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CHAPTER 5

Thoracic and Lumbar Spine

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Spinal disorders, especially low back pain, are endemic to modern industrialized society. Spine fractures can lead to significant morbidity and mortality. Tumors, both primary and metastatic to the spine, often contribute to the suffering and debilitation of patients with cancer. Metabolic and degenerative disorders cause problems in a large number of patients. After colds, low back pain is the next most frequent reason for patients to visit a primary care physician. Thus, familiarity with the evaluation, diagnosis, and initial management of problems in the thoracolumbar spine is crucial for those in the front lines of medical care.

This chapter includes a brief description of the anatomy and biomechanics of the spine. An algorithmic approach to the history taking, physical examination, and laboratory evaluation is included. Also included is a detailed summary of the presentation, diagnosis, and treatment of the more common back disorders with a discussion of conventional and alternative treatments of low back pain. Hopefully, the reader will be more comfortable when confronted with a Monday morning office full of patients with low back pain.

Anatomy

The spine consists of a series of bones (the vertebrae) joined together by discs anteriorly and facet joints postero-laterally. These are held together by sets of ligaments and moved by muscles attached by tendons. The vertebral column protects and surrounds the spinal cord, which gives off segmental branches called nerve roots. These nerve roots then exit the spinal canal via neuroforamina to innervate the chest wall, abdominal cavity, extremities, and perineum. Two adjacent vertebrae with their surrounding structures and intervening disc are commonly referred to as the functional spinal unit.

The thoracic spine is curved in the sagittal plane with its apex posteriorly, forming a kyphosis. The thoracolumbar junction is ordinarily straight in both the anteroposterior (AP) and sagittal (lateral) planes, and the lumbar spine is normally curved with its apex anteriorly into lordosis. This combination of kyphosis and lordosis allows the center of gravity line to fall close to the spine, minimizing the energy expended in maintaining an upright position. These curves are not genetically programmed but are developmental because they are acquired during growth. Paralyzed infants who never sit do not develop a normal thoracic kyphosis or lumbar lordosis. Any curvature in the coronal plane is considered abnormal and is called scoliosis.

VERTEBRAL BODIES

Each spinal vertebra is morphologically similar to the one above and below, with subtle differences. They become progressively larger from the upper thoracic to the lower lumbar spine as well as broader and taller. Each vertebra is composed of the vertebral body anteriorly, which bears approximately 90% of the applied load. The vertebral bodies are convex anteriorly (Fig. 5.1) and concave posteriorly to allow room for the spinal cord and dura. The outer shell of the vertebra is thin cortical bone called endplates, which are at the superior and inferior sides in contact with the discs.

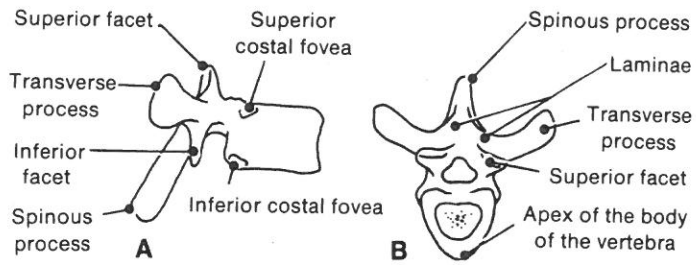

Figure 5.1. *A* and *B*, a thoracic vertebra. Lateral and superior views.

These endplates supply nutrition to the disc via diffusion, as the discs are avascular in adults. The inner part of the vertebra is filled with cancellous (trabecular) bone into which the bone marrow is packed. In adults, most hematopoietic marrow is located in the spine and pelvis. Thus, disorders of marrow cells, such as myeloma or lymphoma, will affect the vertebral bodies preferentially more than the appendicular skeleton.

The vertebral body is connected to the posterior elements by paired pedicles attached at its superior-posterior aspect. Each pedicle expands into four processes: the transverse process laterally for muscle attachments, the superior articular process for the facet joint with the next superior vertebra, the lamina for protection of the spinal cord, and the larger inferior articular process for the facet joint with the next inferior vertebra. The junction of the pedicle with the inferior articular process is also called the pars interarticularis and is the weakest part of the vertebra. The weakness of the pars becomes important in the conditions called spondylolysis and spondylolisthesis (discussed later in this chapter). Collectively, these bony elements from the pedicles on backwards are termed the posterior elements.

Thoracic vertebrae (T1-T12) differ from lumbar vertebrae in that they also serve as attachments for the ribs (Fig. 5.1). On the posterolateral corner of each thoracic vertebrae are joint surfaces called fovea. Each rib articulates with the superior fovea of one vertebra and the inferior fovea of the vertebra above. These paired costovertebral joints act as hinges for the ribs to move up and down during respiration.

The lumbar vertebrae (L1-L5) are larger than the thoracic vertebrae and more mobile because of the lack of support from the rib cage (Fig. 5.1). However, because L5 and, to a lesser extent, L4 sit down in and are attached to the pelvis by strong iliolumbar ligaments, they are relatively immobile. Maximal spinal motion occurs in the mid and upper lumbar spine (L1-L3) and especially at the thoracolumbar junction (T12-L1).

The sacrum (Fig. 5.2) consists of five fused vertebrae at the bottom of the spine. It acts as the keystone in the pelvis, transferring weight laterally from the spine through the immobile sacroiliac joints into the pelvis. At the inferior tip of the sacrum lies the coccyx, a vestigial tailbone. A true diarthrodial joint exists between the sacrum and coccyx that may be injured in falls on the buttocks or during childbirth. Painful disorders of the coccyx are referred to as coccydynia.

JOINTS

Each vertebra is connected to the next adjacent vertebra by three joints: two paired facet joints and one intervertebral disc. Each facet is composed of the inferior articular process from the upper vertebra joining with the superior articular process of the lower vertebra. These are true diarthrodial joints complete with facet capsules, synovial membrane, and fluid and articular hyaline cartilage. Ordinarily, the right and left facet joints are mirror images of each other. Because they are true joints, they may be affected by any disease process, either local or systemic, which affects articular cartilage. These joints are

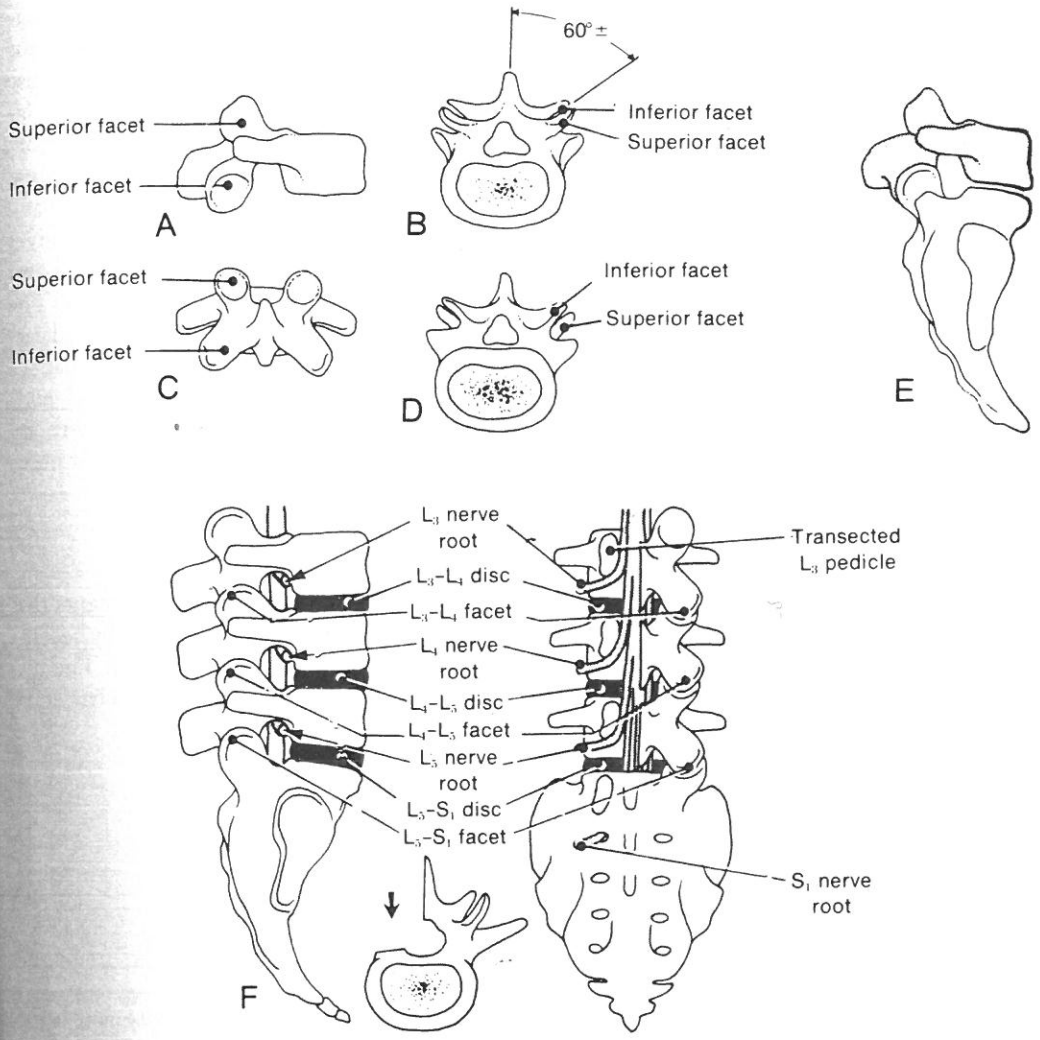

Figure 5.2. The lumbosacral spine. *A* and *B*, the 5th lumbar vertebra. Lateral and superior views. *C* and *D*, the 5th lumbar vertebra. Posterior and inferior views. *E*, the 5th lumbar vertebra, in articulation with the sacrum. *F*, the relationship of nerve roots to discs and the facet joints.

innervated by branches of the sinuvertebral nerve.

Thoracic facet joints are oriented in a sagittal direction so that flexion and extension as well as limited lateral bending are possible. The rib articulations provide some constraint to this motion so that the thoracic spine moves less and is more rigid than the cervical or lumbar spine.

Upper lumbar facet joints are similar to those in the thoracic spine. There is a gradual change from a sagittal orientation to a more coronal and transverse orientation through the lumbar spine so that lateral bending is increased as well as flexion and extension. Almost no rotation is possible, because the facet joints are mirror images of each other. The lumbosacral, or L5-S1 facet joint is a strong articulation, and because it is oriented at approximately 45° to the horizontal in both planes, it resists the large shear force generated by the lumbar lordosis.

INTERVERTEBRAL DISC

The third articulation between adjacent vertebrae is the intervertebral disc. This arises embryonically as the notochord around which the somites form; when persisting into adulthood, the intervertebral disc occasionally gives rise to midline tumors called chordomas. The disc is composed of an outer anulus fibrosus and an inner nucleus pulposus. The anulus consists primarily of type I collagen elaborated by fibroblasts and is structured as an interlocking series of circumferential layers that resist shear, distraction, and bursting forces generated in the nucleus. Only the outer third of the anulus is innervated. Unfortunately, the anulus weakens as it ages and is prone to tearing during twisting injuries.

The nucleus is composed primarily of type II collagen similar to articular cartilage, embedded in a matrix of proteoglycan and adsorbed water. Discs in children are approximately 80% water. This percentage decreases with age to approximately 30% in elderly patients. This age-related dehydration is commonly observed in MRI scans as a dark disc on T2 weighted images and is commonly labeled by the radiologist as disc degeneration, despite being a normal phenomenon of aging. The combination of collagen for strength and water and proteoglycan for cushioning gives the disc unique properties of limited compressibility, load bearing, and motion. The matrix is actively elaborated by embedded cartilage cells, which obtain nutrition by passive diffusion from the adjacent vertebral endplates but function anaerobically. There are no blood vessels, lymphatic channels, or nerve fibers in the nucleus.

LIGAMENTS

All bones are connected by ligaments that function to limit excursion of joints by becoming tight at the extremes of motion. The primary stabilizers of the thoracolumbar spine

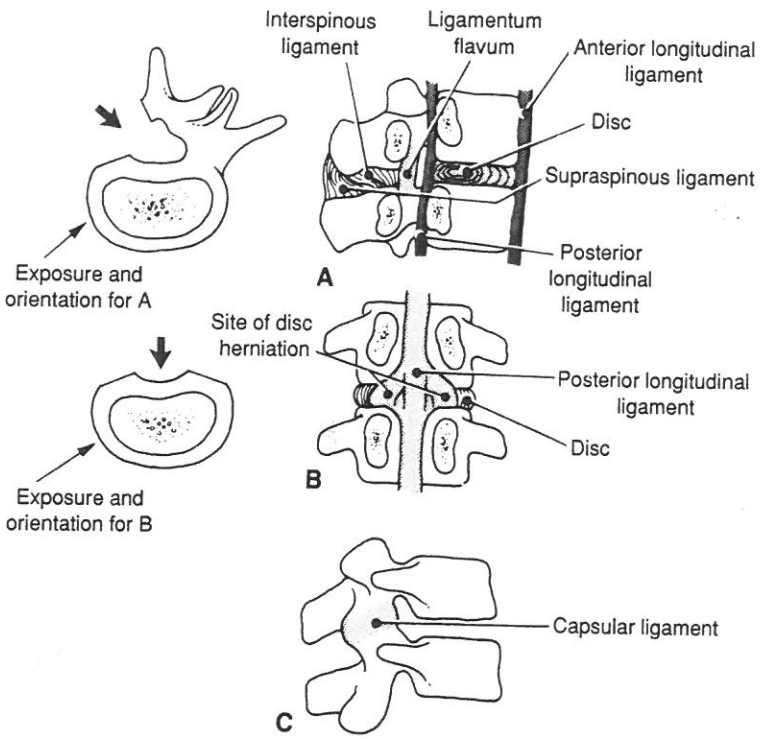

Figure 5.3. *A–C,* ligaments and discs of the dorsolumbar spine.

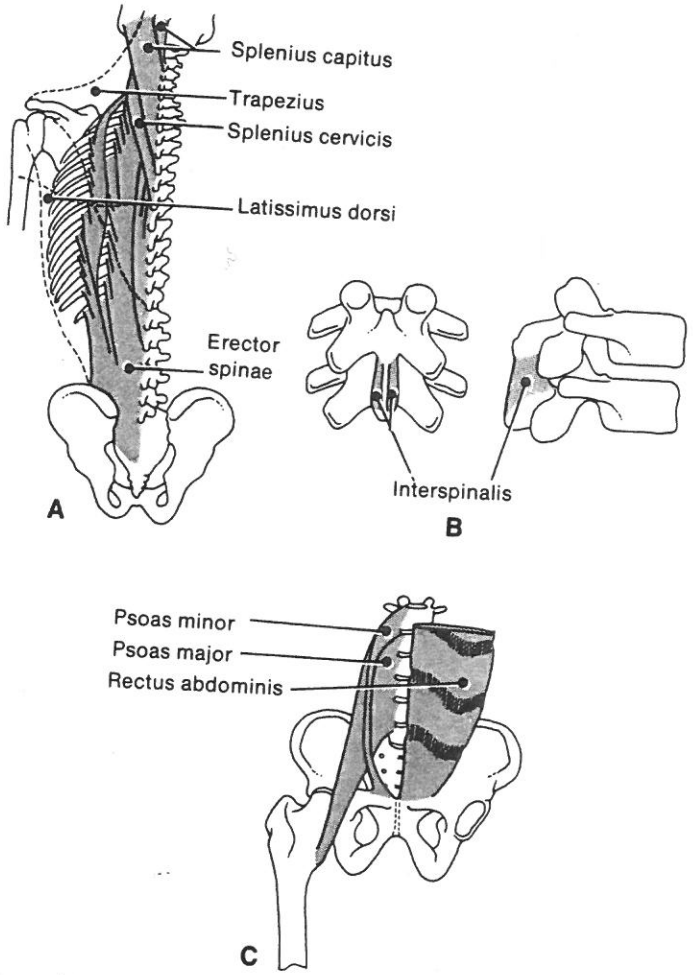

Figure 5.4. Musculature of the back. *A*, splenius and erector spinae muscle groups. *B*, interspinalis, posterior and lateral views. *C*, flexors of the lumbosacral spine.

are the anterior longitudinal ligament, which is anterior to the spine, the posterior longitudinal ligament posterior to the vertebral body, and the interspinous ligaments between the spinous processes and the facet capsules (Fig. 5.3). The posterior longitudinal ligament and interspinous ligament limit flexion (forward bending) of the spine while the anterior longitudinal ligament resists excessive extension (backwards bending). The facet capsules resist lateral bending. Also important is the ligamentum flavum that protects the spinal contents posteriorly and is the most elastic structure in the body. Overgrowth of this ligament results in spinal stenosis.

MUSCLES

Four basic sets of muscles are attached to the thoracolumbar spine (Fig. 5.4). Posteriorly, the most superficial layer includes the latissimus dorsi, trapezius, rhomboids, and levator scapulae, which function to move or stabilize the upper extremity. The intrinsic muscles of the spine are deep to this layer and are comprised of the erector spinae, interspinalis, and transversalis muscles. These are attached in various combinations from one of the posterior elements to another, and function to extend, rotate, and laterally bend the spine. Continuous and coordinated activity of these

muscles balances the spine during sitting or standing. Spasms of these muscles can be painful and cause an involuntary list or bend of the spine in the direction of the spasm.

The third set of muscles, the psoas major and minor, attach to the anterior aspect of the lumbar vertebral bodies and function as hip flexors if the spine is stabilized, or as spine flexors if the hips are held immobile. Infection and tumors in the vertebral bodies may travel along the psoas muscles to the anterior thigh. The final set of muscles is the abdominal wall, composed of the rectus abdominis, the external oblique, internal oblique, and transversus abdominis. These counterbalance the extension force of the posterior intrinsic muscles but are often overlooked as part of the spine.

The different sets of muscles act in concert to balance the spine just as the guide wires of a tent support the central pole by pulling down. Thus, a muscle spasm will deviate the spine in the direction of pull of the particular muscle, whether lateral tilt, rotation, flexion or extension. Similarly, a significant difference in strength or flexibility of opposing muscle groups may result in abnormal posture or excessive muscle fatigue or weakness.

NERVOUS STRUCTURES

The spinal cord conducts nerve impulses from the periphery to the brain (sensory afferents) and from the brain to the periphery (motor efferents). This is a two synaptic relay system. Interruption of the relay between the primary (brain) and secondary (spinal cord) neurons results in loss of inhibition, leading to hyperexcitability, hyperreflexia, and clonus. Interruption of the secondary neurons (peripheral nerves) results in flaccid paralysis and areflexia.

The spinal cord gives off segmental nerves that form predictable patterns of innervation (peripheral nerves) in the appendicular skeleton, although there may be minor variations in individual patients. The thoracic nerve roots innervate the intercostal muscles after exiting the spinal canal under the pedicles. They are primarily sensory in a dermatomal pattern with T4 at nipple level, T10 around the umbilicus, and L1 at the groin.

The lumbar nerve roots are involved in the innervation of the legs (Fig. 5.5). L2 through L4 combine in the midsubstance of the psoas muscles into the femoral plexus, which travels anteriorly into the pelvis to end as the femoral nerve. Portions of L4 as well as L5, S1, and S2 combine into the sciatic nerve anterior to the sacroiliac joint. The dermatomes in the legs wrap around laterally to medially so that L3 innervates the medial thigh, L4 the medial knee, L5 the anterior calf and dorsal foot, and S1 the posterior calf and sole of foot. Motor

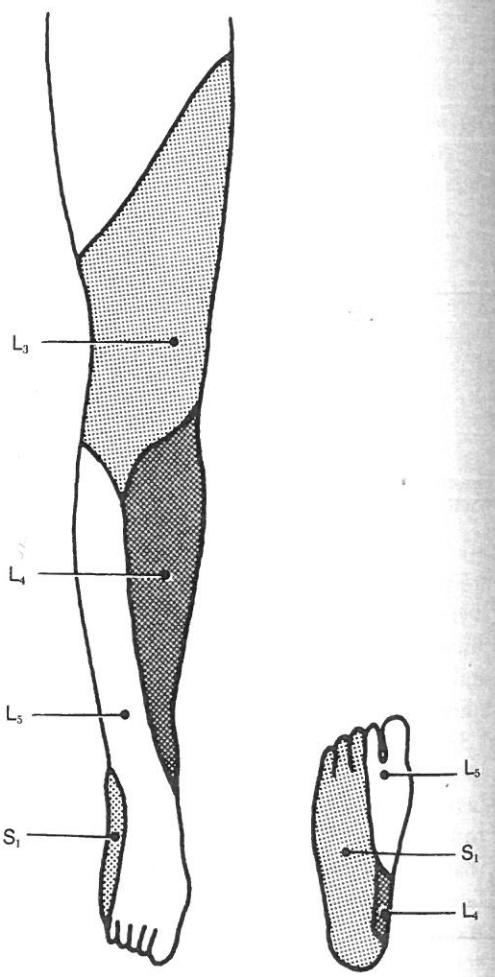

Figure 5.5. Sensory distribution of nerve roots, L-3 through S-1.

function is usually L3 and L4 to the hip flexors, L4 and L5 knee extensors, L5 foot dorsiflexors and S1 foot plantar flexors. The knee reflex is primarily L4, and the ankle reflex primarily S1. The remaining sacral nerve roots, S2 through S4, innervate the perineum, including perirectal and vaginal sensation, and control rectal and urethral sphincter tone.

The spinal cord ends at L1-L2 in 90% of people. Thus, lesions located in the spinal canal above L1 will affect the spinal cord, resulting in upper motor neuron lesions and hyperexcitability, whereas lesions below L1 will cause lower motor neuron symptoms such as paralysis and hyporeflexia.

The motor branch leaves the spinal cord as the ventral ramus, joins the dorsal ramus laterally in the spinal canal, and proceeds out the neural foramen as the peripheral nerve. The sensory ganglion where the sensory nerve cell nucleus lies is normally located in the neural foramen. After exiting the foramen, the nerve root gives off a sensory branch called the sinuvertebral nerve, which innervates the structures around the vertebral column: dura, facet joints, ligaments, and most importantly the outer third of the annulus of the disc. Because the sinuvertebral nerve innervates so many structures around the spine itself, pathologic lesions are often difficult to localize to any specific structure in the spine.

As the nerve root enters the foramen, it is bordered superiorly by the pedicle of the same number (i.e., L4 nerve root under L4 pedicle), posteriorly by the superior articular facet of the next lower vertebra, anteriorly by the posterior vertebral body, and inferiorly by an empty space. It reaches the level of the next lower disc far laterally, outside the foramen. Thus, the L4 nerve root will not be affected by an L4-L5 disc herniation unless in the far lateral position. Instead, a particular disc herniation will affect the next lower nerve root as it exits the spinal canal before the foramen.

VASCULAR SUPPLY

The arterial supply to the spine and associated structures comes as direct branches of the aorta and iliac arteries. In the thoracic spine, the segmental vessels from the aorta branch posteriorly at the level of the midvertebral body. Secondary branches then divide to supply the vertebral body, muscles, facet joints, and adjacent structures. A terminal branch joins the nerve root just lateral to the foramen and travels with this nerve root as the subcostal artery under the ribs. Unfortunately, the blood supply to the thoracic spinal cord is tenuous. Usually, only one or two of the segmental vessels send a significant branch to the spinal cord along the nerve root to anastomose with the anterior spinal artery that runs up and down along the entire length of the cord. This major blood supply to the cord enters between T4 and T10, usually on the right side as the artery of Adamkiewicz. This artery is neither large nor consistent in location. Thus, there is a significant risk of ischemic infarction of the cord during manipulation of or surgery on the thoracic spine.

In the lumbar spine, there is less need for vascular input to the cord as it ends at L1-L2, becoming the cauda equina. Because there are only peripheral nerves involved, the risk of vascular injury is much less. Aside from the branching of the aorta into iliac arteries at L4, the segmental supply to surrounding structures is the same as in the thoracic spine. The venous drainage of the spine is profuse. There is a large network of veins in the epidural space called Batson's plexus, which drains the vertebral bodies, dural space, muscles, facet joints, and segmental nerve roots. This receives tributaries from the pelvis and abdominal cavity in the lumbar spine and thoracic cavity in the thoracic spine. Significantly, these venous channels lack valves. Cancer cells may lodge in these valveless venous sinuses and, because flow is sluggish, become lodged as metastatic implants. Thus, tumors or infections in the genitourinary, gastrointestinal, or respiratory tracts can enter the spine hematogenously and produce foci of metastases or infection easily. This is why metastases to the spine are so common in patients dying of malignant tumors.

The lymphatic drainage is via the thoracic duct.

BIOMECHANICS

The spine has four purposes. Primarily, it supports body weight along with anything carried above the level involved. Evolutionary development of the backbone allowed vertebrates to resist gravity, ultimately culminating in the human's upright posture. To maintain this posture, the spine is balanced by a cervical lordosis for straight-ahead vision, a thoracic kyphosis for posture, and a lumbar lordosis for balance over the feet in bipedal locomotion. Although these curvatures are developmental, growth eventually imprints these curves into the bony anatomy of the spine, altering the shape of the vertebral bodies accordingly. Posture is maintained by the balance of the spinal muscles, primarily the abdominals for anterior support, and the long and short intrinsics muscles posteriorly. By maintaining a relatively constant tension, these muscles hold the spine upright. Excessive contraction of one set of muscles will pull the spine toward that side, as often occurs with muscle spasms after an injury. Similarly, chronic shortening or contraction of a muscle may cause an imbalance in posture.

The spinal curvature and the location of the center of gravity just anterior to the spine results in a compression side (the vertebral bodies anteriorly) and a tension side (the posterior ligament complex). Thus, 90% of weight is born by the vertebral bodies and discs anteriorly, while 10% is transmitted through the facet joints. Failure of either the compression side or the tension side may result in catastrophic spinal instability.

A second purpose of the spinal column is protection of the spinal cord and nerve roots. This is accomplished posteriorly by the strong lamina and spinous process and anteriorly by the large vertebral bodies that are resistant to compressive loading. However, this resistance decreases with metabolic, neoplastic, or infectious insults, which decrease bone mass and resistance to compression and thus may lead to spinal cord or nerve root compromise.

A third function of the spine is as an attachment point for muscles and ligaments responsible for moving the upper and lower extremities. Similarly, if the extremities remain fixed, these appendicular muscles help to move the spine.

The final function is as the primary site for hematopoietic marrow in the adult. In children, most of the skeleton as well as liver and spleen produce blood cells. In adults, these areas shrink to include only the pelvis and spine. Any process that produces diffuse involvement of the bone marrow in the spine (such as myeloma) may result in anemia, leukopenia, and thrombocytopenia, as well as problems in the vertebrae.

EVALUATION OF PATIENTS WITH BACK PAIN

When confronted with an office full of patients on a Monday morning and the first three chief complaints are low back pain, it is tempting to cut corners and proceed directly to an x-ray or MRI. Unfortunately, these and other tests do not always correlate with specific symptoms or disease processes. Thus, the history and physical examination are still crucial to developing the differential diagnosis. Laboratory tests may confirm a clinical suspicion but should never be relied on as the primary diagnostic modality.

HISTORY

The history begins with the chief complaint, usually back pain. Rarely, a deformity or neurologic symptoms may be the presenting complaint. The onset of pain is particularly important, especially whether it was traumatic and sudden or gradual and insidious. Frequently, patients associate the onset of pain with a particular event even though they may not be causally related. If there was trauma, the issue of compensation or litigation may arise (see below), explaining the need of some

patients to blame their problems on a particular compensable event.

Since the onset of the pain, has the pain changed appreciably, and if so, how? Worsening pain should prompt the clinician to be more aggressive with the workup, whereas improving symptoms usually connote a benign or self-limited process. Is the pain continuous or episodic? Constant pain is worrisome. If the pain is changing, what makes it better and what makes it worse? Is the pain different at different times? Mechanical low back pain usually is better at night and while lying down, whereas malignancies, infection, or other serious disorders are often unaffected by posture and are usually worse at night. The pain of herniated discs is worse while sitting and better walking, whereas the symptoms of spinal stenosis are aggravated by being upright and walking and improved when sitting.

It is useful to categorize the pain into one of four types based on location: local (confined to the low back), referred (buttocks and posterior thigh), radicular (following the course of a nerve such as T10 towards the umbilicus or L5 to the big toe), and spasmodic (shooting up and down the spine, secondary to a local muscle spasm or cramp in the back). The character of the pain is often helpful. Sharp stabbing or knifelike pain is usually indicative of a muscle spasm, whereas burning or throbbing may be caused by nerve irritation or compression. Any associated numbness, tingling, paresthesias, loss of muscle control, or other neurologic symptoms should be ascertained. Prior treatments and their efficacy are important to determine, because pain that has not responded to two physical therapy courses carries a bad prognosis for recovery, regardless of the etiology. Does the pain change with Valsalva maneuvers such as coughing, sneezing, or straining? A positive response often indicates nerve root or spinal cord involvement, because Valsalva maneuvers increase the pressure on the nerves via the epidural venous plexus.

Finally, other complaints such as weight loss, fevers, chills, anorexia, nausea, vomiting, and other systemic symptoms should be elicited along with relevant medical and surgical histories, medications, and allergies. Positive response to these questions may indicate spinal involvement by more generalized diseases.

There are a series of positive responses, or red flags, in the history that should alert the clinician to the possibility of a serious condition. Night pain, especially that which forces the patient to arise or pace, is often a warning sign of infection or malignancy. Morning stiffness that improves with exercise often indicates a rheumatologic etiology such as ankylosing spondylitis, Reiter's syndrome, or Lyme disease. Obviously, weight loss or malaise may indicate malignancy, and spiking fevers can be associated with infection. Finally, neurologic symptoms such as sciatica (pain radiating down the back of the thigh to below the knee) are associated with nerve root involvement, whereas bilateral nerve symptoms or loss of sphincter control may indicate cauda equina or spinal cord involvement.

PAIN DIAGRAMS (FIG. 5.6)

Pain diagrams are extremely helpful in identifying patients with functional overlay or nonorganic complaints. While in the waiting area, patients are given a blank body diagram (Fig. 5.6) with instructions to mark all areas of pain, numbness, tingling, or other abnormal sensations on the figure. Patients with organic mechanical low back pain will mark their low back, buttocks, or upper thighs. Radicular pain will have marks following the course of the particular nerve root affected such as anterior thigh for L4 or posterior calf and foot for S1. Occasionally, the patient will draw a face or hair on the blank figure, which indicates a positive self image.

On the other hand, patients with functional overlay (formerly called malingering) or significant psychologic components to their back pain will often label areas outside their body as painful, which is clearly impossible. Occasionally, sharp objects are drawn impaling a part of the body, or blood dripping from an area without wounds. These and other bizarre images are nonorganic manifestations and

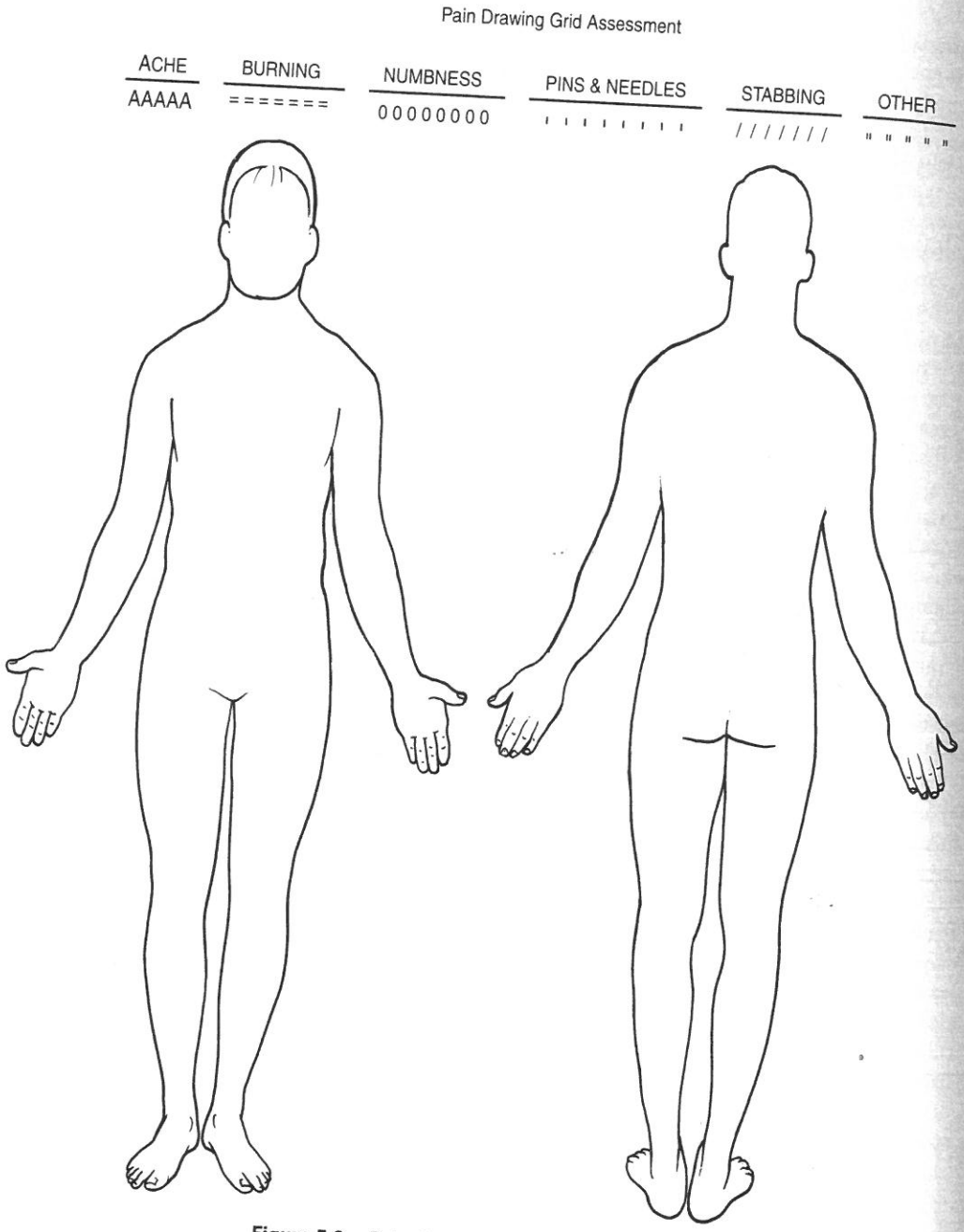

Figure 5.6. Pain drawing grid assessment.

point to an unhappy, poorly adjusted or hostile patient.

Other objective measures, such as the Oswestry pain score, the North American Spine Society (NASS) functional pain questionnaire, or the Minnesota Multiphasic Personality Inventory (MMPI), may give more objective detail about the patient's subjective complaints of pain but are beyond the scope of this chapter.

PHYSICAL EXAMINATION

The patient should be undressed and robed in a loose-fitting gown with the back open. Underwear may be left on, but shoes should be removed. During the history, the clinician observes the patient informally as to comfort level, ease of movement, and favored positioning. During the examination, the patient is asked to walk around the examination room to determine gait. A normal gait is called heel-to-toe, which is heel strike followed by stance phase (full foot contact) and then toe off in a coordinated fashion on both sides. An antalgic gait occurs when standing on one of the legs is painful, causing the patient to avoid weightbearing on that side as much as possible. A foot-drop gait occurs with weakness of foot dorsiflexion (anterior tibialis and extensor hallucis muscles, innervated by L5) causing the foot to slap at heel strike. A Trendelenburg gait is caused by hip weakness or pain and causes the patient to waddle and drop the affected hip while weightbearing on that side. A broad-based gait with imbalance is frequently associated with spinal cord dysfunction. The patient is asked to walk on the heels first and then on the toes to test muscle function in foot dorsiflexors (L5) and ankle plantar flexors (S1).

Next, the back is inspected for scars, deformity (scoliosis, increased or decreased lordosis, or excessive thoracic kyphosis), skin lesions (heating pad burns or ecchymoses), hairy patches or dimples (indicative of spinal dysraphism), shoulder alignment, balance, and pelvic obliquity (indicating true or functional leg length inequality).

Palpation of the midline spinous processes may reveal a forward step-off as seen in spondylolisthesis. Paravertebral muscle spasm is felt as a tight or quivering muscle just lateral to the spinous processes. Masses, areas of fluctuation, and bony defects may be found by palpation. Tenderness to light touch is an important Waddell sign (see discussion on Waddell sign). Finally, palpation of the sciatic nerve just inferior to the ischial tuberosity may indicate a tender and inflamed nerve, and pressure over the greater trochanter may indicate trochanteric bursitis.

Percussion of the spine is rarely useful except in cases of spinal tumors or infection that may occasionally be painful to percussion. Pain on pressure over the kidneys at the costovertebral angle should point the way toward the urinary system as the source of the patient's back pain.

Range of motion of the spine and hips are evaluated next. The patient is asked to bend forward at the waist as far as pain free and then extend backwards in similar fashion. How the patient moves as well as how far he or she moves is observed. The angle of flexion and extension can be estimated as degrees from the vertical, or measured by a goniometer if accuracy is important. Alternately and more reproducibly, the part of the leg that the patient can easily touch can be listed as the point of maximal flexion such as knees, ankles, floor, etc.

During forward bending, the normal lumbar lordosis is reversed into a gentle kyphosis. Muscle spasm, ankylosis, or other abnormality may hinder this smooth transition and should be noted. Any forward slip may be exaggerated by forward flexion, and thoracolumbar scoliosis with a rib hump or lumbar prominence can be detected easily with the patient bent forward at the waist. Lateral bending is noted in degrees. Trunk rotation that is not an inherent motion of the lumbar spine but instead comes from the hips is evaluated as one of the Waddell signs. Range of motion of the hips and knees are best checked with the patient sitting or lying down. Many times the diagnosis of hip arthritis has been missed by skipping this important physical test.

The patient then sits on the examination table. A straight leg raising sign is elicited by asking but never forcing the patient to straighten the knee in front while sitting. The amount of hip flexion and knee extension obtained before pain in the leg occurs should be noted and compared with the supine straight leg raising test obtained with the patient lying down. A significant discrepancy between these values is a positive Waddell sign. To be truly

positive, the straight leg raising (SLR) test must cause leg pain, not back pain alone. Occasionally, an SLR on one side will provoke leg pain on the opposite side, termed the crossed straight leg raising sign. This is 99% specific for a herniated disc on the painful side. The SLR tests for irritation of the sciatic nerve. To test for irritation of the femoral nerve, the patient is placed prone and the hip extended while the knee is flexed. If anterior thigh pain is elicited, this is a positive reversed SLR or flip test. Hip range of motion can be checked easily with the patient sitting on the examination table by stabilizing the knee with one hand and rotating the lower leg back and forth. A difference between sides or pain in the hip, buttock, or groin may indicate a painful hip condition such as osteoarthritis.

The knee reflex (L4) and ankle reflexes (S1) are elicited with the reflex hammer. If necessary, strength of the quadriceps (L4), extensor hallucis longus, and anterior tibialis muscles (L5) and gastro-soleus (S1) can be checked. Sensation or lack thereof can be checked with a paper clip or sterile pin; vibration sense for intact posterior columns is occasionally elicited by tuning fork as can be proprioception. Finally, the Babinski sign (up going is normal) and presence of clonus should be checked to evaluate for upper motor neuron disease. If long tract signs are present, the lesion must be higher than the lumbar spine since the spinal cord ends at approximately L1.

Finally, the patient is asked to lie down on the examining table. Again, the SLR test is elicited with the knee extended along with the hip range of motion test. A crossed leg test, or Faber (flexion-abduction-external rotation) test, is performed by placing the patient's ankle on the opposite knee with the hip flexed and externally rotated into a figure-four position. The knee is pushed downward, stressing the opposite sacroiliac joint. A positive pain provocation may indicate sacroiliitis caused by an infection in the sacroiliac joint or early ankylosing spondylitis. A reverse SLR test is performed by placing the patient prone and flexing the knee while extending the hip. This stretches the femoral nerve and is equivalent to the SLR test for sciatica, but tests the L3 and L4 nerve roots that make up the femoral nerve.

WADDELL SIGNS

Originally described in 1980 by Gordon Waddell, this group of five signs is used extensively to identify patients with functional overlay. Functional overlay is the term currently used to denote patients formerly called malingerers—those with nonorganic signs who may be exaggerating or inventing symptoms, often for secondary gain.

The five signs are listed in Table 5.1. During the history and initial physical examination, the patient is observed for mannerisms and inconsistencies. Suspicion that the story given is untrue, exaggerated, or that the patient is out for secondary gain (money, disability, back massages, etc.) is counted as one positive Waddell sign. Simulation is performed by having the patient rotate his or her trunk back and forth in the standing position. Since the lumbar spine has no inherent rotation, this is accomplished by the hip joints and only simulates spine motion. If the patient complains of back pain during this maneuver, a positive Waddell sign is counted. Tenderness to light touch is documented by lightly pinching or rolling the skin of the back. Complaints of pain or the patient moving away from the examiner is a positive Waddell sign. Nonanatomic neurologic signs, such as numbness of the entire leg or global weakness, in the

Table 5.1. Waddell Signs

1. General appearance: attitude and overreaction.
2. Tenderness:
   a. Superficial
   b. Nonanatomic
3. Simulation:
   a. Axial loading
   b. Trunk rotation
4. Distraction:
   a. Straight leg raising: sitting
   b. Straight leg raising: supine
5. Regional disturbances:
   a. Weakness
   b. Sensory

absence of central brain or cord involvement, is a fourth sign. Finally, a discrepancy in the SLR between lying and sitting can be identified by doing the SLR in both positions. Many patients with functional overlay will have no problem performing the SLR to 90° while sitting but will complain of severe pain in the back or leg at 20° while supine. This counts as the fifth Waddell sign.

In the original paper by Waddell, three or more positive signs correlated well with functional overlay or secondary gain. Many spine surgeons now use two or more as the threshold. Whichever is chosen, many papers have verified the use of Waddell signs to differentiate those who will do well with any particular treatment, whether it is therapy, surgery, or other, from those with functional overlay who will do poorly. Similarly, return to work within a reasonable time frame is inversely correlated with number of positive Waddell signs.

LABORATORY STUDIES

Laboratory studies should be used to confirm a clinically suspected diagnosis or to differentiate between two possibilities in the differential. Rarely will an x-ray or blood test be the primary indication of a particular disease, although there are exceptions such as an elevated erythrocyte sedimentation (SED) rate in infection, a characteristic MRI picture in metastatic cancer, or serum protein electrophoresis (SPEP) for myeloma. This is because many of the tests used in patients with low back pain are not specific, and have high rates of false-positive and false-negative predictive values. Additionally, many radiographic findings, including CT and MRI, are age related and do not necessarily reflect a pathologic disease state. However, laboratory studies remain a significant portion of the diagnostic triad.

X-rays

Plain x-rays give a two-dimensional picture of the three-dimensional spine. The routine series consists of AP (Fig. 5.7), lateral, and spot L5-S1. This last film, L5-S1, is done

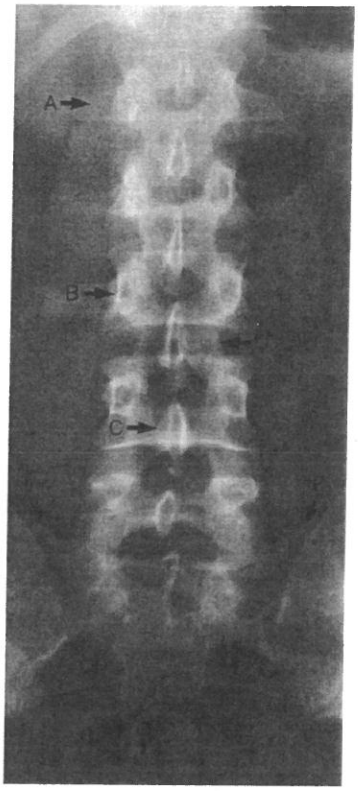

Figure 5.7. Roentgenogram of normal lumbosacral spine. *A,* transverse process. *B,* pedicle. *C,* posterior spinous process. *D,* lamina. *E,* sacrum.

because the pelvis often obscures the lower lumbar spine on the lateral x-ray. On the AP x-ray, the spine is checked for lateral deviation (scoliosis), rotation, missing parts such as an absent pedicle (often the first radiographic sign in metastatic cancer), fractures, and asymmetry. A standing AP can be used to check leg length inequality by determining abnormal pelvic tilt. The normal spine is straight and symmetrical on the AP film.

The lateral and spot films will show the normal lumbar lordosis (concave posteriorly). Abnormalities often noted include compression fractures, bone erosion, disc space narrowing (often part of the normal aging process), endplate erosion (seen in discitis), and facet osteoarthritis. Slippage of one vertebra on top of the one below may be visible and is always abnormal. Forward slippage is called

as spondylolisthesis and backward slippage is called retrolisthesis.

Oblique x-rays are occasionally helpful to visualize the pars interarticularis (the junction of the five parts of the spine). This is the weakest part of the vertebra and may occasionally suffer a stress fracture (spondylolysis), the most common cause of back pain in the adolescent. The facet joints between adjacent vertebrae can also be seen more readily on the oblique films to check for osteoarthritis (spondylosis). Finally, the neuroforamina (exit points for the nerve roots) can be visualized on the obliques, although these are better evaluated by CT or MRI scan.

Dynamic lateral flexion/extension plain films are occasionally useful to document instability. These are best done standing, with the patient asked to bend forward and then backwards as far as possible without undue pain on each x-ray. Displacement forward or backward by more than 4 mm or angulation of more than 15° is considered potentially unstable. Lateral AP bending films to the left and right can be used to check the flexibility of the scoliotic curve, although in the primary care setting these rarely are used.

CT Scan

Initially used extensively to evaluate the soft tissues of the spine, disc, and spinal canal, the CT has largely been replaced by the MRI scan for soft tissue work. However, the CT scan is still useful to delineate the bony anatomy in cases where plain x-rays are unclear or ambiguous. CT gives direct transverse pictures of the three-dimensional spine, and a three-dimensional picture can be constructed with computerized reconstruction techniques. CT is useful to evaluate bony destruction, fractures, spinal canal dimensions, and facet joint abnormalities. Conditions in which this is particularly helpful include spondylolisthesis and spondylolysis, bone tumors, and facet asymmetry. If MRI is unavailable, CT is helpful for conditions such as herniated discs, spinal stenosis, and nerve root abnormalities. The benefit of CT is that it gives better bone detail than MRI, and is much cheaper. The disadvantages are that soft tissues are all shown in various shades of gray and ionizing radiation is used. Also, any metallic artifacts will degrade or scatter the image.

Bone Scan

Technetium pyrophosphate radiolabeled bone scans provide a metabolic picture of the skeleton. Active osteoblasts pick up the radioactive tracer preferentially. Thus, any bone or part thereof that is actively incorporating phosphate into its matrix will be picked up as a hot spot on the bone scan. Conditions that stimulate the bone, such as osteoblastic tumors (both primary and metastatic), fractures (both stress and acute), disc or bone infections, osteoarthritis, and Paget's disease, will cause increased uptake and appear as dark spots on the bone scan. These various conditions can often be differentiated from each other by their characteristic patterns, especially with the use of single photon emission computed tomography (SPECT) bone scans, which give a CT type of image and are more sensitive than the plain bone scan.

Conversely, any process that causes bone to be less active will show up as a void on bone scan. These include large osteolytic tumors, some hemangiomas, and surgical bone resections. However, it is important to note that marrow diseases, such as lymphoma, leukemia, and myeloma, will be normal on the bone scan, because these conditions do not cause bony reaction.

MRI

Since its introduction in the 1980s in the United States, the MRI has become the gold standard test in many clinical situations. MRI shows primarily soft tissues, and in the spine, this refers primarily to the discs, spinal cord and nerve roots, blood vessels, and muscles. To a lesser extent, bones, tendons, and ligaments can be visualized. This is primarily because MR images hydrogen nuclei best, and the well visualized structures contain water, whereas the less well visualized structures are dry. In addition, MRI is useful in differentiating tumors from normal tissue and in identi-

fying infections. Also, unlike CT scanning, MRI can give true pictures in any plane desired, whether sagittal, coronal, or transverse.

The major drawbacks to using MRI are expense (sometimes amounting to more than $1,000 per examination), degradation of the image by the presence of ferromagnetic implants, claustrophobia on the part of some patients, and the loss of clairvoyance in one case.

In the evaluation of back problems, MRI is primarily used to visualize the spinal cord, vertebral column, and enclosed structures. MRI is the test of choice in identifying infections around the spine such as tuberculosis and discitis, herniated discs, spinal stenosis, and other causes of radiculopathy. Spinal tumors, including metastases to bone and intradural and extradural extensions, are well visualized. By injecting Gadolinium intravenously, scar tissue from prior surgery can be differentiated from otherwise normal or pathologic structures such as recurrent disc herniations. To a large extent, MRI has supplanted myelography as the best test for spinal canal problems, because the latter is invasive and entails the risk of infection and spinal headaches.

Clinical problems where MRI is not useful include the evaluation of fractures in which x-rays and CT scans are more helpful, and in active spondylolysis where bone scanning is better.

Unfortunately, like other tests MRI is rarely diagnostic. Several authors have found a high false-positive rate of up to 30% in normal healthy asymptomatic volunteers. This error rate approaches 65% in older patients. Thus, any abnormality seen on an MRI scan must be correlated with the patient's history and physical examination to arrive at a clinical diagnosis. MRI should be used to confirm or localize a clinically suspected diagnosis, not as a fishing expedition for possible spinal pathology.

Blood Tests

As with the MRI, blood tests will most commonly support or clinch but rarely provide a clinical diagnosis. A complete blood count (CBC) is rarely useful, except as a marker for anemia in marrow-occupying lesions or occasionally in infections. The erythrocyte sedimentation rate (ESR) is one blood test that should be used more frequently. An uncommon but potentially serious cause of back pain is bacterial infection, either in the disc (discitis), vertebra (osteomyelitis), or epidural space (epidural abscess). In all three, the ESR as well as the C-reactive protein (CRP) are significantly elevated early in the disease process when the infection is contained in the affected structure and before systemic spread resulting in sepsis. These are often the only blood tests that are abnormal, because frequently the white blood cell count (WBC) is normal before systemic spread. Thus, if there is any question of a spinal infection, an ESR should be ordered and may occasionally save the patient and clinician from a potentially disastrous delayed diagnosis or misdiagnosis.

Metabolic problems such as hyperparathyroidism, tumor induced hypercalcemia, renal abnormalities, hypothyroidism, etc., that affect the skeletal system can be picked up by blood tests, but usually these diagnoses are suspected on other grounds rather than initially presenting in the spine. In general, the following tests will cover most spinal abnormalities: CBC, ESR, Ca, Phos, BUN, Creat, Glucose, thyroid levels, and alkaline phosphatase. The alkaline phosphatase may be elevated in any abnormality involving bone destruction or excess activity and thus is nonspecific.

Finally, rheumatologic tests should be considered with any possibility of inflammatory arthritis, such as lupus (ANA), rheumatoid arthritis (Rheumatoid factor), ankylosing spondylitis (HLA B-27), and Lyme disease (Lyme titer). Except for ankylosing spondylitis, these inflammatory spondyloarthropathies almost always affect the spine late in the disease course. However, because ankylosing spondylitis usually begins in the axial skeleton (often in the sacroiliac joints), back pain is frequently the primary initial complaint (see "Spondylolysis and Spondylolisthesis"). Thus, in any otherwise healthy young patient with back pain, the diagnosis of ankylosing spondylitis

must be considered, and an HLA B-27 positive test may point the way to this diagnosis.

COMMON SPINAL CONDITIONS

The aim of the workup is to obtain a diagnosis so that treatment can be initiated. It has been estimated that an exact pathologic diagnosis will be discovered in less than 50% of patients with low back pain. However, because so many of the identifiable causes of low back pain are serious with such capacity for spinal destruction and instability, the diagnostic algorithm discussed above should be followed. This section describes many common etiologies of back pain as well as early management strategies.

SPONDYLOLYSIS AND SPONDYLOLISTHESIS

There is generally much confusion about these terms. *Spondylos-* denotes spine, *-lysis* derives from broken, and *-listhesis* denotes slipped. Thus, a spondylolysis by common usage refers to a stress fracture of the pars interarticularis, whereas a spondylolisthesis refers to one vertebra slipping forward relative to the one below. The term anterolisthesis is equivalent to although less common than spondylolisthesis, while the term retrolisthesis denotes slipping backwards. Spondylosis, however, has come to mean abnormal spinal degenerative disease, or osteoarthritis of the spine, and is discussed separately.

Spondylolysis (Fig. 5.8) is a fracture through the pars interarticularis of a vertebra. It is most common at L5 but may occur in any vertebra. Usually, this is a stress fracture where this weakest part of the vertebra is consistently overloaded and finally snaps. Spondylolysis commonly occurs in adolescents, with an increased prevalence in football linemen, ballet dancers, gymnasts, and rowers. Common to all these activities is prolonged or repetitive extension of the lumbar spine. One population-based series found a prevalence of 4% in healthy first graders, increasing to 5.8% in the same adolescents 10 years later. This study was based on a radiographic survey of all children in a town in northern Pennsylvania, so it probably represents a true prevalence rate. Some, but not all of the children were asymptomatic, and many had

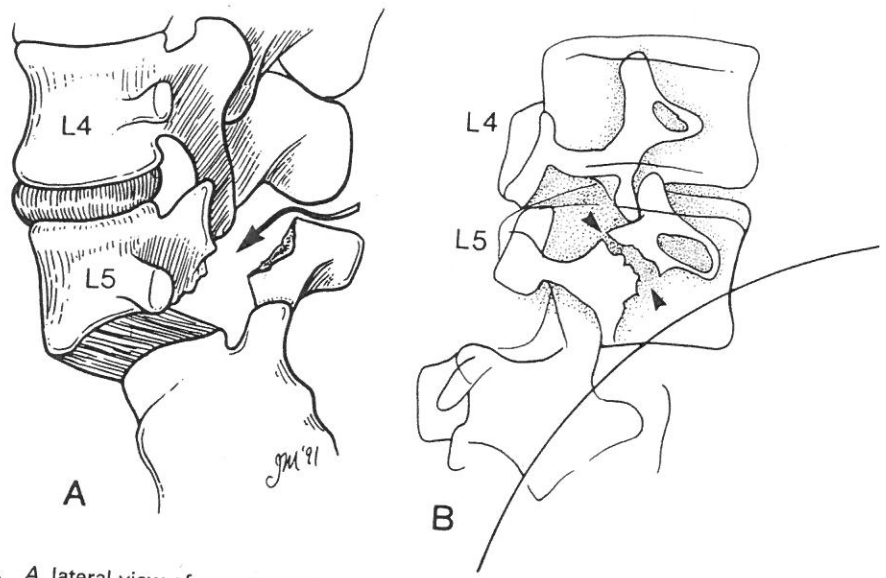

Figure 5.8. *A,* lateral view of spondylolytic spondylolisthesis. *B,* spondylolysis. 45° oblique view of the lumbar space will show a defect in the pars interarticularis.

no recollection of any spinal trauma. Significantly, no cases of spondylolysis have been found in an autopsy series of 500 stillborn infants. Therefore, spondylolysis is not a congenital defect. A group of Eskimos that were studied in Alaska have a higher than 50% prevalence rate of spondylolysis, indicating that both genetic and traumatic factors are involved in the etiology of this condition.

The usual, but by no means only, presentation of spondylolysis is the teenage athlete with sudden or gradual onset of low back pain. In fact, spondylolysis is the most common cause of back pain in the adolescent. The pain is usually localized to the lower back and is aggravated by extension, relieved by bending forward or resting, and may radiate to the buttocks and posterior thighs. Morning stiffness is common and the causative activity is usually too painful to be continued. Night pain is extremely rare.

On examination, there may be tenderness in the lumbar spine with muscle spasms. Neurologic examination is usually normal, and frequently the hamstrings are abnormally tight. Active extension is painful, and the patient will usually avoid this activity.

Laboratory tests are normal with the exception of the x-ray. Because the pars interarticularis is oblique to the coronal and sagittal planes, routine AP and lateral films will frequently fail to visualize the fracture. Thus, oblique x-rays are indicated that will profile the pars. Occasionally, even oblique films miss the fracture, so a CT scan can be used in cases with negative plain films and a high index of suspicion.

The same set of symptoms can occur in an incipient but incomplete stress fracture, which will not be seen on x-ray or CT scan. Thus, a bone scan or, if available, a SPECT scan is often useful to detect the increased bone activity around an incipient stress fracture.

Once the diagnosis has been made, treatment is initially symptomatic. Avoidance of the offending activity is mandatory until symptoms disappear. Nonsteroidal anti-inflammatory drugs (NSAIDs) can be used but will not speed healing. Physical therapy to stretch the tight hamstrings and improve lumbar strength and flexibility is helpful. Promotion of antilordotic posture may ease the pain.

If these conservative treatments fail, a trial of immobilization in the Boston brace should be considered. This orthosis is a plastic lumbosacral orthosis that is fitted in an antilordotic position. This positioning promotes contact of the two sides of the fracture and has been found to heal the defect in 54% of patients at follow-up x-ray. More importantly, it alleviates pain in a significant majority of adolescents and allows gradual resumption of full activities after cessation of symptoms. The brace is ordinarily worn for at least 3 months and then a weaning process is begun; after 9–12 months, the brace can be discarded.

If all conservative treatment fails, surgery may be the only option. Traditionally, a posterolateral fusion of the slipped vertebra to the one below is the standard technique, since initial attempts to heal the lytic defect by bone grafting resulted in a high failure rate. Wiltse has reported a better than 90% success rate with simple posterolateral fusion without instrumentation in alleviating back pain, radicular symptoms, and the hamstring tightness. Most patients were able to resume full activities without restriction after 6 months.

If the spondylolysis is present at L4 or above, direct repair of the fracture with bone grafting and circular wiring or screw insertion can be done. This avoids the necessity of fusing two vertebrae together and thus may retain more lumbar spine motion; however, in most series, this procedure has a higher failure rate and is technically more difficult. Thus, the Wiltse posterolateral fusion remains the gold standard for surgical treatment of spondylolysis.

Spondylolisthesis is the slipping of one vertebra forward on top of another. It is generally secondary to a spondylolysis, but occasionally may result from abnormal facet joints, pathologic bone (as in Paget's disease), or surgical removal of enough bone to allow instability. On x-ray, spondylolisthesis is measured as the amount of forward slip on the standing lateral x-ray compared with the AP length of the

lower vertebral body. This can be denoted as a percentage, e.g., 40% slip, or as a grade, where grade 1 denotes a slip of from 1% to 25%, grade 2 as 25% to 50%, grade 3 as 50% to 75%, and grade 4 as more than 75% forward slip. Currently, many authors group grade 1 and 2 into low-grade slips and grade 3 or 4 as high-grade slips, because recommended treatment differs for the two categories.

Low-grade slips can be treated in the same fashion as simple spondylolysis, with conservative treatment having a high rate of success. However, high-grade slips are treated surgically with fusion as soon as discovered, because these tend to progress to higher degrees of slips, are refractory to conservative treatment, and are usually symptomatic. Once again, posterolateral fusion is the gold standard, although many surgeons also will perform a decompression of the loose posterior elements at the same time, and frequently surgical instrumentation (screws, rods, or plates) is added to improve fusion rates and clinical success.

The preceding discussion applies primarily to spondylolysis and spondylolisthesis discovered and treated in the adolescent. A frequent clinical problem encountered is the adult with sudden or gradual onset of back pain who is found to have spondylolysis or a low-grade spondylolisthesis on lateral x-ray. Usually, these patients have no history of back problems, even during adolescence, and frequently the onset of back pain comes after a work-related injury. It is simplistic to ascribe the patient's current back pain to spondylolysis, because these are not commonly new fractures, evidenced by the usually negative bone scan. At times, another condition may cause the back pain such as a herniated disc, muscular strain, or compensation related back pain. Thus, the patient should still be worked up for other causes of back pain before the current episode is ascribed to spondylolysis. However, if nothing else is found, spondylolysis can present suddenly in middle age. Current thinking is that a disc injury or degeneration will allow a sudden increase in slip leading to the episode of back pain in a previously asymptomatic individual. These patients will present just as in adolescents, with primary back pain plus or minus leg pain and tight hamstrings. Radicular pain is more common in the adult, probably from foraminal narrowing above the slip, and athletics are not usually involved. Extension of the lumbar spine is more painful than flexion, and the neurologic examination is often positive for mild L5 nerve deficits (weak ankle and great toe dorsiflexion, numbness of the big toe and top of foot). The radiographic workup is the same as previously described, except that the bone scan is almost always negative, indicative of a chronic or longstanding lysis.

Treatment in the adult is directed more at functional improvement rather than healing the fracture. Thus, physical therapy is more important, with postural exercises and lumbar muscle and abdominal strengthening. Reliance on modalities such as heat, ultrasound, and other passive modalities should be avoided. Braces are usually ineffective and many adults will not wear them, although a simple corset for support is often helpful. Injection of corticosteroids with Xylocaine into the spondylolysis is often used both diagnostically and therapeutically. If successive injections into the pars defect relieve the pain temporarily but the pain returns, surgical treatment is usually effective, because the injections help confirm that the pars fracture is truly the cause of the patient's symptoms. If no relief is obtained from the injections even temporarily, a more thorough search for the cause of the patient's pain must be undertaken.

If surgery is ultimately undertaken, the same protocol is followed as with adolescents, except that instrumentation is more often used to assure a higher fusion rate. Reduction of the slip by instrumentation can lead to unintended L5 nerve stretch, causing chronic and unrelieved radicular pain, and should be avoided if possible. Treatment for high-grade spondylolistheses is difficult and has a high complication rate, and fortunately, this condition is extremely rare in adults.

Finally, pseudospondylolisthesis, or degenerative spondylolisthesis, occurs in older patients caused by extensive osteoarthritis of the lumbar facet joints. This most commonly occurs in women at L4-L5 and when the pars is intact. Because the presentation is usually as spinal stenosis, this will be discussed in that section.

SPINAL INFECTIONS

Although rare, spinal infections are potentially more dangerous than any other spinal problem. Before the advent of effective antibiotic therapy, tuberculosis of the spine was extremely common. In fact, surgical treatment of this problem led to the development of many surgical techniques still used today for other maladies (anterior debridement, posterior fusions). Now that tuberculosis has receded from the clinical experience of many physicians, spinal infections are not often part of the common differential diagnosis. A high index of suspicion is necessary to avoid missing one of these potentially lethal infections.

Infection in the spine commonly occurs in two age groups: children and debilitated older adults. In children, the edges of the vertebral endplate and outer disc are vascularized. Because most infections enter the spine hematogenously, bacteria may circulate to these vascular areas of the disc, lodge in the vascular sinusoids present there, and set up a nidus of infection. The bacteria then invade the nonvascularized disc where host defense mechanisms will not reach and gradually develop an abscess cavity or infiltrative infection. In children, the most frequent organism is Staphylococcus aureus, although streptococcus can occur in neonates and other bacteria in immunocompromised individuals. Only rarely can a prior source of infection be identified in children.

In adults, there is usually a preceding source of infection elsewhere in the patient, such as endocarditis, skin ulcer, urinary tract infection, or pneumonia. The bacteria then spread hematogenously and lodge in the venous channels next to a degenerated disc or bone, setting up an infection. These patients are usually debilitated with pre-existing risk factors such as diabetes, alcoholism, chronic urinary catheterization, etc., which predispose them to frequent bacteremia. The organism is often staphylococcus, but almost any bacteria or fungus may be involved.

Regardless of age, the common presenting symptom is unremitting back pain. This pain usually is present both day and night, often is worse at night, and is not posture dependent (unlike mechanical back pain). Many times the patient will be awakened from sleep and will pace the hall, a red flag in the history. Characteristically, the pain worsens gradually and the patients may return many times to the practitioner complaining of worsening back pain. This clinical picture should alert one to possible spinal infection and the workup should be aggressive. Radicular or myelopathic symptoms (gait abnormalities, saddle anesthesia, or urinary incontinence) present late in the course and indicate a serious prognosis. The pain is usually deep and difficult to localize, although it will generally be around the area of the infection. In normal children, back pain is a rare complaint, even when an important test at school is scheduled. Thus, any child complaining of back pain should be investigated early and aggressively, because discitis is one of the common causes of back pain in children.

The physical examination is usually noncontributory except that occasionally tenderness to percussion is found. Outward sign of infection is almost never present around the spine such as erythema, drainage, or lymphangitis, because the infection remains deep in the spine.

Infection is one case in which laboratory tests are diagnostic. Usually the WBC is normal. However, the ESR is sensitive and will be elevated early, often near 100 mm/hour. Thus, if there is any suspicion of infection, the ESR should be obtained. Once the probability of infection is considered, the MRI is an excellent study to locate the infection and ascertain the extent of spread. Characteristically, pus can be visualized as a cavity in the disc or bone with high intensity on T2

weighted images. Because most infections begin in the disc, any disc abnormality affecting the bone on both sides on the lateral x-ray should be suspected as being discitis. This is especially true in children in which frequently the only early radiologic sign is endplate erosions or indistinctness on both sides of the disc.

Treatment depends on obtaining the organism and prescribing the appropriate antibiotic. In children, the most common organism is Staphylococcus aureus; therefore, a presumptive diagnosis can be made and IV antistaphylococcus antibiotics given. If the clinical course does not improve rapidly, then biopsy or aspiration should be performed to identify the organism. In adults, however, any organism is possible, thus direct isolation of the organism is mandatory. Often, the bacteria can be identified from blood cultures or culturing the primary site of infection. However, cases of simultaneous infection with two or more organisms have been reported, especially in the compromised host, thus direct aspiration or biopsy of the spine is frequently necessary in adults. This can be performed radiographically with CT guided fine needle aspiration under local anesthesia.

Ordinarily, 6 weeks of intravenous antibiotics will be necessary, with consultation of infectious disease specialists to monitor antibiotic levels and efficacy. Occasionally, 2 weeks of IV antibiotics followed by 4 weeks of effective oral antibiotics can be given in children, although effective bactericidal levels must be assured. In children, a rigid brace is recommended to rest the infected spinal segment and prevent bone collapse. In adults, a brace is helpful to lessen pain but will not usually prevent collapse into kyphosis or scoliosis.

If the infection is left untreated or ignored, consequences may be severe. The bacteria gradually form an abscess that will eventually break out of the disc or bone. If breakout occurs anteriorly, a retroperitoneal or intrapleural abscess will occur. If the psoas muscle is involved anterolaterally, the abscess may track into the medial thigh. Most severe is posterior extension into the spinal canal. This will lead to an epidural abscess with compromise of the spinal cord or nerve roots. Often, this catastrophic event (paraplegia) is the first presentation of a previously ignored or downplayed episode of discitis. Once the neurologic structures are involved, surgical debridement as soon as possible is mandatory.

If an abscess is present on MRI or if neurologic compromise is evident, surgical debridement is recommended. This can be performed posteriorly via a laminectomy, although most surgeons will approach the problem anteriorly via a thoracic or retroperitoneal approach. Effective drainage of the abscess, debridement of the necrotic bone and soft tissue, and adequate stabilization with bone graft or instrumentation can be performed usually with good results.

To summarize, spinal infections are dangerous and must be diagnosed and treated aggressively to avoid catastrophe.

SPINAL TUMORS

Primary spinal tumors are extremely rare. Benign tumors include osteoid osteoma, osteoblastoma, eosinophilic granuloma, and chondroblastoma. Aggressive but theoretically benign spinal tumors include giant cell tumors and chordomas. Malignant primary tumors include osteosarcomas, chondrosarcomas, malignant fibrous histiocytomas, and fibrosarcomas. All are extremely rare in the spine. Included in the list of primary spinal malignant tumors is multiple myeloma and lymphoma, which, because they actually arise from marrow elements, will be discussed separately.

Primary bone tumors usually present with pain, localized to the particular area of the spine. Occasionally, a mass will be the chief complaint if the tumor occurs in the posterior part of the spine. Characteristically, the pain from osteoid osteomas, most common in young patients, will be intense at night and relieved almost completely by aspirin. In children, scoliosis caused by muscle spasm will often be found, but the neurologic examination will be normal. X-rays will suggest the

presence of an abnormality; therefore, the workup should include MRI, CT scan, or bone scan, depending on tumor type. Blood tests are normal. Treatment depends on tumor type and aggressiveness. Primary bone tumors should be referred to a specialist in this type of pathology.

Malignant bone tumors are almost always metastatic. The five most common tumors that metastasize to bone are breast, prostate, lung, renal, and thyroid, accounting for 80% of primary sites. Metastases to the spine are found at autopsy in 75% of patients who have died of cancer. Most commonly, the primary site will be known before discovery of the spine lesion, although occasionally a clinician is faced with a patient with back pain of unknown etiology, which turns out to be secondary to a metastasis.

These patients usually present with back pain, again of an unremitting nature and gradually worsening. Night pain is common along with weight loss, cachexia, and other systemic signs of cancer. Frequently, radicular or spinal cord symptoms are present, as the tumors invade the epidural space causing cord or root compression. This neurologic pain is often severe and unremitting, described as agonizing and sharp while the back pain is deep and aching. Occasionally, a catastrophic collapse of a pathologic fracture will cause sudden paraplegia that is usually irreversible.

The physical examination of the spine may reveal deformity following pathologic fracture, overlying masses, and tenderness to percussion. The neurologic examination will often be positive for radicular or myelopathic signs. Obviously, other nonspine physical findings will depend on the spread of the tumor to other organ systems such as the lung, brain, etc.

Radiographic evaluation begins with plain x-rays of the affected area. This will indicate any pre-existent bony collapse or pathologic fractures. Impending collapse can often be predicted on plain x-ray, although it has been estimated that at least 60% of the vertebral body must be destroyed before plain x-rays are positive. Often, the first radiographic sign is the loss of a pedicle on AP x-ray (denoted as the winking owl sign) as the tumor that begins in the vertebral body grows down along the pedicle destroying it from inside out.

MRI is by far the best test to detect occult or overt malignancies in the spine. Tumors have a characteristic MRI appearance and almost always spare the disc space, differentiating tumors from bone destroying infections (see "Spinal Infections"). In addition to the suspected site, MRI of the entire spine can be done to search for other metastatic sites that might prove more dangerous in the long run and also require treatment.

Treatment depends on several variables. Paramount is the length of expected survival. A patient with only a few weeks or months to live should not be subjected to a lengthy surgical procedure just to restore spinal stability when a simple brace might suffice. In general, most surgeons will use 6 months of expected survival as a cutoff for surgical stabilization. Of secondary importance is the tumor type. For instance, osteoblastic prostate carcinoma may be slow growing and rarely cause vertebral collapse. Others such as squamous cell carcinoma of the lung or renal cell carcinoma are aggressive and result in significant spinal collapse. Whether the tumor is radiosensitive or chemosensitive will determine treatment options. Finally, the degree of actual or predicted vertebral collapse and instability will indicate whether a brace, surgery, or no stabilization is required. Harrington has reported that any tumor with major involvement of the vertebral body or collapse, or one that involves neurologic compromise and bony involvement should be surgically stabilized, if life expectancy is appropriate. Malignancies involving the spine should be referred to an orthopaedist or other specialist as soon as possible so that adequate stabilization, biopsy, or decompression can be performed as required.

Finally, multiple myeloma and lymphoma technically are classified as spinal tumors. In fact, myeloma is the most common malignant primary spine tumor. These tumors usually present with systemic signs such as anemia,

fevers, infections, or bleeding consistent with the systemic nature of these diseases. When present in the vertebrae, often the first sign is a compression fracture and subsequent back pain. The plasma cells or malignant lymphocytes infiltrate the bone marrow spaces causing destruction of the cancellous (marrow) bone but not the cortical bone. Thus, the vertebra is hollowed out and collapses as a compression fracture. The radiographic picture appears identical to a benign osteoporotic compression fracture; therefore, a high index of suspicion for myeloma must be weighed when evaluating patients with otherwise routine compression fractures (see below). MRI is rarely helpful in myeloma and lymphoma, because the marrow signals may be similar to normal bone marrow. Bone scan is almost always negative.

Blood tests including the ESR almost always will be abnormal. The SPEP will reveal a monoclonal spike, and the patients will usually be anemic and leukopenic secondary to marrow replacement by malignant cells. The SPEP may be normal in light chain disease. In this situation, the urine protein electrophoresis will be diagnostic.

Treatment of myeloma is rarely surgical, although occasionally a biopsy of a spinal lesion is required. Once the diagnosis is made, a brace can be prescribed for comfort of any pathologic compression fractures. Chemotherapy is the treatment of choice, although expected survival from myeloma is not good.

HERNIATED DISCS

Low back pain is common. Approximately 80% of the general population will suffer at least 2 weeks of back pain at some time during their lives. Of these, approximately 10% are related to disc herniations. Before 1934, cartilage-containing masses that were compressing nerves in the lumbar spine were thought to be tumors arising de novo from the disc. In that year, Mixter and Barr published a landmark paper explaining that these cartilage masses were in fact protrusions of normal disc tissue into the spinal canal, which caused back and radicular pain. This ushered in the era of the disc.

The normal disc is composed of two parts: the inner nucleus pulposus and the outer annulus fibrosis. The nucleus begins during childhood as a well-hydrated compressible gel, gradually changing through life into a more fibrous, dehydrated, degenerated lump of cartilage as one ages. The disc is responsible for cushioning and supporting the loads on the spine as well as functioning as the joint between vertebrae. The nucleus is contained by the outer annulus, which is composed of tough type I cartilage in a circular orientation around the nucleus that resists shear and tensile forces. The outer third of the annulus is innervated, but not the inner two-thirds or the nucleus. Unfortunately, both age-related and trauma-related changes can occur in the annulus, predisposing it to tearing or other injury, usually during twisting activities. If an annular tear is incomplete but involves the outer innervated portion, back pain can result as so-called discogenic back pain (see "Miscellaneous Causes of Low Back Pain"). If the tear is complete, the nucleus may protrude or herniate outward. Because the weakest part of the annulus is at the posterior-lateral corners, most disc protrusions occur in these spots where the nerve roots are located. Thus, a herniated disc may cause back pain or radicular pain, depending on the size, extent, and location of the protrusion.

In the past, when myelography was the test of choice for diagnosis of disc herniations, it was assumed that the size of the herniation determined the degree of pain and dysfunction, because the myelogram is usually read as showing either nerve root compression or normal findings (no gradations). With the advent of CT scanning and subsequently MRI, which is able to measure the size of a disc herniation, it has been discovered that there is often a poor correlation between the size of a disc herniation and the degree of pain. In fact, Boden has shown that there may be a 10% rate of asymptomatic disc herniation in normal healthy volunteers. This has led to the

conclusion that it is the disc material itself, not the mechanical pressure, that causes radiculopathy. In fact, several studies have shown that disc material induces changes in the nerve roots in contact with the disc material, including elevated substance P levels and various inflammatory products. This may be why NSAIDs and epidural steroids are often effective in treating radiculopathy from herniated discs.

Patients with a herniated disc usually present with a history of back pain that subsequently evolves into leg pain, usually unilateral because of the relative strength of the annulus in the midline forcing the disc rupture postero-laterally. There is often a history of trauma or lifting, especially when compensation issues are involved, although only approximately 40% of patients can remember the exact incident that initiated the pain. Certain occupations are involved at a higher rate than the general population, such as nurses, heavy laborers, and truck drivers. The average age of these patients is 37; this condition is rare in teenagers and the elderly. Smokers have a higher rate of disc protrusion than nonsmokers, and there is often a family history of disc problems. Interestingly, no animals are known to rupture discs, although many dogs suffer from other spinal problems seen in humans, such as spinal stenosis. Thus, disc herniation in humans is a common problem in industrialized society of multifactorial origin.

The most common location of the herniated disc is at L4-L5, followed closely by L5-S1, and then much less often at upper lumbar discs. If at L4-L5, the L5 nerve root is usually affected, resulting in pain down the back of the thigh to the lateral calf and anterior foot. If at L5-S1, the S1 nerve root is affected, with pain in the posterior calf and sole of the foot. The pain is usually worse with Valsalva maneuvers such as coughing, sneezing, or straining. Sitting is usually more uncomfortable than standing, although if the disc fragment has become dislodged from the main part of the disc, occasionally sitting is better. Lying down is commonly best, and night pain is not usually significant. Numbness, tingling, paresthesias, or other neurologic symptoms may accompany the pain. The patient often perceives the affected leg to be weaker than the other leg. Bowel and bladder disturbances are rare and should raise the possibility of a cauda equina syndrome.

If a higher lumbar disc is involved, the pain will radiate into the anterior or medial thigh, and more proximal muscles will be involved, such as the quadriceps in an L3-L4 herniation. Pain down the back of the thigh that stops above the knee should not be considered as sciatica, since it is usually referred pain from the annulus or other spinal problems.

On examination, the patient may limp on the affected side. Commonly, a list or bend to the opposite side is seen, as if the patient does not want to press on the affected nerve by leaning toward it. Depending on the nerve root involved, various combinations of weakness may be encountered, such as inability to walk on the toes for an L5-S1 herniation or on the heels for an L4-L5 protrusion. Reflex changes may be present, such as loss of the ankle reflex at S1. Muscle spasm may be present in the lumbar spine. The straight leg raising test (SLR) is usually positive for lower lumbar herniations, because the nerve root is stretched over the irritating cartilage lump with this maneuver. However, this test becomes less reliable in patients over the age of 40. For upper lumbar herniations, the reverse SLR (stretch of the femoral nerve) may be positive. A positive bowstring sign (tenderness of the sciatic nerve or branch behind the knee) with SLR is often present, especially in young patients. Finally, a crossed SLR, in which straightening one leg causes radicular pain in the opposite affected leg, is 99% specific for a herniated disc.

Laboratory workup of a suspected herniated disc is relatively straightforward. Plain x-rays are rarely useful because discs are invisible to plain x-rays. The MRI has become the gold standard in visualizing the cord, dura, nerve roots, and discs, but because of the relatively high false-positive rate, any findings must be correlated with the history and examination. CT scans are useful but not as

distinct as the MRI. Bone scans and blood tests are not helpful, except to rule out other diagnoses such as spondylolysis or spinal infections.

Once the diagnosis of an acute herniated disc has been made, treatment is initially conservative. Approximately 80% of patients will be successfully treated with conservative (nonoperative) methods of which there are innumerable types. Rest is advised for the acute episode, with analgesics, NSAIDs, and muscle relaxants provided short-term. One study showed that 2 days of bedrest were as effective as 2 weeks, so prolonged bedrest should be discouraged. Activity should be at whatever level the patient can withstand without undue pain. Physical therapy may help regain spinal motion and muscle strength but has not been shown to heal the disc more quickly. Currently in vogue is the McKenzie approach with enforced extension of the spine. Modalities such as heat, ultrasound, massage, transcutaneous electrical nerve stimulator (TENS) units, and electrical stimulation may make the patient feel better but have not been subjected to prospective trials. In fact, a recent Health Care Financing Administration (HCFA) report states that these methods should be discouraged because they do not work.

One study has shown that short-term chiropractic manipulation may have a role in the treatment of acute back pain with or without sciatica. Rolfing, acupuncture, herbal therapy, moxibustion (heated glass globes applied to the skin), and other nontraditional therapies have many adherents and may be tried at the clinician's discretion but have not been rigorously tested.

If an adequate trial of effective conservative treatment has failed, if the patient is getting rapidly worse, or if the clinician deems it beneficial, epidural steroids may be effective. As noted above, disc tissue is inflammatory to nerve tissue, so washing out or suppressing the inflammatory products around the herniation may have a role in reducing nerve pain. Steroids can be given orally but may have complications in the gastrointestinal tract or endocrine system. Classically used are epidural steroids in which a large volume of steroid solution is infiltrated into the epidural space, but because of the location of most herniations, these injections may not reach the site of nerve root irritation. The most efficient method for delivery of steroids to the nerve root is via selective extraforaminal nerve block, after the offending disc and nerve root have been located by scanning. This requires fluoroscopy and technically is more difficult than epidural steroids but is more effective. Ordinarily, injected steroids are used for an acute attack of radiculopathy caused by a herniated disc, but it should be noted that a prospective randomized trial failed to find any significant difference between steroids and placebo.

If the aforementioned treatments fail, surgical disc removal is an excellent option. Standard discectomy formerly consisted of a large laminectomy, big incisions, and muscle trauma. Currently, microdiscectomy with loupe or microscopic magnification has become standard, with incisions less than 5 cm long, unilateral exposure, and 1-day hospitalizations. In this operation, only the disc fragment that is in direct contact with the nerve root is removed, and fusions are not indicated. Results in most series have been 85 to 95% good to excellent with early return to work. Leg pain, not back pain, is the symptom best relieved by this procedure. Muscle strength often improves, but numbness and reflex loss may persist no matter what the treatment. A few complications can occur with this operation. General anesthesia is usually required, although a few surgeons operate under local anesthesia. Nerve injury can occur with a rate of less than 2%, and infection can happen with any open procedure. The smaller incisions carry an increased risk that a significant piece of disc will be missed, resulting in failure to relieve pain and a subsequent need for reoperation. Endoscopic discectomy is still investigational at this point but may soon be perfected. Chymopapain, popular in the 1980s, has been withdrawn secondary to anaphylactic reactions to the enzyme. Recent enthusiasm for laser discectomy, in which the center of the

disc is dissolved by laser light, has waned with the relatively high complication rate of nerve injury. Thus, the excellent results make microdiscectomy the procedure by which all others will be measured.

Finally, the rare but significant clinical problem of cauda equina syndrome must be noted. If a disc herniation occurs in the midline, compression of the thecal sac and central (sacral) nerve roots will occur. If the disc herniation is large enough, the sacral nerve roots will cease to function, leading to loss of bowel and bladder control, and saddle (down the back of both legs) anesthesia. This is a true surgical emergency, because the longer the nerve roots are compressed, the slower is the recovery. Thus, any patient who presents with bilateral leg pain or neurologic dysfunction and sphincter control difficulties requires an immediate MRI scan and surgical decompression.

INFLAMMATORY BACK PAIN

The most common systemic inflammatory disorder to involve the lumbar spine is ankylosing spondylitis. This disorder characteristically starts in the sacroiliac joints, most commonly and severely in young males. The lumbar facet joints can be the first involved, and peripheral joints are only involved later in an outward radiating (hips, knees, ankles) fashion. Thus, the initial symptom reported most often is low back or buttock pain. Rarely is there any radicular component, because the nerves are not involved. Morning stiffness is extremely common, and improvement with activity or exercise should make the clinician suspect this diagnosis.

On examination, patients with ankylosing spondylitis are stiff; thus, the original common name was "stiff man" syndrome. Forced motion in the sacroiliac joints (Faber test) will usually be painful, and the range of motion of the lumbar spine and the hip joints are usually less than predicted. The neurologic examination is normal, as are all blood tests except for HLA B-27. This marker occurs in approximately 20% of the normal population but occurs in 99% of patients with ankylosing spondylitis.

X-ray evaluation of the lumbar spine and pelvis will often show sclerosis of the sacroiliac joints. Later in the disease process, the lumbar vertebrae show a characteristic squaring off of the normally rounded upper and lower vertebral endplates. As the disease progresses, the discs in the spine, both lumbar and eventually thoracic and cervical, become ossified, limiting spinal motion and functionality and turning the spine into one long bone. Occasionally, a bone scan is required initially that will show significantly increased uptake in the pelvis and sacrum around the sacroiliac joints.

Treatment initially is with NSAIDs. Response to indomethacin is often dramatic, and occasionally a patient will require up to 150 mg/day to alleviate stiffness and pain. Physical therapy should be advised to teach flexibility and postural exercises, but will not stop the disease process. In fact, nothing currently available stops the inexorable ossification of the lumbar discs. Thus, the patient should be encouraged to remain as active as possible and, most importantly, to maintain an upright posture, because the spine will eventually ankylose in whatever position is typically assumed. Braces may help enforce a good posture but should not be worn all the time, because this fosters dependence on the external support and weakens muscles.

Surgical treatment of the spine is hazardous at best. Ordinarily, this is reserved for patients with extreme kyphosis in the neck or lower back who cannot look ahead or keep their balance. The procedures involve osteotomies (breaking the spine under anesthesia) followed by realignment and fusion with instrumentation. This is risky in terms of blood loss and infection and, most significantly, to the spinal cord in which many cases of iatrogenic quadriplegia have been reported.

Because the spine eventually becomes one long bone, fractures with even trivial trauma can have catastrophic results. When the spine is fractured, the two ends form large levers, and any movement can make the broken ends move, damaging the spinal cord. Thus, any

patient with ankylosing spondylitis involved in trauma, even a minor fall, who complains of increased spine pain should be assumed to have a fracture until ruled out. This may require sophisticated x-rays, CT scan, or even a bone scan to delineate the anatomy; therefore, the evaluation is best performed by a center with experience in trauma.

Other inflammatory diseases such as Reiter's syndrome, rheumatoid arthritis, Lyme disease, and polymyalgia rheumatica can rarely involve the spine. Rheumatoid arthritis in the spine is almost always confined to the cervical spine. The diagnosis of these other conditions will usually be suspected before thoracolumbar spine involvement. Treatment is that which is appropriate for the generalized disease process, i.e., antibiotics for Lyme arthritis, medications for rheumatoid arthritis, etc.

SPONDYLOSIS (OSTEOARTHRITIS OF THE SPINE)

Many anatomic, physiologic, and radiographic changes occur in the normal spine as it ages. Thus, separating out what is part of the normal aging process from what may be clinically significant in any individual patient is often problematic. Almost everyone over the age of 50 will have radiographic evidence of degeneration either in the disc, facet joints, or bones. Yet, the prevalence of low back pain is actually lower in patients over the age of 50 than in people from 30 to 50 years old.

However, a small number of patients will suffer from what is eventually diagnosed as spondylosis (not spondylolysis). These patients are usually over the age of 50, and the pattern of pain is akin to the complaints seen in any other arthritic joint. Commonly, these patients present with low back pain referred to the buttocks and posterior thighs. Any radiation below the knees should raise the suspicion of spinal stenosis (see below). Morning stiffness is extremely common, and the pain is usually aggravated by extension of the spine as more pressure is transferred to the facet joints during extension than flexion. The pain is not aggravated by Valsalva maneuvers, and aerobic exercise such as walking usually improves the pain. It is also important to inquire about night pain, worsening pain, and systemic factors so as not to miss one of these red flags that might indicate a more serious disorder.

On examination, range of motion of the spine is usually restricted. It is vital to check the range of motion of the hips when evaluating these patients, because concomitant osteoarthritis of the hips may turn out to be the true cause of the buttock and thigh pain, and can be markedly helped by hip replacement. The neurologic examination is usually normal. Radiographs of the lumbar spine characteristically show severe degeneration of the facet joints and discs. Decreased lordosis on the lateral x-ray and degenerative scoliosis on AP x-rays are common. Unless there are associated neurologic findings or symptoms, MRI is not indicated. CT scans can be helpful in preoperative planning, although routine use in the evaluation is not indicated. Most importantly, a thorough search must be made for more serious spinal or extraspinal causes before ascribing the patient's symptoms to osteoarthritis of the spine.

Treatment is analogous to the treatment of any arthritic joint. NSAIDs are often beneficial but must be taken at an adequate dosage, and the type of NSAID must be chosen that does not cause side effects such as gastrointestinal irritation or fluid retention. A once-a-day NSAID is best so that the patient does not become confused. Additionally, the patient must be instructed that the NSAID is a true medication to be taken on schedule, not just p.r.n. (when necessary) as often occurs. Lumbar supports, such as a corset or occasionally more rigid lumbosacral plastic orthosis, may help in alleviating symptoms, especially when the patient does not want to give up a painful activity such as gardening, etc. The support must not be worn all the time. Bedrest is absolutely contraindicated.

Exercises, whether supervised by a therapist or on their own, are helpful. Pool therapy is beneficial because it improves aerobic fit-

ness, range of motion, and general health. Logistically, it may be difficult. Once serious spine pathology has been ruled out, the patient should be encouraged that this is not a serious life-threatening condition, and that whatever activities the patient likes to do that do not cause significant pain are appropriate. In general, most patients are able to accommodate their lifestyle so that they can live with any restrictions.

Surgery is rarely helpful, except in cases of extreme deformity such as rapidly collapsing degenerative scoliosis, or in the case of concomitant spinal stenosis.

SPINAL STENOSIS

Spinal stenosis is closely associated with spondylosis. Technically, this term indicates any condition that causes decreased caliber (diameter) of the lumbar spine whether caused by tumor, fracture, or osteoarthritis, etc. By common use, it has come to mean the clinical syndrome of decreased lumbar spinal canal size caused by disc and facet degeneration or, occasionally, by a disc herniation in an older patient.

As noted above, as the spine ages, degeneration occurs in the facet joints and discs. This degeneration causes infolding of the ligaments and other soft tissues around the spinal canal, as well as hypertrophy of the facet capsules and bony osteophytes in the facet joints. When the spinal canal diameter is narrowed below 100 mm^2, the clinical picture of spinal stenosis usually occurs (Fig. 5.9).

Patients with spinal stenosis present with low back or leg pain in the upright position. Characteristically, they can walk upright only for a limited distance and then must either sit or otherwise bend at the waist to alleviate pain. This is because the upright position narrows the spinal canal slightly in everyone; a patient with a restricted spinal diameter caused by spinal stenosis then effectively shuts off the blood flow to the spinal nerve roots and dorsal root ganglia, which become ischemic. This results in pain in the back and legs that is relieved only by re-establishing blood flow to the nerve roots by flexion of the spine.

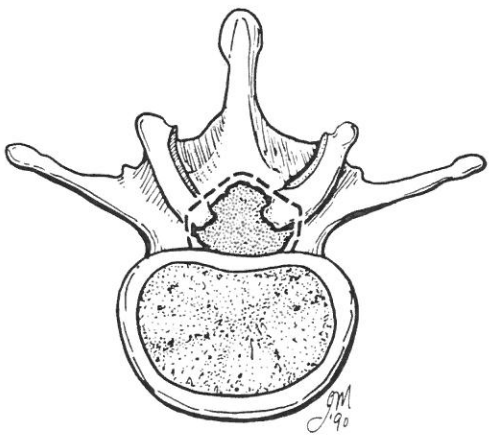

Figure 5.9. Spinal stenosis. Facet joint hypertrophy with thickening of the capsule and ligamentum flavum diminishes available space of the cauda equina. The dotted line marks the normal shape of the canal.

These patients can walk a reproducibly specific distance before stopping. They often lean on the cart in the grocery store and avoid prolonged shopping or standing because of the pain. Loss of bowel or bladder control is not associated with this condition, because the dorsal root ganglia for the sacral nerve roots are never involved. Valsalva maneuvers are not usually provocative of the pain. There may be a history of relative waxing and waning of the symptoms, but usually the distance walked has been gradually decreasing for months or years. Physical examination is usually not particularly helpful. The neurologic examination is usually negative, except that prolonged extension may cause symptoms. Range of motion of the hips should be checked to rule out painful osteoarthritis of these joints. It is important to check the pedal pulses, because vascular claudication can cause the same symptoms. In fact, the leg pain of spinal stenosis is commonly called pseudoclaudication. To differentiate these two, the provocative maneuver should be determined. In spinal stenosis, the patient bends forward to relieve the pain, whereas in vascular claudication, the patient simply stops to rest the legs without having to bend forward. If there is any doubt, noninvasive vascular studies can be checked to

determine arterial insufficiency. Significantly, patients with spinal stenosis cannot walk far upright but can often bicycle for long distances, since the spine becomes flexed in bicycling.

Radiographs are not helpful except in the case of degenerative spondylolisthesis. This condition usually occurs in older women and results from degeneration of the facet joints, most often at L4-L5. The forward slippage of L4 on L5 can result in pinching of the spinal canal and symptoms of spinal stenosis. The imaging study of choice is the MRI because it will show the spinal canal, nerve roots, discs, and joints. The true diameter of the canal can be determined, because cross-sectional areas below 100 mm^2 are highly correlated with the clinical symptoms of stenosis. The CT scan is a good alternative, especially when the bony anatomy is to be evaluated. Blood tests are normal, except in the case of other spinal or systemic pathology. Spinal stenosis is one disease in which EMGs are important to rule out peripheral neuropathy from diabetes or other neurologic disorders. Surgical treatment will not be helpful if the problem is caused by an intrinsic neurologic disease with coexistent spinal stenosis.

Treatment falls into one of three categories. Conservative treatment includes NSAIDs and a graded exercise program. Education is paramount. Often, the patient is relieved to hear that they do not have a serious spinal disorder such as cancer and are relatively happy adjusting their lifestyle to accommodate their walking restrictions. Lumbar corsets usually are not helpful and in many cases will make the symptoms worse by forcing the spine into an extended position. Physical therapy is rarely helpful except as an encouragement to exercise. Many patients cannot walk long distances but can bicycle or swim for extended times because these activities do not extend the spine. Thus, this type of exercise should be encouraged. Basically, the patient is instructed to listen to their back but to remain active. There is no need to restrict activities beyond those that are significantly painful. Spinal stenosis can be accommodated for many years without any drastic treatment necessary if the patient is happy with this situation or if there are major risk factors to more invasive treatment.

A second line of treatment is epidural steroids. Because part of the pathologic condition is inflammation or swelling of the facet joints, discs, and nerve roots, reduction of this inflammation may have a salutary effect in spinal stenosis. Commonly, epidural steroids are given as a series of one to three injections in the midline over a 6-week period. Results can be up to 60% long-term relief, although the injections may have to be repeated 6 to 12 months later. Many patients are happy receiving an occasional series of epidural steroids for the bad times and accommodating to the other less severe periods.

If all methods of treatment fail, surgery is an appropriate last resort. Decompression combined in some cases with fusion has an 80 to 90% success rate initially, although in one series these results deteriorated with time. The aim of surgery is to increase the distance the patient can walk without symptoms so that activities such as shopping, golf, walking, or hiking can be resumed. Often, a gratifying improvement in the patient's outlook, activities, and enjoyment of life can be achieved with this relatively safe surgical decompression. The risks of surgery are primarily those associated with general anesthesia and blood loss, and neurologic complications are rare. The major deficiency is that surgery does not cure concomitant neurologic disorders such as diabetic neuropathy, occasionally responsible for a poor surgical outcome.

OSTEOPOROTIC COMPRESSION FRACTURES

Compression fractures are a significant problem in elderly patients, second only to fractures of the hip as a source of morbidity in this group. Significant loss of trunk height is extremely common as people age, due to multi-level disc degeneration and to symptomatic or asymptomatic thoracolumbar compression fractures. Unfortunately, little can be

done to prevent these from occurring other than to treat osteoporosis as a systemic disorder. This treatment classically involves weightbearing exercise, effective hormonal replacement in the appropriate patient, calcium supplementation throughout life (especially important in younger women), and treatment of other conditions that cause osteoporosis such as hyperthyroidism and hypothyroidism, prolonged steroid use, hyperparathyroidism, calcium and vitamin D deficiency, etc.

Compression fractures remain a significant problem in today's elderly. The patient usually presents with the acute onset of upper or lower back pain, often following a trivial injury. Neurologic complaints or symptoms are rare except in longstanding severe kyphosis. Many times, the patients present only with a slowly developing loss of truncal height or are brought in by family members because they are "shorter than they used to be." At this point, x-rays will show the compression fractures; however, the age of the fracture cannot be predicted from an x-ray. In general, if there is an acute event, it must be presumed that the fracture is new. The most important part of the evaluation is to workup the patient for treatable causes of osteoporotic fractures such as multiple myeloma or other etiologies. One cannot simply assume that a compression fracture is due to postmenopausal osteoporosis until other causes have been eliminated.

Treatment of the acute fracture remains supportive. A brace can be comfortable, provided it does not aggravate any symptoms of spinal stenosis, and it is eventually weaned off. Pain medications should be prescribed, but avoiding dependency may be difficult. Gradual resumption of full activities should be encouraged. Swimming or pool therapy may help the patient increase aerobic fitness most rapidly. Bedrest is absolutely contraindicated because bedrest will result in a patient never regaining functional activities. Obviously, any treatable symptoms should be treated aggressively. With the recent introduction of effective medical treatments for osteoporosis, such as hormonal therapy and alendronate, osteoporotic compression fractures may be less of a clinical problem in the future.

MISCELLANEOUS CAUSES OF LOW BACK PAIN

There are innumerable other causes of low back pain. A partial list includes intrinsic spinal problems such as acute fractures, scoliosis, and muscle strains. Extrinsic causes include gynecologic problems, renal abnormalities (infections, tumors, kidney stones), retroperitoneal tumors (pancreatic cancer), aortic aneurysms, and occasionally cardiac etiologies. Most of these will be obvious based on the other systemic signs present.

After the full workup is pursued, and no specific diagnosis can be made, the clinician is left with the dilemma of what is the cause of the low back pain. It has been estimated that the full workup detailed in the preceding text will yield a specific diagnosis in less than 50% of cases. Without a specific diagnosis, nonspecific treatment occurs.

Many theories exist as to the true etiology of nonspecific low back pain. In the acute situation, it is commonly labeled low back strain or sprain, implying injury to the muscles or ligaments, respectively. As anyone who participates in athletics knows, muscular strains or sprains rarely last longer than a few days, or at most, a few weeks. Thus, calling acute low back pain that is caused by a specific injury a sprain or strain is adequate for the first few weeks, but thereafter it must be caused by another factor.

Currently, the favored causative structure is the disc. Because the outer third of the annulus is innervated, tears or irritation of the outer annular fibers can be felt as low back pain. Thus, a commonly used synonym for low back strain is discogenic low back pain, similar to the pain encountered in an acute disc herniation but without the radicular component. Characteristically, the pain presents with the acute onset of back or buttock pain after a twisting, bending, or lifting injury. This is especially true for compensable situations such as at work or after a motor vehicle

accident. Low back pain is most common in ages 30–50, with a bell-shaped curve on either side of the age distribution. Usually, a severe initial episode occurs followed by the development of a chronic ache or pain in the low back, buttocks, or posterior thighs. The pain is normally aggravated by maneuvers that increase pressure on the disc, such as carrying, lifting, or twisting. Bending forward and sitting, which doubles the pressure in the disc, are especially painful, whereas extension and lying down usually relieve the pain. Often, the patient is stiff in the morning, after which the pain is tolerable until later in the day when, as the disc is compressed with upright activities during the day, the pain worsens again. The patient may have had prior episodes of back pain, and the family history is often positive for relatives with similar problems. Again, during the history phase of the workup, the presence of red-flag symptoms must be sought to direct the workup towards more serious pathologic etiologies.

On examination, the patient is usually uncomfortable. Muscle spasm may be present in the more acute situation, but no masses should be palpable. There may be a list or involuntary bend away from the affected side, if there is one. The neurologic examination is usually normal or noncontributory, and straight leg raising will cause low back pain, not sciatica. Physical signs for other etiologies must be sought. Waddell signs are especially important to detect the presence of malingering or functional overlay, which will decrease effectiveness of treatment and herald a poor prognosis for recovery.

Laboratory tests are almost always normal, with the exception of the x-ray and MRI, which will show nonspecific age-related changes. Most importantly, any suspicion of a more dangerous etiology such as infection, tumor, etc., should prompt laboratory investigations in that particular direction.

To confirm the diagnosis of discogenic low back pain, an old test called discography has once again become popular. Originally used in the 1960s to confirm disc ruptures before the advent of axial imaging (CT scanning), discography fell into disrepute when Holt found a high false-positive rate in asymptomatic convicts. As currently performed, discography involves placement of a needle under sterile conditions into the lumbar discs, usually L3-L4, L4-L5, and L5-S1. Hypertonic dye is then injected under fluoroscopic control, and the morphologic appearance of the inner nucleus is visualized radiographically. Any leakage of dye from the nucleus into or through the annulus can be seen, indicating a tear in the annular fibers. Most importantly, the patient is questioned blindly as to whether each injection reproduces their low back pain, which is then graded as concordant (for the exact pain), similar, dissimilar, or none. Reproduction of the patient's typical pain (concordant) confirms the diagnosis of that disc as the source of the problem. Discography is thus a useful test to indicate the diagnosis. Complications include infection (less than 1%), nerve injury, and inadvertent cerebrospinal fluid leakage if needle placement is incorrect. This procedure is also intensely painful because it aims to reproduce the patient's pain.

Anecdotal evidence recently has shown that steroid injection into the painful disc at the time of discography may help a significant percentage of patients, some for prolonged intervals. However, no prospective trials of intradiscal steroids have been published. The problem with discography arises from the dilemma of what treatment to follow after delineation of the painful lesion.

Because back pain is so common, treatment of low back pain has been extremely varied. Standard medical treatment includes brief periods of bedrest in the acute situation with NSAIDs, muscle relaxants, or narcotic analgesics prescribed depending on the severity. Hospitalization should be avoided because it may foster the unfortunate idea that this is a serious medical condition. Prolonged bedrest is also contraindicated. Physical therapy is often helpful, both to improve lumbar range of motion as well as to show the patient that gradual resumption of exercise is beneficial. Modalities such as heat, ultrasound, and TENS units have never been proven effective

effectiveness.

in prospective trials, although they may make the patient temporarily feel well. Swimming or pool therapy is also beneficial, because the disc is weightless in water and may have time to recover. In well-run prospective trials, no specific conservative treatment has been shown to affect the course of discogenic low back pain, which is usually one of gradual recovery over 6 weeks in 80% of patients. Once the workup has eliminated the possibility of a serious underlying medical cause, the clinician should reassure the patient that the problem will gradually improve and that expensive or dangerous tests and invasive therapies are not indicated.

Failure of standard medical treatment has opened the door to all kinds of nontraditional "cures." Chiropractic treatment of low back pain has evolved considerably since its introduction by Palmer in the 1890s. Many patients report significant relief, sometimes long-lasting with a few simple manipulations. A recent prospective trial has shown higher success rates with a short course (not more than 6 weeks) of chiropractic care. Why this works has never been successfully explained, although manipulative therapy does alter positions and forces in the facet joints and discs. Other therapies include acupuncture, Rolfing, herbal therapy, moxibustion, fire walking, gravity boots, etc. None of these are proven, although if the patient experiences relief with any treatment that is nontoxic and not too prolonged or expensive, such treatment should be allowed. Insurance payment for these, however, may not be forthcoming. No treatment should delay the search for a more dangerous medically treatable disorder.

Aside from anecdotal reports of intradiscal steroids helping low back pain, spinal injections are rarely helpful for discogenic low back pain. If there is suspicion of spondylosis as the cause, facet injections may be diagnostically and sometimes therapeutically effective. Trigger point injections are invasive, costly, and do not help. Epidural steroid injections similarly are not indicated because of the risk of inadvertent dural penetration and unproven effectiveness.

Surgery has been uniformly ineffective to date. One study, a meta-analysis of all papers on spinal fusion for low back pain, documented a 54% rate of failure for posterior fusion, with a high reoperation rate. Additionally, posterior fusion, especially that involving the use of spinal instrumentation (screws and rods), is expensive. Radiographic fusion, which many surgeons use as the measure for success, can be technically achieved, but relief of symptoms often does not correlate with this achievement.

Recently, intradiscal fusion using threaded cages or screws has been advocated, performed either anteriorly, posteriorly, or laparoscopically through the abdomen. Preliminary studies are promising, but no long-term results are available, and only time will tell if these invasive therapies are successful. Disc replacement is on the horizon, but none have been successfully implanted in humans to date.

A brief word should be made about compensation-induced low back pain. In our litigious industrial society, low back pain is the most frequent cause of disability, costing up to $40 billion per year in direct and indirect costs. Clearly, there are some back injuries that are work related and should be covered. However, the majority of low back disabilities are prolonged by overreliance on expensive and dangerous therapies, and their duration is excessively lengthened by the adversarial nature of the legal process. Ideally, early institution of effective treatment and job modification or retraining should get the patient back to gainful employment as soon as possible with a minimum of cost to society. This is currently not the case, because the legal process drags the proceedings out for the benefit of the lawyers, clinicians, and therapists and to the detriment of the patient. Effective resolution of the problem is a societal and not a medical endeavor.

SUMMARY

This chapter hopefully will have given the clinician a useful algorithmic approach to the

investigation and treatment of thoracolumbar spinal disorders. Included in the suggested readings list are papers and books that the author has found helpful, should the reader desire more detailed or alternate sources of information.

SUGGESTED READINGS

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