Class Copy

8 Bone Tissue

Objectives

In this chapter we will study

- methods used to diagnose bone disorders;
- three noncancerous bone diseases—osteoporosis, osteomyelitis, and osteochondrosis; and
- four forms of bone cancer—osteosarcoma, chondrosarcoma, fibrosarcoma, and myeloma.

Diagnosing Bone Disorders

As living organs, bones are subject not only to fractures but also to several other diseases. Some of these are briefly described in your textbook (see *A&P,* pp. 248–54, including tables 8.3 and 8.4). The signs and symptoms of a disorder of the bone tissue per se can be difficult to distinguish from those of other skeletomuscular diseases, thus testing the diagnostic skill of a physician. Some of the procedures described in this chapter of the clinical manual also apply to chapters 9 and 10, which deal with the skeleton as a whole and the joints, respectively.

Pain is the most common symptom of a bone disorder, but patients often wait until other symptoms arise before seeking help. Such delay may allow the disease to reach a more advanced stage or to involve additional tissues or body structures. Pain alone does little to help a clinician make the proper diagnosis. The physical examination must include careful observation of the patient's gait and posture for clues as to which bones or joints are involved. Bone abnormalities can often be detected by palpation. In addition, various tests can aid diagnosis, including the following:

- **Imaging techniques** such as X rays and CT and MRI scans may reveal dislocations, tumors, and changes in bone size.
- **Bone scans** (densitometry) help detect bone cancers, infections, necrosis, trauma, degenerative bone diseases, and metabolic disorders that affect the skeleton. To perform a bone scan, the patient is injected with a radioisotope that has an affinity for bone. After allowing the radioisotope to accumulate in the bones, the pattern of gamma-ray emission is monitored. Diseased bones show a different pattern of emission than healthy bones.
- **Angiography** is the process of making an X ray of the blood vessels (see *A&P,* pp. 22–23). The circulatory system must be injected with a contrast medium, such as barium or iodine compounds, to enhance the visibility of the vessels on an X ray. Although this procedure is not limited to examination of the skeletal system, it is useful for evaluating the blood flow to the bones.
- **Hematologic tests** can provide clues to bone disorders by measuring the concentrations of enzymes and other chemicals in the blood serum. For example, an elevated concentration of alkaline phosphatase may indicate bone cancer or osteitis deformans. Bone cancer, fractures, and long-term immobility can raise the serum calcium concentration. Bone tumors raise the serum phosphate level.
- **Biopsy** is used to evaluate both the gross and microscopic anatomy of a small sample of bone.

Common Bone Disorders

A wide variety of disorders affect the bones, skeleton, and joints. Although these disorders can be difficult to separate, this chapter covers some of the common ones that primarily affect bone tissue itself.

Osteoporosis

Osteoporosis, discussed in your textbook (see *A&P,* clinical insight 8.4, p. 253), is the most common disorder of the skeletal system. In the United States alone, osteoporosis is estimated to cost billions of dollars per year, including treatment expenses and indirect costs such as lost work. Here we explore further aspects of this disease.

Osteoporosis is a metabolic disease in which the density of bone is reduced, but the remaining

bone has a normal proportion of minerals to organic content. The histology of the bone remains normal, but the amount of bone becomes inadequate to provide mechanical support for the body. Thus, a person with osteoporosis becomes increasingly susceptible to fractures, especially of the wrist and hip. About half the people who suffer hip fractures as a result of osteoporosis never walk again.

Osteoporosis mainly involves a loss of spongy bone; compact bone is relatively unaffected. Osteoporosis is caused by aging in 95% or more of patients, but it can also occur due to hormonal imbalances, immobilization (as when a limb is in a cast), bone tumors, lack of weight-bearing exercise, and prolonged space flight. When osteoporosis affects only a particular part of the body, such as one limb, it is called **regional osteoporosis.**

As noted in clinical insight 8.4, postmenopausal white women are at greatest risk for osteoporosis. Estrogen helps preserve bone mass by inhibiting the bone-dissolving action of osteoclasts, but after menopause the ovaries are inactive and estrogen is no longer secreted. In the absence of this inhibitory stimulus, bone resorption by osteoclasts increases and exceeds the bone deposition by osteoblasts. Thus, there is a net loss of bone mass. Other risk factors for osteoporosis are discussed in your textbook.

The clinical manifestations of osteoporosis depend on the bones involved. The first symptom is pain in the bones, often described as an aching back. This pain is short-lived, but is aggravated by weight-bearing, even standing. The patient often does not seek medical attention because the pain usually subsides within a few weeks. Blood tests show relatively normal circulating concentrations of calcium and phosphorus, but parathyroid hormone (PTH) concentrations are lower than normal. Chemical indicators of bone turnover are high, including urine levels of calcium and certain collagen derivatives released by the degenerating bone. The loss of bone density can be detected by X ray, but only after 25% to 30% of the bone mass has already been lost.

Treatment of osteoporosis is aimed at preventing further bone loss and halting the progression of the disease. Dietary intakes of calcium and vitamin D are prescribed to increase the absorption of calcium. Patients are advised to limit their intake of caffeine, alcohol, nicotine, and carbonated beverages. Regular, moderate, weight-bearing exercise is recommended to slow the loss of bone and in some cases to stimulate bone formation. Hormone replacement (estrogen and progestin) is recommended to decrease osteoclast activity in postmenopausal women. Estrogen does not significantly restore lost bone, but it slows the progression of the disease by inhibiting bone resorption. However, estrogen may increase the incidence of breast and uterine cancer for some women and is therefore not always an option. Other treatments include calcitonin, given by injection or in a nasal spray, as well as oral calcitriol and other medications to minimize calcium loss. Paradoxically, intermittent low doses of parathyroid hormone can increase bone mass. This is being explored as a possible treatment for osteoporosis.

Although patients with osteoporosis should exercise, they must also take precautions to avoid falling, which can result in fractures. As an early preventive measure, weight-bearing exercise and proper nutrition are now being encouraged for young girls in the hope that depositing a greater bone mass will protect them from osteoporosis in later years.

Osteomyelitis

Bone may become infected by viruses, bacteria, fungi, and parasites; bacterial infection of bone is called **osteomyelitis.** This is an especially difficult and expensive disease to treat because when bacteria invade the bone, they are relatively sheltered from the body's disease-fighting white blood cells and antibodies. Furthermore, the bacteria may secrete toxins that promote bone necrosis, and osteocytes are unable to significantly replace necrotic bone.

Osteomyelitis is classified according to the route of bacterial invasion. *Exogenous osteomyelitis* occurs when bacteria invade from outside the body—for example, through open fractures, wounds, or surgical procedures such as joint replacement. *Endogenous osteomyelitis* occurs when bacteria, most often *Staphylococcus aureus,* invade the bone from infected sites elsewhere in the body—especially from ear, sinus, cutaneous, and dental infections. This is a common complication of sickle-cell disease and animal bites.

In children, the inflammation induced by either type of osteomyelitis causes the periosteum to move away from underlying tissues. This "lifting" of the periosteum results in decreased blood flow and the subsequent necrosis and death of the infected area of the bone. Osteoblasts surround the

infected bone with new bone, but the openings in the newly synthesized bone allow pus to escape into the surrounding soft tissues. In adults, the periosteum is firmly attached to the bone surface, so this does not occur. Instead, the infection weakens the bone and makes it more susceptible to fracture.

Signs and symptoms of osteomyelitis vary depending on the infectious agent (type and source), duration (acute, subacute, chronic), site of infection, and age of the patient. Osteomyelitis is marked at first by relatively vague signs: low-grade fever, inflamed lymph nodes *(lymphadenitis),* and local pain and swelling. If the infection progresses, it causes high fever, nausea, pain, inflammation of the neighboring tissues, and muscle spasms. In chronic osteomyelitis, the long bones may develop large lesions, up to 4 cm in diameter, at their ends.

Osteomyelitis is diagnosed by means of radioisotopic bone scanning, CT, and MRI. Blood testing can also aid diagnosis since the disease typically produces an elevated leukocyte count. Osteomyelitis is treated by means of drainage and antibiotics. It may require drilling holes into the bone to allow for drainage and for antibiotics to reach the site of infection. In some instances, surgery is required to remove the exudate. If the infection occurs at the site of an artificial joint (prosthesis), the prosthesis may need to be removed in order to treat the surrounding bone.

Osteochondrosis

Osteochondrosis is a family of *avascular bone diseases* occurring in children—that is, skeletal deformities resulting from disturbances in the blood supply to the ossification centers of growing bones. It is still uncertain why the ossification centers sometimes lack a normal blood supply. Tissues around the area of bone necrosis become inflamed, joints are weakened, and bones may fracture at cartilaginous regions in and near the joints. The synovial membranes become inflamed and trigger pain and muscle spasms, often the first clinical signs of the disease. In the late stages of the disease, new blood vessels grow into the affected area and the bone is repaired. However, this restorative growth is structurally abnormal and may cause discomfort, a limp, and altered joint function. Younger children are more likely than older ones to realize a complete restoration of normal joint structure and function.

Bone Tumors

Bones are comprised of multiple tissue types, each of which can give rise to a tumor. Bone tumors are classified as osteogenic, chondrogenic, collagenic, or myelogenic, depending on whether they involve overgrowth of osseous tissue, cartilage, collagenous tissue, or bone marrow, respectively. Here we consider one example of each. Recall from your textbook that a *neoplasm* is any tumor (new, abnormal, nonfunctional tissue growth). Tumors may be *benign* or *malignant* (cancerous). All of the tumors we consider here are malignant neoplasms.

Osteogenic (bone-forming) tumors exhibit excessive growth of osseous tissue. The most common malignant osteogenic tumor is **osteosarcoma,** which accounts for 38% of all bone tumors. Osteosarcomas occur most frequently in adolescents and young adults, and they most commonly affect the humerus, femur, or tibia; half of the cases involve the knee. The tumor is usually found in the bone marrow, but it also has highly destructive effects on the surrounding bone. The growing tumor eventually breaks through the bone surface and lifts the periosteum from the bone. This triggers bizarre abnormal bone growth at the surface. The area becomes progressively painful and swollen. The tumor is treated primarily with surgery; chemotherapy and reconstructive techniques are helpful in reducing the need for amputation.

Chondrogenic tumors produce excessive growths of cartilage or a cartilage-like substance called chondroid tissue. **Chondrosarcoma,** the most common form (20% of bone tumors), usually occurs in people 50 to 70 years of age. It most often affects the femur and pelvis. The tumor is composed of large masses of hyaline cartilage and fibrous tissue. It erodes the bone, enlarges it, and often invades the joint cavity. The tumor can be surgically excised, but often returns. Therefore, amputation is often the treatment of choice.

Fibrosarcoma is a solitary collagenous tumor seen most often in the metaphysis of the femur or tibia. Its progression is from the inside of the bone out—that is, it begins in the marrow cavity, spreads to the compact bone, and eventually breaks through into the soft tissue around the bone. Fibrosarcoma often metastasizes to the lung. Radiotherapy is usually ineffective against fibrosarcoma; amputation or other radical surgery is generally necessary to save the patient.

Myeloma, responsible for about 27% of bone tumors, is the malignant proliferation of certain immune cells called *plasma cells*. About one out of six patients exhibit *multiple myeloma,* the presence of more than one tumor. Myeloma is common in people over 40 and is more common in males than in females and in blacks than in whites. The progression of myeloma is opposite that of fibrosarcoma—that is, it invades the bone from the outside in, eventually invading the marrow. It causes increasingly severe pain that is often mistaken at first for arthritis or a herniated intervertebral disc. The prognosis is poor, and patients are generally treated only to relieve discomfort. Radiotherapy and chemotherapy are not very effective against myeloma.

Case Study 8 The Bike Rider with a Broken Hip

Susan is a 55-year-old woman who regularly exercises by riding her bicycle around her neighborhood and on trails in a nearby park. One day while she is riding, a dog runs across her path, causing her to fall. Susan lands heavily on her right side and feels a sharp pain in her hip as she tries to move. When she attempts to stand, she cannot put any weight on her right leg. Some joggers help her to a nearby bench and call for assistance.

When the emergency medical technicians arrive, they immobilize Susan's leg and check for additional injuries. Upon initial examination, it appears that Susan has some abrasions on her right side and a broken hip. The emergency team transports her to the hospital. There, the emergency room physician notes that Susan's vital signs are stable and that, with the exception of her injuries, she is in relatively good health.

Suspecting a fracture of the femur, the physician orders a series of X rays to determine the site and extent of the injury. Results show a nondisplaced oblique fracture of the neck of the femur. In reviewing her medical history, the physician notes that Susan is postmenopausal and not using steroid hormone (estrogen and progestin) replacement therapy. But because she is physically active, the physician believes the fracture may be pathological (caused by a disease) and suggests further testing. When Susan asks why he suspects a problem, he tells her that, considering her age, the fracture could have resulted from either osteoporosis or a bone tumor. The only way to confirm either diagnosis is to conduct further tests.

Susan consents to both a CT scan and bone densitometry. These scans reveal no tumors but a loss of bone mass, specifically spongy bone. The physician advises her to increase her dietary calcium intake to 1,500 mg/day, take vitamin D supplements, and decrease her intake of soft drinks, alcohol, caffeine, and nicotine. In addition, the physician recommends steroid replacement therapy to slow bone loss and other drugs to facilitate calcium absorption. He also encourages Susan to continue exercising once she recovers from the fracture.

The following day, surgery is performed to insert screws to internally fix the position of the femur and allow proper healing. The surgery is successful, and after a period of observation, Susan is released from the hospital. But approximately one week after the surgery, she begins to experience an increasing amount of pain in her hip. The surgical area feels warm to the touch and is redder than the surrounding tissue. Because she has an appointment with the surgeon the following day, Susan does not think she needs to visit the emergency room. But the next day at the surgeon's office, it is noted that her temperature is elevated and her lymph nodes are swollen. Blood drawn for evaluation shows an elevated concentration of lymphocytes. The surgeon orders a CT scan, which reveals a subperiosteal abscess at the surgical site.

The surgeon immediately hospitalizes Susan and prescribes antibiotics to fight the infection. In addition, a tube is inserted in the abscess to allow drainage. The surgeon tells Susan that if her condition worsens, a second surgery may be necessary to replace the screws. However, he feels that at this time antibiotics and drainage will suffice.

Honors Physiology
Skeletal System
Bone Tissue Case Study

Name: _____

Bone Diseases

As you read the case study, compare the following four bone diseases.

	Osteoporosis	Osteomyelitis	Osteochondrosis	Osteogenic Tumors
Cause of the disease				
Symptoms				
Methods used to diagnose the disease				
Treatment				

On a separate sheet of paper...

Based on this case study and other information in this chapter, answer the following questions.

1. Why does the emergency room physician suspect osteoporosis or bone cancer?
2. What would the CT and densitometry scans reveal if Susan had bone cancer rather than osteoporosis?
3. What is the relevance of vitamin D to Susan's prescribed course of treatment?
4. Describe the type of fracture Susan presents with.
5. Name the bone disease that develops a week after Susan's surgery. What are the signs and symptoms on which you base your answer?
6. Based on the information given, what is the likely source of Susan's bone infection?
7. John has chondrosarcoma of the tibia, and Marvin has chondrosarcoma of the pelvis. Why would John's prognosis be better than Marvin's?
8. Why would a bone tumor be a risk factor for a pathological fracture? How does a pathological fracture differ from a stress fracture?
9. Imaging techniques such as X ray, CT, and MRI are used to diagnose many bone disorders. Why do these tools play such an important role?
10. Why are osteochondroses more prevalent in children than in adults?

Selected Clinical Terms

chondrosarcoma A malignant neoplasm of cartilage or chondroid tissue of the skeleton, invading and weakening the bone.

fibrosarcoma A malignant neoplasm that arises from deep fibrous (collagenous) tissue and invades the bones and other adjacent tissues.

myeloma Malignant proliferation of plasma cells with destructive invasion of the bone.

osteochondrosis Bone necrosis, deformity, and weakness resulting from ischemia of the ossification centers.

osteomyelitis Bacterial infection of a bone.

osteoporosis A degenerative bone disease in which spongy bone is lost although the remaining bone is histologically normal; the bones become incapable of providing normal mechanical support and increasingly susceptible to fractures.

osteosarcoma A malignant neoplasm of the osseous tissue.

Hint:
use your graphic organizer & the reading to help answer these questions.