs in athletes. A ballplayer complains of a transient burning pain in the neck, arm, and possibly hand following an injury that occurs while tackling or blocking an opponent, i.e., when the involved shoulder is depressed and the neck is bent to the opposite side on contact. This may produce injuries to the spinal cord, cervical roots, and supporting tissues of the neck and shoulder, and traction on elements of the brachial plexus. Variable degrees of pain, weakness, paresthesia, and sensory and reflex changes are noted on physical examination. Pain, tenderness, and limited motion of the cervical spine and, occasionally, the shoulder are present. This is treated as a moderate or severe cervical sprain-strain. Further evaluation is necessary to rule out fracture, dislocation, subluxation, and associated injuries to the cervical disc and root complex at the level of injury, and injury to the brachial plexus. The symptoms usually resolve within a few minutes, but the player should not resume play and should be evaluated by an orthopaedic surgeon.

CERVICAL FRACTURE, DISLOCATION, SUBLUXATION

As with soft tissue injury, the mechanisms of injury causing fracture and/or dislocation of the cervical spine include excessive flexion, extension, bending, rotation, compression, and distraction, alone or, more commonly, in some combination. A compressive force may produce a burst or explosion type fracture of the vertebral body, with ruptures of the anterior and/or posterior longitudinal ligaments. Extension forces produce fractures of the posterior bony elements, with disruption of the anterior longitudinal ligament. Flexion injuries disrupt the posterior longitudinal ligament and compress the vertebral bodies; there may be injury to the facet joint capsule and

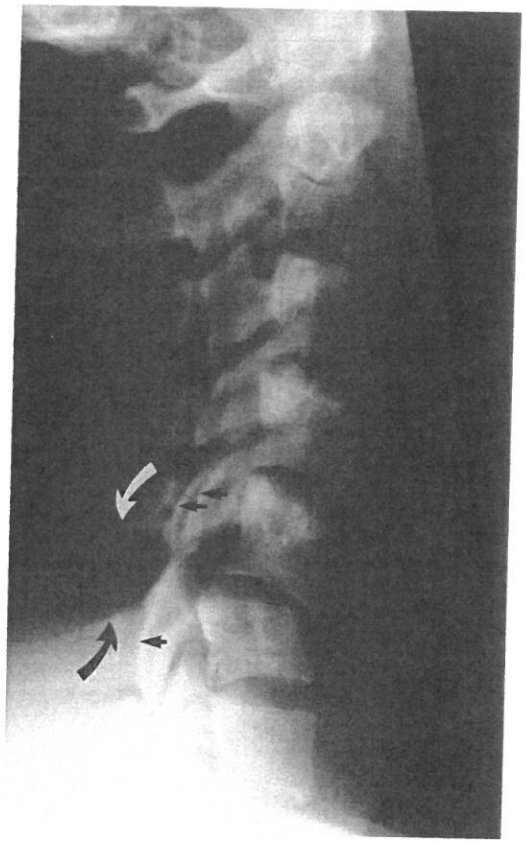

Figure 1.22. C5-C6 unilateral interfacetal malalignment in a 20-year-old male who dove into the shallow end of a swimming pool. There is anterior subluxation at C5-C6, which is approximately 25% of the AP diameter of C5 associated with abrupt kyphosis, anterior subluxation of the facet joints (arrows), and splaying of the spinous processes (curved arrows). Rotation is indicated by the abrupt loss of overlap of the lateral masses comparing C5 with C6 (short arrows).

intervertebral disc. Rotational injuries cause disruption of the ligaments, with fracture or dislocation of the facet joints. The vertebral body also may be injured. Injuries that are the result of a combination of forces tend to be more severe and more unstable.

The classification of a fracture-dislocation as stable or unstable is not always a simple judgement; however, the three-segment concept is helpful. As described previously (Fig. 1.10), if two of the three segments of the spine are disrupted, the fracture-dislocation is considered unstable. An unstable injury cannot withstand normal physiologic forces without abnormal deformity, and jeopardizes the underlying spinal cord and/or nerve roots. Such instability may be acute or chronic as a result of late bony deformity. It must also be noted that in the cervical spine, cord injury has been documented in the presence of what appears to be a stable fracture.

Whenever a fracture-dislocation of the cervical spine is noted, the primary care physician's role is to stabilize the spine until orthopaedic and/or neurosurgical care can be instituted. In addition, initial treatment of a patient with a documented spinal cord injury should include the administration of high-dose methylprednisolone. Recent studies indicate that a dose of methylprednisolone, 30 mg/kg of body weight, administered within 8 hours of injury has a positive effect on neurologic recovery. After this initial bolus, a dose of methylprednisolone, 5.4 mg/kg of body weight per hour, should be administered for 23 hours.

Following is a brief description of the common fractures and dislocations of the cervical spine.

Fractures of C-1 (atlas) are caused by axial loading that compresses and explodes the atlas; they are usually not associated with cord

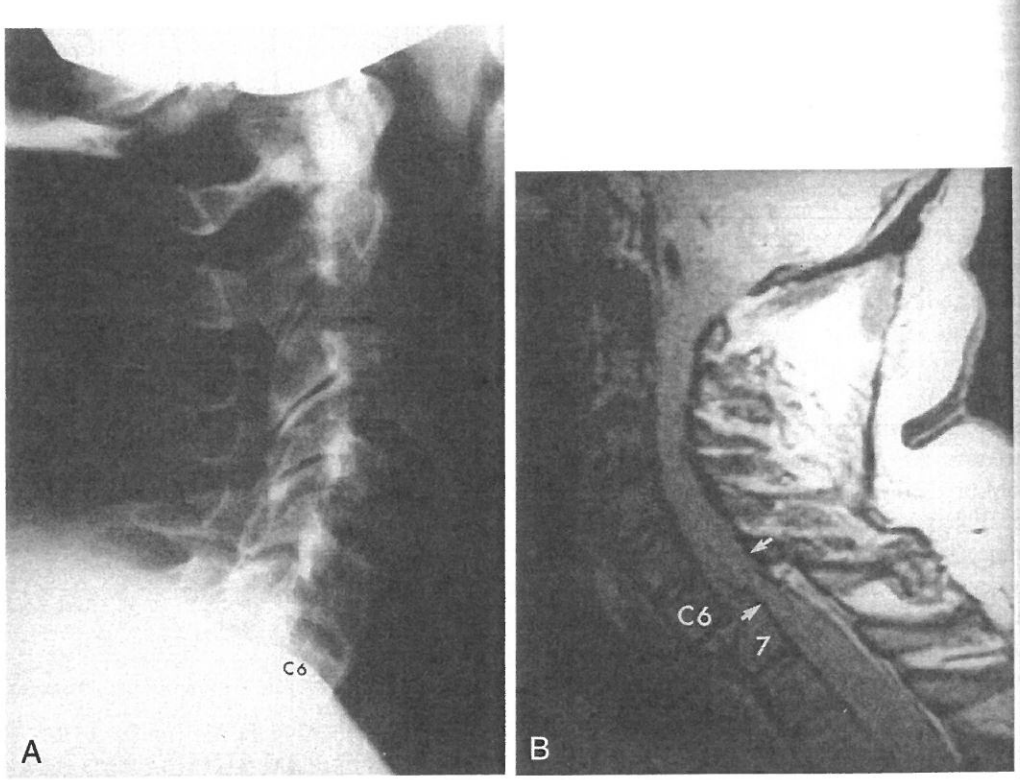

Figure 1.23. Fracture-dislocation at C6-C7 in a 39-year-old male involved in a motor vehicle accident. *A,* initial portable lateral that was interpreted as unremarkable is inadequate since visualization is seen only to the mid C6 level. *B,* sagittal MR proton density scan (TR 2000, TE 30) through the cervical spine demonstrates gross disruption at C6-C7 with marked encroachment upon the neural canal (arrows).

ation of the
primary care
e spine until
cal care can
al treatment
spinal cord
nistration of
Recent stud-
rednisolone,
tered within
ct on neuro-
bolus, a dose
kg of body
nistered for

of the com-
f the cervi-

sed by axial
plodes the
d with cord

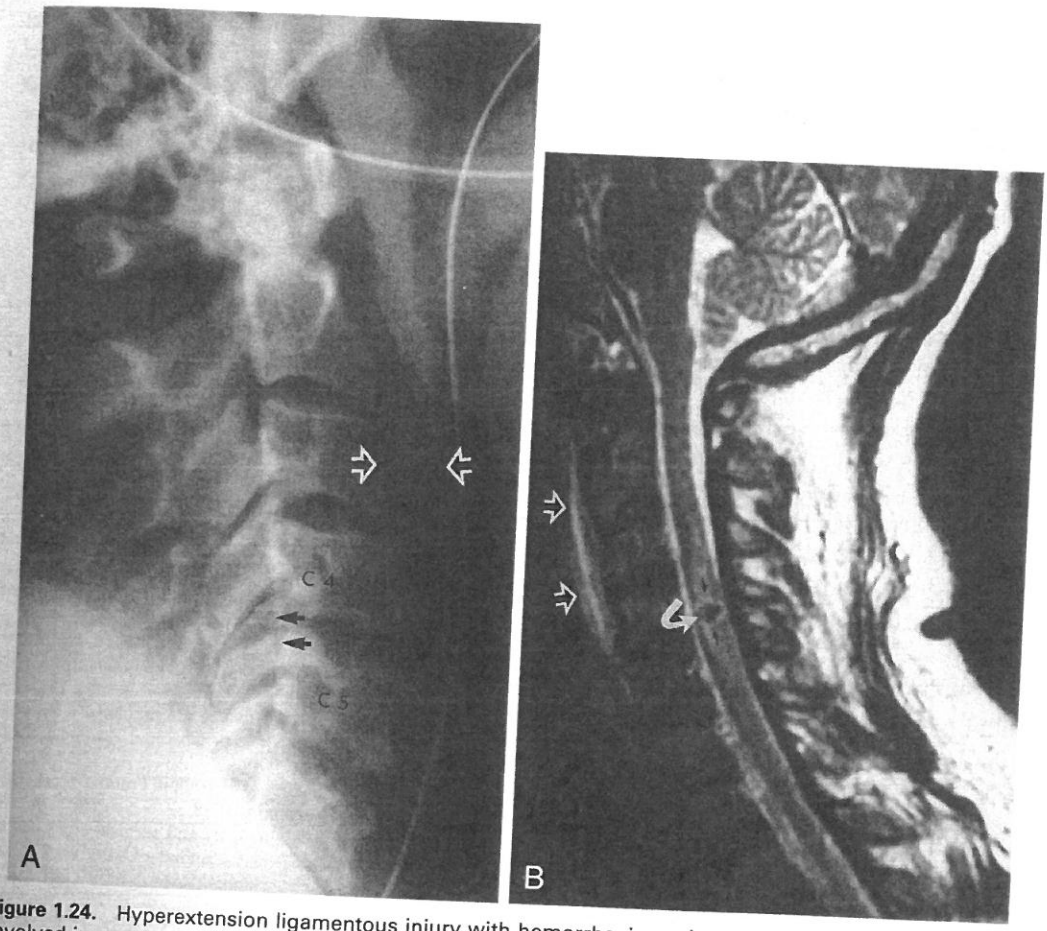

Figure 1.24. Hyperextension ligamentous injury with hemorrhagic cord contusion in a 39-year-old male involved in a motor vehicle accident. *A,* lateral view of the cervical spine shows subtle retrolisthesis at C4-C5 (solid arrow). *B,* sagittal MR T2-weighted (TR 2100, TE 112) shows bulbus enlargement of the cervical cord, centered at C4-C5, related to a broad area of cervical contusion manifested as high signal (white arrows). Focal area of low signal (curved arrow) indicates subacute hemorrhage and qualifies the cord contusion as a hemorrhagic contusion, which has a more ominous prognosis. Associated prevertebral hematoma shows high signal (open arrows).

ccident. A
seen only
bine
ows).

injuries. However, they are unstable and should be treated initially with a rigid neck brace. A neurosurgeon or orthopaedic surgeon should be consulted. Definitive treatment is usually with a halo jacket or halo vest for at least 8 weeks, followed by a cervical orthosis.

C-2 fractures usually involve fracture of the odontoid. The success rate for healing depends on the degree of displacement, the age of the patient, and the location of the fracture. Most of these injuries are treated with a halo body jacket, although some injuries with a poor prognosis should be stabilized immediately. Fractures associated with spinal cord injury at this level are often fatal.

In addition to fractures through the odontoid, C-2 fractures also may be through the pedicles. This is the so-called "hangman's" fracture. These injuries usually unite well when treated with a halo brace.

Fractures of C-3 through C-7 may involve all possible combinations of forces. One of the most severe is the injury caused by combined axial compression force with flexion. This is the common diving accident where the head strikes a solid object. This produces a comminuted fracture of the vertebral body with

retropulsion into the spinal canal and injury to the cord. Many of these patients need surgical stabilization.

The common dislocations of the cervical spine usually occur between C-3 and C-7 (Fig. 1.22). These involve unilateral or bilateral facet dislocations. The injury is indicated on the lateral cervical spine x-ray by varying degrees of displacement of the superior vertebra anteriorly on the adjoining inferior vertebra. In unilateral facet dislocation, there is approximately a 25% anterior listhesis of the superior on inferior vertebra. In bilateral dislocation, this is usually in the 50% range. In addition to the listhesis, careful review of the x-ray shows the abnormal relationship of the facet joints (Fig. 1.23). An MRI is useful to define cord injury (Fig. 1.24).

Occipital/C-1 dislocations are rare and almost always fatal. If the patient does not die as a result of his injury, halo immobilization is indicated, followed by surgical stabilization.

C-1/C-2 dislocations or subluxations may occur with or without odontoid fracture. One type of C-1/C-2 dislocation is the "adult rotatory subluxation of the atlantoaxial joint," which presents with the same characteristics as the childhood variant but is related to significant injury. This injury occurs when a rotational force is applied to the head, causing the inferior facet of C-1 to slip forward on the superior facet of C-2. If the articulation becomes fixed in this position, there is marked limitation of motion, and a painful post-traumatic torticollis develops. Neurologic deficits often occur. X-rays demonstrate an asymmetry in the position of the odontoid. The odontoid is deviated to one side and remains deviated (i.e., fixed subluxation), even with rotation of the head and repeat x-ray. CT scan is helpful in evaluating this.

INJURY TO THE CERVICAL DISC

Acute cervical disc injuries occur in decreasing frequency between units C-5/C-6, C-6/C-7, and C-7/T-1 (Fig. 1.1). Injury to the disc–annular ligament–posterior ligament complex may result in protrusion or herniation of the nucleus pulposus, with subsequent radicular pain patterns, depending on the level of injury. Mechanisms of injury are similar to those producing fracture, dislocation, or subluxation. Clinical features and treatment are described in the section "Acute Disc Herniation."

SUGGESTED READINGS

Anderson JE. Grant's Atlas of Anatomy. 8th ed. Baltimore: Williams and Wilkins, 1983.

Bracken MB, Shepard MJ, Collins WF, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal-cord injury. N Engl J Med 1990;322(20):1405–1411.

Bracken MB, Shepard MJ, Holford TR, et al. Administration of methylprednisolone for 24 or 48 hours or tirilazad mesylate for 48 hours in the treatment of acute spinal cord injury. Results of the Third National Acute Spinal Cord Injury Randomized Controlled Trial. JAMA 1997; 277:1597–1604.

Cervical Spine Research Society Editorial Committee. The Cervical Spine. 2nd ed. Philadelphia: JB Lippincott Co., 1989.

Committee on Trauma. Advanced Trauma Life Support Course Instructor Manual. Chicago: American College of Surgeons, 1990.

Daffner RH, ed. Imaging of Vertebral Trauma. Rockville, MD: Aspen Publishers, 1988.

Edmonson AS. Spinal anatomy and surgical approaches. In: Crenshaw AH, ed. Campbell's Operative Orthopaedics. 8th ed. St. Louis: Mosby Yearbook, 1991.

Evarts C McC, Mayer PJ. Complications. In: Rockwood CA Jr, Green DP, Bucholz RW, eds. Fractures in adults. 3rd ed. Philadelphia: JB Lippincott Co., 1991.

Freeman BL III. Fractures, dislocations, and fracture-dislocations of spine. In: Crenshaw AH, ed. Campbell's Operative Orthopaedics. 8th ed. St. Louis: The Mosby Yearbook, 1991.

Grant JCB, Basmajian JV. Grant's Method of Anatomy by Regions, Descriptive and Deductive. 8th ed. Baltimore: Williams and Wilkins, 1971.

Harris JH Jr, Mirvis SE, eds. The radiology of acute cervical spine trauma. 3rd ed. Baltimore: Williams and Wilkins, 1996.

Hollinshead WH. Anatomy for Surgeons, Vol 3: The Back and Limbs. 2nd ed. New York: Harper and Row, 1969.

Hoppenfeld S. Physical Examination of the Spine and Extremities. Norwalk, CT: Appleton-Century-Crofts, 1976:105–132.

Iverson LD, Swiontkowski MF. Manual of Acute Orthopaedic Therapeutics. 4th ed. Boston: Little, Brown and Co., 1994.

Keats TE. Atlas of Normal Roentgen Variants That May Simulate Disease. 6th ed. St. Louis: Mosby, 1996.

Novelline RA, ed. Squire's Fundamentals of Radiology. 5th ed. Cambridge, MA: Harvard University Press, 1997.

Pappas AM. Muscles, joints, and ligaments. In: South-