

1. Which of the following statements about open fractures is/are correct?

- A. Intravenous antibiotics should be administered as soon as possible.
- B. They should be regarded as an emergency.
- C. Wound closure is necessary within 8 hours.
- D. Systematic wound débridement and irrigation should be performed.
- E. They most often result from low-energy injuries.

Answer: ABD

DISCUSSION: Open fractures represent an orthopedic emergency. They result most frequently from high-energy injuries. Current treatment includes administration of intravenous antibiotics, systematic wound irrigation, and débridement with respect for the neurovascular bundles. Immediate wound closure is rarely indicated and should be performed once the wound contamination is determined to be low.

2. The goals of proper fracture reduction include which of the following?

- A. Providing patient comfort and analgesia.
- B. Allowing for restoration of length of the extremity.
- C. Correcting angular deformity and rotation.
- D. Enabling immediate motion of all fractured extremities.
- E. Providing a foundation for bone healing and union.

Answer: ABCE

DISCUSSION: The goals of fracture reduction include patient comfort and analgesia through stabilization of the bone ends. Furthermore, restoration of the length, angulation, and rotational alignment of the extremity should be achieved to allow proper union. Reduction does not, however, allow immediate motion for all fractures.

3. Which statement is true about the “three-column concept” of spinal fracture stability?

- A. An unstable spine consists of bone or soft tissue injury in a single column.
- B. An unstable spine involves injury to all three columns.
- C. Instability results from injury to two columns plus evidence of compression of the dural tube.
- D. Instability results from significant bone and/or soft tissue injury in two columns.

Answer: D

DISCUSSION: Denis developed a classification system for a thoracolumbar spine injury based on a three-column concept. In this system, the spine is divided into three longitudinal regions or columns: anterior, middle, and posterior. Although references to such “columns” is anatomically imprecise, the term is clinically useful in assessing the stability of the injured spine. In general, instability results when significant disruption is present in two of the three columns, regardless of the presence or absence of neurologic deficit.

4. All of the following statements are true of Jefferson's fracture of the atlas except:

- A. The injury results from an axial load to the cervical spine.
- B. The fracture fragments characteristically displace into the spinal canal.
- C. Neurologic injury is uncommon.
- D. Computed tomography (CT) best demonstrates the fracture's configuration.

Answer: B

DISCUSSION: Fracture of the atlas (Jefferson's fracture) occurs from an axial load, usually to the top of the head. The resulting forces fracture the ring of C1 and displace the fragments outward. This results in an increase in the cross-sectional area of the spinal canal at the level of injury. Neurologic injury is, therefore, unusual in this fracture. CT is the best roentgenographic study available to evaluate fractures of the atlas.

5. Which of the following statements about burst fractures of the thoracolumbar spine are correct?

- A. The injury most often occurs at the thoracolumbar junction.
- B. The injury results from axial loading of the spine, often with concomitant flexion.
- C. Anterior and middle column failure are always present in this injury.

D. Laminectomy provides satisfactory decompression.

Answer: ABC

**DISCUSSION:** Burst fractures result from axial compression of the spine, frequently associated with varying degrees of flexion. These injuries, which most often occur at the thoracolumbar junction, are characterized by circumferential expansion of the entire vertebra with failure of the anterior and middle spinal columns and in some cases, the posterior ones. Middle column failure in burst fractures results in retropulsion of the posterior superior portion of the vertebral body into the spinal canal. With marked retropulsion, compression of the dural tube occurs, often with associated neurologic deficit. Surgical procedures designed to decompress and stabilize thoracolumbar burst fractures can be performed through anterior or posterior approaches. The major site of compression is anterior, and for this reason laminectomy does little to relieve compression of the spinal cord over an anterior lesion. Indeed, laminectomy further increases the instability of the spine.

6. The neurovascular structure most commonly injured as a result of an anterior dislocation of the shoulder is the:

- A. Musculocutaneous nerve.
- B. Axillary nerve.
- C. Axillary artery.
- D. Median nerve.

Answer: B

**DISCUSSION:** The axillary nerve is at greatest risk for injury. Occasionally a more severe neurologic deficit can occur as a result of injury to the brachial plexus. Rarely has injury to the axillary artery been reported.

7. The classification of fractures of the proximal humerus is based on:

- A. The number of fracture segments and amount of displacement.
- B. The mechanism of injury.
- C. Presence or absence of associated dislocations.

Answer: A

**DISCUSSION:** The classification is based on fracture patterns involving the four “segments” of the proximal humerus (anatomic neck, surgical neck, and greater and lesser tuberosities). Fractures are one-, two-, three-, or four-part fractures, depending on the number of fracture segments and amount of displacement.

8. The radial nerve is at greatest risk for injury with which fracture?

- A. Fracture of the surgical neck of the humerus.
- B. Fracture of the shaft of the humerus.
- C. Supracondylar fracture of the humerus.
- D. Olecranon fractures.

Answer: B

**DISCUSSION:** The radial nerve lies in proximity to the humerus as it courses laterally at the junction of the middle and distal thirds of the shaft of the humerus. Therefore, it is at greatest risk of injury in shaft fractures. If radial nerve paralysis is present in association with this fracture, it is advisable to observe the patient since most nerve injuries recover spontaneously within 6 to 12 weeks.

9. The best method of treating a supracondylar fracture of the humerus in a child that is unstable when the elbow is flexed to 90 degrees is:

- A. Hyperflexion of the elbow to 130 degrees and casting.
- B. Open reduction and internal fixation.
- C. Percutaneous pinning.

Answer: C

**DISCUSSION:** Best results with this fracture are obtained with percutaneous pinning. Hyperflexion of the elbow usually achieves stability but incurs the risk of occluding arterial inflow and may cause permanent neuromuscular deficit. Open reduction is not indicated unless the fracture is irreducible or associated with a vascular injury.

10. Both-bone forearm fractures in adults are best managed by:
- Closed reduction and casting.
  - Closed reduction and application of an external fixator.
  - Open reduction and placement of intramedullary rods.
  - Open reduction and internal fixation with compression plates.

Answer: D

DISCUSSION: Studies have shown that function is best restored with less complications if open reduction and rigid fixation is achieved with compression plates. Closed reduction rarely achieves an anatomic position and some forearm rotation is therefore usually lost. External fixation is occasionally used in severe open fractures.

11. The most consistent sign of a fracture of the carpal scaphoid is:
- Wrist pain during attempted push-ups.
  - Diffuse swelling on the dorsum of the wrist.
  - Localized tenderness in the anatomic snuffbox.
  - Wrist popping on movement.

Answer: C

DISCUSSION: Wrist pain during attempted push-ups or diffuse swelling on the dorsum of the wrist may be caused by a variety of factors. Wrist popping on movement may be the result of carpal instability, subluxation of a tendon on extension and flexion of the wrist, or intra-articular problems such as an articular cartilage flap or a tear of the triangular fibrocartilage. Localized tenderness at the anatomic snuffbox (scaphoid) is the most consistent sign of scaphoid fracture.

12. A patient describes a fall on the outstretched hand during sports activities. Multiple radiographic views show no distinct fracture. He is tender to palpation in the anatomic snuffbox. The most suitable method of management is:
- Diagnose "sprained wrist" and apply an elastic bandage.
  - Diagnose suspected scaphoid fracture and apply a short-arm cast to include the thumb.
  - Apply a canvas wrist splint for immobilization.
  - Prescribe salicylates and permit continued activity.

Answer: B

DISCUSSION: If the patient sustained a fall on the outstretched hand and is tender to palpation in the anatomic snuffbox, fracture of the scaphoid should be suspected. Neither an elastic bandage nor a canvas wrist splint provides adequate immobilization for the scaphoid. A short-arm cast to include the thumb is the most appropriate treatment. Salicylates and continued activity would not treat scaphoid fracture. If no fracture is noted initially, the cast is applied and films are taken at 10 days to 2 weeks since nondisplaced scaphoid fractures are often more easily visualized at that time.

13. Median nerve compression syndrome in which the patient has motor weakness of the flexor pollicis longus and the flexor digitorum profundus of the index finger without alteration in sensibility is due to:
- Compression of the median nerve at the elbow by the lacertus fibrosus.
  - Compression of the median nerve in the axilla.
  - Compression of the anterior interosseous nerve by the arcade of Frohse.
  - Compression of the anterior interosseous nerve by an aberrant accessory forearm muscle.

Answer: D

DISCUSSION: Compression of the median nerve at the elbow by the lacertus fibrosus causes symptoms at more locations than just the flexor pollicis longus and flexor profundus at the index finger, since the entire median nerve is affected. Compression of the median nerve at the axilla affects both motor and sensory elements diffusely. The arcade of Frohse is a fibrous band at the origin of the supinator muscle. It can compress the posterior interosseous portion of the radial nerve but does not involve the median nerve. The anterior interosseous portion of the median nerve can be compressed by an aberrant accessory forearm muscle (Gantzer's muscle).

14. Total interruption of the radial nerve at midarm produces specific findings on physical examination. The most complete description of the neurologic deficit includes:

- A. Paralysis of the thumb extensors, interphalangeal joint extensors, extensor carpi radialis, and extensor carpi ulnaris.
- B. Paralysis of the extensor carpi radialis longus and brevis, abductor pollicis longus, extensor pollicis brevis, and extensor pollicis longus.
- C. Paralysis of the brachioradialis, extensor carpi radialis longus and brevis, extensor carpi ulnaris, thumb extensors, and metacarpophalangeal (MCP) joint extensors, and loss of cutaneous sensibility at the dorsal aspect of the thumb and index fingers.
- D. Paralysis of the brachioradialis, extensor carpi radialis longus and brevis, radialis, thumb extensors, finger MCP joint extensors, and flexor carpi radialis, and loss of sensation in the cutaneous distribution over the dorsal aspect of thumb and index fingers.

Answer: C

**DISCUSSION:** The extensor carpi radialis, extensor carpi ulnaris, and thumb extensors are innervated by the radial nerve. Although finger MCP joint extension is performed by the extensor digitorum communis muscle, which is innervated by the radial nerve, the interphalangeal joints of the fingers are extended by the intrinsic muscles in the hand, which are innervated by the ulnar and median nerves. The extensor carpi radialis longus and brevis, the abductor pollicis longus, and the extensor pollicis longus and brevis are all innervated by the radial nerve. However, answer B is not complete because MCP joint extension of the fingers and radial sensory deficit are not included. The brachioradialis, extensor carpi radialis longus and brevis, extensor carpi ulnaris, thumb extensors, and finger MCP joint extensors are all innervated by the radial nerve. The superficial radial nerve provides sensibility to the dorsal aspect of thumb and index finger in the dorsal radial aspect of the hand. The extensor carpi radialis longus and brevis and thumb extensors are innervated by the radial nerve. The superficial radial nerve provides sensibility at the dorsal aspect of thumb and index. Not included in answer D is the extensor carpi ulnaris. It should be remembered that although the extensor ulnaris is on the ulnar aspect of the wrist and uses the term ulnaris, it is innervated not by the ulnar nerve but by the radial nerve and would not function with complete interruption of the radial nerve at midarm. In addition, despite the fact that the wrist flexor on the radial aspect of the wrist is termed the flexor carpi radialis, it is not innervated by the radial nerve. It is innervated by the median nerve. Therefore, it should not be included in this list.

15. The most common physical findings in a patient with median nerve compression at the wrist (carpal tunnel syndrome) are:

- A. Diminished two-point discrimination and dryness of the index and long fingers.
- B. Atrophy of the abductor pollicis brevis and opponens pollicis.
- C. A positive percussion test at the wrist and a positive wrist flexion test producing paresthesias at the thumb, index, and long fingers.
- D. A weak grip in addition to hand cramping and difficulty writing.

Answer: C

**DISCUSSION:** While patients with carpal tunnel syndrome often complain of subjective symptoms such as numbness of the thumb, index, and long fingers, objective decreased sensibility is not usually present. Testing with von Frey filaments produces the most sensitive results. Decreased light touch is noted before decreased two-point discrimination. Dryness of the skin in the median nerve distribution is evident with severe injury to the nerve but not in the routine carpal tunnel syndrome. Although the abductor pollicis brevis and opponens pollicis are supplied by the motor branch of the median nerve, atrophy of these muscles is not seen until long-term median nerve compression has occurred. Symptomatic carpal tunnel syndrome without evidence of thenar atrophy has a greater frequency than the more severe median nerve compression, with demonstrable thenar atrophy. Percussion over the median nerve at the wrist producing paresthesias distally in the distribution of the median nerve and paresthesias caused by wrist flexion are two of the most common signs of median nerve compression at the wrist. Although patients with carpal tunnel syndrome intermittently complain of weak grip and dropping objects, cramping of the hand while writing and difficulty writing are not routine symptoms of this condition.

16. Which of the following describes the most desirable position in which to immobilize the hand?

- A. Wrist is flexed, MCP joints are extended, and IP joints are flexed.
- B. Wrist is flexed, MCP joints are flexed, and IP joints are extended.
- C. Wrist is extended, MCP joints are extended, and IP joints are flexed.

- D. Wrist is extended, MCP joints are flexed, and IP joints are flexed.
- E. Wrist is extended, MCP joints are flexed, and IP joints are extended.

Answer: E

DISCUSSION: Plaster splints and dressings should hold the digits in the “intrinsic plus” position. This includes 60 to 80 degrees of flexion at the MCP joints, 10 to 20 degrees of flexion at the proximal interphalangeal (PIP) joints, and 5 to 10 degrees of flexion at the distal interphalangeal (DIP) joints. With the MCP joints in flexion and the PIP joints in extension the collateral ligaments are elongated, thereby decreasing the likelihood of ligament contracture and subsequent joint stiffness. At times, however, the PIP joint is immobilized in greater flexion to correct palmar angulation and to maintain proper rotation of the digit after an unstable fracture.

17. An early sign of compartment syndrome in the hand includes:

- A. Pain with passive stretch of the digits.
- B. Absent radial pulse.
- C. Motor paralysis.
- D. Swelling of the digits.
- E. Stiffness of the digits.

Answer: A

DISCUSSION: Early sign of compartment syndrome is pain with passive motion. Paralysis occurs later, and absence of the radial pulse is an even later finding.

18. Palmar dislocation of the PIP joint with fracture:

- A. Is more common than dorsal dislocation.
- B. Is treated by splinting with the PIP joint in flexion.
- C. Is treated by splinting with the PIP joint and DIP joints in extension.
- D. If not splinted properly, will cause a boutonniere deformity.
- E. If not splinted properly will cause a swan neck deformity.

Answer: D

DISCUSSION: Palmar dislocation of the PIP joint is much less common than dorsal dislocation. Palmar dislocation of the PIP joint can disrupt the central slip of the extensor mechanism at the proximal part of the middle phalanx and can disrupt the dorsal capsule in addition to the palmar plate. If the joint is stable after reduction it is treated by splinting to immobilize the PIP joint in extension, while the DIP is allowed to actively flex. If not splinted properly, this injury can cause boutonniere deformity with resultant loss of normal PIP extension and hyperextension of the distal joint.

19. Fracture of the fifth metacarpal neck:

- A. Usually requires open reduction and internal fixation.
- B. Must be reduced anatomically and stabilized with pins.
- C. Is called a “boxer's fracture.”
- D. Will result in significant functional disability if angulated 30 degrees dorsally.
- E. Is uncommon.

Answer: C

DISCUSSION: Fifth metacarpal neck fracture is a common injury. It is termed boxer's fracture because the mechanism of injury is often that of hitting the fist against a firm object. This fracture does not need to be reduced anatomically and usually does not require open reduction and internal fixation. The relative mobility of the fifth metacarpal (as compared with the relative lack of mobility at the index and long fingers) allows excellent function despite dorsal angulation of 30 degrees.

20. A Bennett's fracture is:

- A. An extra-articular fracture of the base of the thumb metacarpal.
- B. Displaced by the pull of the abductor pollicis longus and adductor pollicis.
- C. Displaced by the pull of the abductor pollicis longus and extensor pollicis longus.

- D. Usually successfully treated with closed reduction and casting.
- E. A comminuted T-type fracture of the base of the thumb metacarpal.

Answer: B

**DISCUSSION:** A Bennett's fracture is an intra-articular fracture of the proximal end (base) of the thumb metacarpal. The resulting bone fragment is held by the intermetacarpal ligament. The base of the metacarpal is displaced laterally by the pull of the abductor pollicis longus. The adductor pollicis pulls the proximal phalanx and distal metacarpal toward the palm and the proximal metacarpal away from its adjacent fracture fragment. These forces acting on the fracture tend to displace the metacarpal, usually making cast treatment alone ineffective. Treatment is by percutaneous pinning if closed reduction can be achieved, or by open reduction and internal fixation if significant displacement cannot be corrected by closed methods. A comminuted T-type fracture of the base of the thumb metacarpal was described by Rolando.

21. A 39-year-old male presents in the emergency room after a high-speed motor vehicle accident. The patient has been intubated by paramedics at the scene and is on assisted ventilation. He is unconscious. Physical examination reveals a distended abdomen, and initial screening x-rays reveal a displaced fracture of the pelvic ring. Initial evaluation should include which of the following?

- A. Fluid resuscitation and establishment of venous access.
- B. Diagnostic peritoneal lavage.
- C. Thorough physical examination, including evaluation of the urinary and lower gastrointestinal tract.
- D. Emergent application of external fixation.
- E. CT of the abdomen.

Answer: ABC

**DISCUSSION:** This trauma patient has presented with a displaced pelvic fracture and a distended abdomen. In this setting, it is quite difficult to distinguish intra-abdominal trauma from abdominal distention related to a fracture of the pelvis and secondary bleeding. Diagnostic peritoneal lavage would be indicated as well as physical examination of the genitourinary and lower gastrointestinal tract to rule out an open pelvic fracture. Application of an external fixator for the pelvis would be withheld unless the patient became unstable. Without evidence of intra-abdominal trauma, pelvic bleeding is implicated as the source of instability. Imaging studies of the pelvis and abdomen would be indicated after the initial resuscitation.

22. A patient sustains a displaced fracture of both columns of the acetabulum with extension into the sciatic notch. The patient is initially placed in traction. After treatment of other associated injuries, pre-operative evaluation should include which of the following?

- A. CT evaluation of the acetabular fracture.
- B. Aspiration of the hip joint.
- C. Pelvic arteriography.
- D. Preoperative ventilation-perfusion lung scan.
- E. Prolonged bed rest.

Answer: AC

**DISCUSSION:** Treatment of a displaced fracture of both columns of the acetabulum requires careful preoperative evaluation, including CT with three-dimensional reconstruction, if the fracture anatomy is not clear from standard radiographic imaging. If an extended iliofemoral approach is considered, preoperative pelvic angiography should be performed to ascertain patency of the superior gluteal artery. For this approach, the flap is dependent on a superior gluteal artery for survival. Early operative intervention and expeditious mobilization decrease the incidence of pulmonary complications, and preoperative pulmonary evaluation is not indicated unless specific problems arise.

23. Which of the following statements about the blood supply to the hip are true?

- A. The medial femoral circumflex artery circles around to the posterior aspect of the hip, where it becomes confluent with the retinacular blood vessels.
- B. A small portion of the blood supply of the femoral head is provided by the obturator artery via the ligamentum teres.
- C. Displacement of a femoral neck fracture can disrupt the branches of the medial femoral circumflex artery.
- D. The retinacular vessels are supplied by the lateral femoral circumflex artery, which takes a posterior course.
- E. Muscular attachments to the periarticular bone structures provide blood supply to the femoral head.

Answer: ABC

**DISCUSSION:** The blood supply to the femoral head is provided predominantly by the branches of the medial femoral circumflex artery, which take a posterior course and are confluent with the retinacular vessels. The lateral femoral circumflex artery runs anteriorly.

24. A 24-year-old woman presents to the emergency room with a dislocated knee. In transferring the patient from stretcher to examining table, the knee is spontaneously reduced. Physical examination reveals no palpable or “Dopplerable” pulses in the foot on the affected side and booming pulses in the foot on the nonaffected side. Proper treatment would include which of the following?

- A. Doppler evaluation of the arteries in the lower extremity followed by arteriography if the Doppler study was abnormal.
- B. Magnetic resonance imaging (MRI) of the affected leg.
- C. Close follow-up examination.
- D. Emergent transfer to the operating room for exploration of the popliteal artery.
- E. Immobilization of the knee with gentle warming of the extremity and elevation.

Answer: D

**DISCUSSION:** An abnormal vascular examination after a documented dislocation of the knee indicates damage to the popliteal artery at the level of the knee dislocation. This is a limb-threatening injury that requires expeditious exploration of the popliteal artery to provide appropriate treatment and decrease the chances of vascular compromise leading to amputation of the extremity.

25. The Ilizarov device aids in management of tibial fractures because of its ability to:

- A. Stabilize acute fractures.
- B. Correct angular deformities in cases of malunion.
- C. Transport bone by distraction callotasis.
- D. Noninvasively provide fixation for juxta-articular fractures, such as the tibial plateau and pylon.
- E. All of the above.

Answer: E

**DISCUSSION:** The Ilizarov device is a very useful external fixation device that is versatile and has had a positive impact on the management of tibial fractures.

26. An 8 cm. by 10 cm. soft tissue defect over the proximal third of the tibia with exposed bone devoid of periosteum is best treated with:

- A. Skin graft.
- B. Gastrocnemius rotational myoplasty.
- C. Soleus rotational myoplasty.
- D. Free tissue transfer.

Answer: B

**DISCUSSION:** The proximal third of the tibia can be covered effectively with the gastrocnemius rotational flap using the medial hem of the gastrocnemius. The middle third can be successfully covered by the soleus myoplasty. Open fractures with soft tissue defects over the distal third usually require free tissue transfer because of lack of available local tissue coverage.

27. Prognosis of healing in tibial fractures correlates best with:

- A. Energy absorption at the time of fracture.
- B. Amount of soft tissue damage.
- C. Location of the fracture (i.e., in the proximal, middle, or distal third).
- D. Age of patient.

Answer: A

**DISCUSSION:** The amount of energy absorption and the degree of bony comminution is the most significant factor in predicting healing of tibial fractures. Location along the tibia and age are not thought of as significant factors in healing.

The soft tissue damage may contribute to lack of vascular envelope, but the destruction of soft tissue is based on the amount of energy absorbed.

28. Management of a III-b tibia fracture is best treated initially by:

- A. Plaster immobilization.
- B. Immediate plating.
- C. Reamed intramedullary nailing.
- D. External fixation.

Answer: D

DISCUSSION: Studies by Hansen and others have demonstrated that open reduction and internal fixation of Grade III-b or Grade III-c fractures are likely to cause more stripping of soft tissue and therefore further devascularize an already devascularized tibia. The external fixator is selected because it is a treatment apparatus that reduces and holds the bone fragments and provides important stability for soft tissue healing. Treatment of open wounds with a plaster cast is impractical and wound care is difficult. Reaming intramedullary nailing further compromises blood supply to the bone by destroying the intramedullary blood supply that may be critical to fracture healing.

29. The most frequent forces acting on the foot that cause ankle fractures are:

- A. External rotation.
- B. Internal rotation.
- C. Plantar flexion.
- D. Dorsiflexion.

Answer: A

DISCUSSION: Fractures most frequently involve external rotation of the foot and ankle joint, which is usually due to an internal rotation or twisting of the leg on a foot that is fixed by weight bearing. Axial loading injuries commonly produce distal tibia fractures.

30. Patients who have abduction injuries to the foot are prone to injure the following structures:

- A. Medial malleolus and deltoid.
- B. Lateral malleolus and deltoid ligament.
- C. Interosseous ligament.
- D. Posterior tibiofibular ligament.

Answer: A

DISCUSSION: If the mechanism of fracture is an abduction force, the medial malleolus fractures below or at the level of the ankle joint, and this may include tears of the deltoid ligament. These are usually accompanied by a fibula fracture as well.

31. Of the following bones in the foot, the tarsal bone that is most prone to vascular compromise is the:

- A. Calcaneus.
- B. Navicular.
- C. Talus.
- D. Cuboid.

Answer: C

DISCUSSION: The blood supply of the talus is somewhat tenuous because there are no muscles or tendons associated with this bone.

32. A Lisfranc fracture is a fracture-dislocation involving:

- A. Calcaneocuboid joint.
- B. Tarsometatarsal joint.
- C. Metatarsophalangeal joint.

D. Talocalcaneal dislocation.

Answer: B

DISCUSSION: The fracture can be either divergent, dorsal, or plantar. It usually involves a significant soft tissue injury that, if unrecognized, leads to ischemia of the forefoot and gangrene resulting in amputation.

33. The most common reason for surgical amputation in the general population is:

- A. Trauma.
- B. Tumor.
- C. Infection.
- D. Congenital deformity.
- E. Ischemia.

Answer: E

DISCUSSION: Congenital deformities leading to amputation are relatively rare, as are musculoskeletal tumors. Traumatic amputations are the most common in the younger population, but the majority of amputations are of the lower extremity and are caused by ischemia secondary to peripheral vascular disease. Approximately 50% of the patients suffering from extremity ischemia also suffer from diabetes.

34. The level of amputation in a dysvascular extremity is determined by:

- A. Clinical inspection.
- B. Xenon skin clearance.
- C. Doppler systolic blood pressure ratios.
- D. Transcutaneous oxygen measurements.
- E. Nutritional competence and immunocompetence.

Answer: ABCDE

DISCUSSION: Clinical competence of the extremity with observations of skin turgor, discoloration, perfusion, sensation, and integrity is the mainstay of surgical decision making. This can be complemented by transcutaneous PO<sub>2</sub>, ankle-arm systolic pressure ratios, xenon skin clearance, serum albumin levels, and total lymphocyte count.

35. Knee disarticulation has the following advantages over above-knee amputation:

- A. Longer lever arm.
- B. Better cosmetic result.
- C. Easier prosthetic fitting.
- D. End-bearing stump.
- E. Supracondylar suspension.

Answer: ADE

DISCUSSION: Patients with knee disarticulations have a slightly worse cosmetic appearance due to an inequality of knee heights particularly noticeable when sitting. Additionally, prosthetic fitting is significantly more difficult and requires the involvement of a prosthetist familiar with the specific considerations. On the other hand, the increase in lever arm, the end-bearing stump, and the use of supracondylar suspension far outweigh the disadvantages when such an amputation is possible from an anatomic standpoint.

36. Hematogenous osteomyelitis most frequently affects:

- A. The diaphysis of long bones.
- B. The epiphysis.
- C. The metaphysis of long bones.
- D. Flat bones.
- E. Cuboidal bones.

Answer: C

**DISCUSSION:** Hematogenous osteomyelitis occurs most frequently in children and involves the metaphyseal ends of long bones. The cause is thought to relate to the pattern of blood flow in the metaphysis wherein arterioles empty into numerous sinusoidal veins with sluggish blood flow favoring the lodgement of bacteria.

37. A 5-year-old child presents with a 2-day history of the atraumatic onset of pain, erythema, and swelling of the right knee joint. The child is febrile with an elevated white blood cell count. The differential diagnosis includes:

- A. Acute rheumatic fever.
- B. Leukemia.
- C. Scurvy.
- D. Acute septic arthritis.
- E. Acute juvenile rheumatoid arthritis.

Answer: ABCDE

**DISCUSSION:** All of the above conditions may present with the clinical and laboratory findings described above. Aspiration of the joint and examination of the synovial fluid is required to rule out pyogenic arthritis. Ancillary laboratory testing for juvenile rheumatoid arthritis and acute rheumatic fever may be required.

38. Skeletal tuberculosis is:

- A. Of historical interest only.
- B. Increasing in association with patients with human immunodeficiency virus (HIV) infection.
- C. Most frequently encountered at the thoracolumbar junction.
- D. Seen in the absence of visceral tubercular infection.

Answer: BC

**DISCUSSION:** Skeletal tuberculosis is still present and is occurring with increased frequency in patients with HIV infection. The thoracolumbar junction is most frequently affected. Skeletal tuberculosis is a sequel to pulmonary or gastrointestinal tuberculosis.

39. A radical margin in the resection of a musculoskeletal tumor removes:

- A. The entire limb.
- B. A 5-cm. margin of normal tissue around the neoplasm.
- C. The anatomic compartment in which the tumor arises.
- D. The joint adjacent to the neoplasm.
- E. The reactive capsule around the tumor.

Answer: C

**DISCUSSION:** A radical resection defines removal of the anatomic compartment in which the tumor arises and does not necessarily mandate an amputation.

40. The appropriate surgical procedure for the treatment of an osteosarcoma is based on:

- A. Staging information.
- B. The age of the patient.
- C. The response of the lesion to neoadjuvant chemotherapy.
- D. The radiographic aggressiveness of the lesion.

Answer: AC

**DISCUSSION:** The surgical treatment of an osteosarcoma is either amputation or wide excision with limb salvage. The decision to do a limb-salvage operation is based on the staging information and on the response of the lesion to chemotherapy. If staging studies indicate involvement of vital structures or if the response to neoadjuvant chemotherapy is inadequate, amputation may be selected rather than limb salvage. The age of the patient and the radiographic appearance of the lesion are not factors in this decision.

41. Which of the following statements about selection of an amputated part for replantation is/are correct?

- A. A good choice for replantation is an amputated thumb at the level of the proximal phalanx of the dominant hand of a 35-year-old salesman.
- B. The index finger should be replanted in an adult male if the amputation is at the base of the proximal phalanx.
- C. In a 12-year-old child with an arm amputated above the elbow by an avulsion injury, replantation should be attempted.
- D. In a 42-year-old male accountant with a complete amputation of the leg just below the knee, replantation should be attempted.
- E. Replantation is advisable for a 20-year-old male with a complete amputation at the proximal forearm with 11 hours of warm ischemic time.

Answer: AC

**DISCUSSION:** The thumb is a prime choice for replantation. If the patient is healthy replantation of the thumb is advisable at just about any level and any age. Amputations of fingers proximal to the flexor superficialis tendon insertion (middle phalanx) generally result in poor active digital motion, and in most adults isolated finger amputations at this level are not replanted. In general, in children replantation should be attempted at any level. Replantation of lower extremity amputations is seldom indicated in adults because of leg-length discrepancy, pain, and poor function. Prosthetic replacement usually results in a more functional gait. Replantation of a forearm amputated at the proximal forearm level is difficult because of the large amount of muscle mass and the multiple nerves entering the muscle. Additionally, over 6 hours of warm ischemia time at this level will most likely cause massive myonecrosis and replantation failure.

42. Which of the following statements about preservation of a completely amputated digit is/are correct?

- A. The amputated digit should be wrapped in a sterile, dry cloth and kept at body temperature.
- B. The amputated digit should be wrapped in a cloth moistened with saline or Ringer's lactate solution and kept at body temperature.
- C. The amputated digit should be wrapped in a clean cloth and placed directly on ice.
- D. The amputated digit should be placed in a plastic bag containing Ringer's lactate or saline solution, and the plastic bag placed on ice.
- E. The amputated digit should be wrapped in a cloth or sponge moistened with Ringer's lactate or saline solution and placed in a plastic bag to rest on ice.

Answer: DE

**DISCUSSION:** The amputated part must be kept cool (4° C or less) but not frozen. Cooling lowers the metabolic needs of the severed part, which allows replantation for up to 12 to 14 hours for major limb amputations and 24 to 36 hours for major digital amputations. The amputated part is preserved by one of the two following methods: (1) Place the amputated part in a plastic bag containing lactated Ringer's or saline solution and place the bag on ice or (2) wrap the amputated part in a cloth and place it in a plastic bag to be put on ice.

43. Which of the statements about major limb replantations (amputation proximal to the hand or foot) is/are correct?

- A. Bone shortening is usually necessary.
- B. If the amputation occurred more than 6 hours before arrival in the operating room some type of temporary vascular shunting is indicated.
- C. Primary closure of all of the skin is generally recommended.
- D. Myonecrosis is a common cause of failure of the replantation.
- E. There are few indications for replantation of the lower extremity in adults.

Answer: ABDE

**DISCUSSION:** Bone shortening of at least 2 cm. is critical in most major limb replantations, to allow thorough débridement of injured structures and approximation of normal tissue to normal tissue (e.g., nerve, vessel, and tendon repair). If the anticipated cold ischemic time for an amputated limb will exceed 6 hours before circulation can be re-established, a temporary silicone shunt should be applied. This is usually the setting, for rarely can the artery be reconnected within 6 hours of the amputation. Primary closure of all of the skin is rarely recommended. Because of the edema associated with reperfusion of the ischemic limb, tight skin closure can compromise the circulation. Skin grafts and/or delayed closure is indicated. Some degree of myonecrosis occurs in all major limb replantations. Thorough surgical excision of damaged muscle tissue diminishes the amount of necrosis. Excessive myonecrosis leads to infection and failure. There are few indications for replantation of lower extremities in adults. The amount of débridement and shortening that is necessary to obtain a viable lower extremity replantation results in excessive leg length discrepancy. Prosthetic replacement can result in a nearly normal gait, especially when the amputation is below the knee.

44. The most crucial elements of the flexor retinacular or pulley system needed for full digital flexion include which annular pulleys?

- A. A 1.
- B. A 2.
- C. A 3.
- D. A 4.
- E. A 5.

Answer: BD

DISCUSSION: The flexor retinacular system from the metacarpophalangeal joint to the distal interphalangeal joint maintains the flexor tendons against the digit during flexion, preventing bow stringing and allowing the digital tip to flex to the distal palmar crease. Division of the A 1, A 3, or A 5 pulleys minimally compromises this function; however, division of the A 2 or A 4 pulleys can significantly limit digital excursion.

45. Continuous passive mobilization following flexor tendon repair of Zone II injuries produces:

- A. Increased total arc of digital range of motion.
- B. Decreased incidence of poor results.
- C. Increased incidence of postoperative tendon rupture.
- D. Increased incidence of infection.

Answer: AB

DISCUSSION: Continuous passive mobilization (CPM) causes a 16% improvement in range of digital motion compared to intermittent mobilization. The incidence of poor results is much lower (3% versus 26%) despite no postoperative ruptures or infections. Continuous passive mobilization appears to be a more effective yet safe means of improving postoperative function following flexor tendon injury.

46. Isolated flexor digitorum superficialis tendon function is determined by assessing:

- A. Flexion of the metacarpophalangeal joint.
- B. Flexion of the proximal interphalangeal joint with the adjacent digits held in extension.
- C. Flexion of the distal interphalangeal joint.
- D. Flexion of the proximal interphalangeal joint.

Answer: B

DISCUSSION: Metacarpophalangeal joint flexion is effected by intrinsic flexor digitorum profundus or flexor digitorum superficialis contraction and therefore cannot be utilized to assess isolated flexor digitorum superficialis integrity. The flexor digitorum superficialis tendon, by inserting on the middle phalanx, acts to flex the proximal interphalangeal joint. Since the flexor digitorum profundus tendon inserts distal to this level, it may also flex this joint. To negate this influence of the flexor digitorum profundus, the adjacent digits should be passively maintained in full extension to isolate flexor digitorum superficialis function in the digit. Distal interphalangeal flexion is the isolated function of the flexor digitorum profundus. The proximal interphalangeal joint may be flexed by the flexor digitorum profundus or flexor digitorum superficialis.

47. The zone of flexor tendon injury that carries the poorest prognosis following injury and repair is:

- A. Zone I.
- B. Zone II.
- C. Zone III.
- D. Zone IV.
- E. Zone V.

Answer: B

DISCUSSION: Zone I extends from the distal margin of the flexor digitorum superficialis insertion to the flexor digitorum profundus insertion. Injury at this level involves only the profundus tendon. Zone II is defined as the proximal edge of the first annular pulley to the distal margin of the flexor digitorum superficialis insertion. At this level both the superficialis and

profundus tendons are contained in a rigid fibroosseous canal. The smooth gliding required at the interfaces at this level may be compromised by adhesions following injury, thus making this the level with the poorest functional prognosis after injury. Injuries in Zones III, IV, and V, at the level of the palm, carpal canal, and distal forearm, respectively, may injure both or either of the flexor tendons to a digit. However, because of a less constrictive environment at the levels, adhesions that limit motion are less likely and the prognosis better than with Zone II injuries.

48. The contraindications to primary repair of a flexor tendon injury are:

- A. Contaminated wound.
- B. Severe soft tissue trauma.
- C. Inexperienced surgeon.
- D. Compromised general condition of the patient prohibiting prolonged anesthetic.

Answer: ABCD

DISCUSSION: The prerequisites for primary repair (within 24 hours of injury) of a flexor tendon injury are (1) a clean wound or one that may be débrided to a clean status, (2) minimal soft tissue injury providing a relatively stable soft tissue environment, (3) a surgeon experienced in flexor tendon repair, (4) adequate anesthetic condition of the patient, and (5) appropriate supportive staff (operating room personnel). If all of these conditions are met, primary repair may be performed allowing accurate anatomic alignment and quicker rehabilitation. Delayed repair is indicated if one or more of these prerequisites are not met.

49. Principles to be considered when using open reduction and internal fixation include which of the following ?

- a. Anatomic reduction and fixation stability
- b. Maintenance of maximal soft tissue coverage and interposition between the device and skin surface
- c. Creation of fixation constructs that minimize load shielding of the underlying bone
- d. Maximal maintenance of periosteal and vascular tissue without compromising stability

Answer: a, b, c, d

When open reduction and internal fixation treatment are chosen, the following principles should be considered: 1) maximal maintenance of periosteal and vascular tissues without compromising stability; 2) anatomic reduction and fixation stability; 3) the use of high strength biocompatible implants; 4) the creation of fixation constructs that minimize load shielding of the underlying bone; and 5) maintenance of maximal soft tissue coverage and interposition between the device and skin surface.

50. Serum proteins that have been demonstrated to influence bone induction include:

- a. Platelet-derived growth factor
- b. Transforming growth factor-b
- c. Osteogenin
- d. Fibroblast growth factor

Answer: a, b, c, d

A number of proteins have been demonstrated to directly or indirectly influence bone induction. Platelet-derived growth factor from platelets and macrophages has been shown to induce migration and mitosis of mesenchymal cells in wounds and to enhance cartilage and bone formation in adult rats. Fibroblast growth factors is a mitogenic and angiogenic protein that favors new bone formation, particularly if neo-vascularization is required. Transforming growth factor-b is secreted from bone cell cultures. This protein appears to be naturally released from platelets at the time of a fracture and stimulates proliferation of osteoblasts and increases their production of collagen. Finally, a purified and partially sequenced regulator from bovine bone matrix termed osteogenin has been isolated. This substance has the ability to induce cartilage and bone formation and to play a major controlling role in the development of de novo bone in muscle and subcutaneous tissues.

51. Which of the following statement(s) is/are true concerning the treatment of diaphyseal fractures?

- a. The use of intramedullary rods allows early weight bearing and minimal immobilization
- b. The infection rate using intramedullary fixation devices is minimal

- c. Results for the use of intramedullary rods are better for fractures of the femoral shaft than the tibia
- d. Loss of limb length is inevitable with segmented or comminuted fractures

Answer: a, b, c

Treatment for diaphyseal fractures (particularly tibial, femoral, and humeral fractures) uses intramedullary fracture fixation devices. The use of intramedullary rods allows early weight bearing and requires minimal immobilization of the joints above and below the fracture. Little long-term remodeling (loss of bone) has been documented. Rehabilitation is rapid, and blood loss is minimized. For simple transverse or oblique closed fractures, the infection rate is nearly zero. When used to treat segmented or comminuted fractures or other unstable fractures with proximal and distal bone loss, the interlocking allows for surgical reestablishment of the bone compartment and therefore limb length. The device can maintain length until the fracture is healed. Although this technique is the optimal treatment for most fractures of the femoral shaft, application of these same principles to the tibia has not resulted in such dependable results.

52. Which of the following statement(s) is/are true concerning the biologic mechanisms of fracture repair?

- a. The mechanisms involved depend primarily on the stability of the fracture
- b. The first material formed by osteoblasts at the fracture site is woven bone
- c. Callus increases the cross-sectional area of the injury therefore weakening the structure
- d. Woven bone provides a permanent microstructure in the area of a fracture

Answer: a, b

After initial inflammation and neovascularization of an area fracture, the repair continues by a combination of mechanisms: endochondral ossification, direct bone apposition, and primary healing involving an acceleration of the normal remodeling process directed across a stable, securely reduced fracture line. The occurrence and distribution of these mechanisms depends primarily on the stability of the fracture during the treatment and secondarily on the fracture location. The more unstable the fracture, the more endochondral the repair process and the greater the cross-sectional area of the callus. The biologic processes are driven by the need to establish mechanical integrity as quickly as possible. The first material formed by osteoblast at the fracture site is woven bone. Although woven bone has inferior mechanical properties when compared to lamellar bone, it can be laid down rapidly and at high density. The laws of mechanics dictate that an increase in the cross-sectional area as produced by surrounding callus, greatly increases the resistance of the structure to bending or torsional loads. An increase in unit diameter of the cross-section raises the strength of the structure by the fourth power of the diameter change. Therefore, even if callus is made of an inferior material, the cross-sectional attributes more than compensate for the inferior substance. Once the fracture is stabilized by the initial woven bone proliferation, secondary remodeling occurs.

53. The most important structural component of connective tissue is collagen. Which of the following statement(s) is/are true concerning types of collagen?

- a. All collagen is fiber forming
- b. Type 1 collagen is the most abundant in the human body
- c. Type 2 collagen is found in cartilage
- d. The basement membrane collagens, type 4 and 5, do not form regular fibers

Answer: b, c, d

At least 15 separate collagen molecules have been identified, each with a specific confirmation associated with a unique kinetic or mechanical property. The collagens can be categorized into two major groups—fiber-forming collagens and collagens that do not form regular fibers. The fiber-forming collagens include Type 1, Type 2, and Type 3. Type 1 collagen is the most abundant in the human body and is the dominant constituent in tendons, ligaments, bone, skin, vessel walls, and scar and granulation tissues. Type 2 collagen is found in the cartilage and Type 3 collagen is found in tendon and ligament sheaths, as well as in muscle, skin, blood vessel walls, and scar tissue. The remaining collagens do not form regular fibers and include the basement membrane collagens, Types 4 and 5.

54. Which of the following statement(s) is/are true concerning soft tissue repair?

- a. The first stage involves a formation of granulation tissue

- b. The initial pattern of collagen fibers and the degrees of waviness is random and therefore not as functional as the normal structure
- c. Early immobilization, regulated physical stimuli, and good vascular supply are beneficial to healing
- d. Normal physiologic loading conditions impair wound remodeling

Answer: a, b, c

The healing of soft tissue occurs in stages. The first stage involves a granulation tissue, in which the collagen fibers are oriented in a random pattern and the degree of waviness is likewise random. This tissue is not as functional as the more optimal normal structure. In time, the soft tissue is remodeled to produce an architecture more nearly that of normal intact tissue. Factors associated with beneficial effects on healing include early immobilization, regulated physical stimuli, and good vascular supply. Remodeling or adaptation of soft tissues has also been shown to occur under normal physiologic loading conditions. There are reports of training effects increasing the properties of tissues and metabolically active cells incorporated within the matrix.

55. Which of the following statement(s) is/are true concerning types of bone found in the human body?

- a. Trabecular and cortical bone differ in their chemical, molecular and cellular components
- b. Primary bone must be formed on existing surfaces
- c. Woven bone reflects a highly organized microstructural organization
- d. Secondary osteonal bone is the primary constituent of adult cortices

Answer: b, d

Two major types of bone are found in the human body: trabecular and cortical. Although the chemical, molecular and cellular components are similar, the organization of these components at the ultrastructural and microstructural level leads to significant differences in their mechanical and metabolic activities. The microstructural organization of bone can be classified into three types: primary bone, secondary bone, and woven bone. The most important characteristic of primary bone is that it must be formed on existing surfaces. The surfaces can be cartilaginous or preexisting bone. This bone is highly organized and exhibits excellent mechanical properties. Secondary osteonal bone is the primary constituent of adult cortices. The final microstructural type of bone is woven bone. Although the collagen matrices in lamellar and osteonal bone are precisely organized, providing maximal mechanical properties with minimal material, woven bone is composed of disorganized yet highly mineralized tissue and is expressed in the course of fracture or damage repair. It has the advantage of being quickly deposited but the disadvantage of significantly reduced mechanical properties when compared to a highly ordered primary and secondary bone.

56. Which of the following statement(s) is/are true concerning operative arthroscopy?

- a. Arthroscopy is unquestionably the most effective method for diagnosis and treatment of knee ligament injuries
- b. Arthroscopic repair allows almost immediate rehabilitation
- c. Despite advances an anterior cruciate ligament tear will essentially end any high level sports activity
- d. The presence of loose osteochondral fragments requires open arthrotomy

Answer: a, b

Arthroscopy is unquestionably the most effective method for the diagnosis and treatment of knee ligament injuries. Previously there was not certainty that there was a torn ligament, or how many, or whether the tears were complete. With arthroscopy, ligament injuries can be diagnosed with certainty on the day of injury or shortly thereafter and reparative surgical treatment initiated. Complete tears of the anterior cruciate ligament of the knee are devastating injuries. The arthroscope allows immediate and certain diagnosis of an anterior cruciate ligament tear and is a valuable tool in operative reconstruction of function. Using small external incisions, special drilling guides, and the arthroscope, strong bone-ligament-bone grafts may be placed in an anatomic location. Considerable increased stability is often achieved, allowing patients to return to a high-level sports activity. The small size of the incision, the clear visualization of the interior of the joint, and the ability to perform definitive surgical corrections with minimal damage to other structures often allows immediate rehabilitation. Muscular atrophy due to extensive immobilization and nonweight bearing is prevented. Loose fragments from minuscule injuries can easily be removed by the arthroscope. If they are too large for removal using the standard small, delicate arthroscopy instruments, a small direct arthrotomy can be performed and arthroscopically directed open loose body removal easily accomplished. Similarly, loose bodies that have previously required open arthrotomy for removal are more easily treated with arthroscopic instrumentation.

57. Which of the following statement(s) is/are true concerning bone remodeling?

- a. Remodeling can occur only on the surface of trabeculi
- b. The remodeling process takes approximately 120 days in an adult
- c. Trabecular bone remodeling occurs up to 10 times faster than cortical bone remodeling
- d. Bone modeling involves bone formation without resorption

Answer: b, c, d

After the initial development and deposition of bone, it is remodeled in an effort to produce a more optimally aligned and constructed structure. This process involves the resorption by osteoclasts followed by deposition of nonmineralized matrix (osteoid) by osteoblasts. During mineralization, the osteoblasts become entrapped in their matrix, thereby serving as the resulting bone cells (osteocytes). This remodeling can occur on the surface of trabeculi, on the surface of cortical bone, and intercorally. It precedes as a method of normal turnover, providing access to minerals needed for normal homeostasis. Under normal circumstances, the process takes about 120 days in an adult. Trabecular bone remodels at a rate 5 to 10 times that of cortical bone remodeling, probably because of its porosity and greater surface/volume ratio.

It is important to differentiate bone remodels from modeling. Bone remodeling involves the resorption of existing bone followed by formation within the resorption cavity. Modeling describes the phenomenon of bone formation without resorption. This modeling can occur only through the deposition of woven bone and occurs during fracture healing.

58. Which of the following statement(s) is/are correct concerning total joint replacement arthroplasty?

- a. Total knee and hip prostheses have a life expectancy of approximately 10 years
- b. The major failure of total joint arthroplasty is aseptic mechanical loosening at the interface between the bone, cement, and implant
- c. Biologic tissue ingrowth into a prosthesis worsens long-term results
- d. Rigid fixation at the time of implantation is important to secure tissue ingrowth

Answer: b, d

Significant technological advances in both the biomaterial and manufacturing process have lead to dramatic improvement in total joint replacement surgery during the last 20 years. These advances have significantly improved the longevity of artificial joints, particularly hip and knee prostheses, which are by far the most common. Despite these advances the procedure is still considered primarily for elderly patients. Total knee and hip prostheses have a fixation life expectancy of about 15 years or more in many patients. The major failure of total joint arthroplasty is aseptic mechanical loosening at the interface between the bone, cement, and implant. Factors which contribute to loosening include excessive weight, high activity level, component misalignment, and breakdown of the cement interface. An important potential advance, and one that has demonstrated some clinical success already, is the use of porous surface coated prostheses that promotes biological tissue ingrowth and fixation of the implants. These implants are designed to be inserted surgically into carefully prepared bone under conditions of interference fit (tight intimate contact). It is proposed that significant bone tissue infiltration into the porous surface will begin within 8 to 12 weeks and that after an appropriate amount of time (perhaps 1 year) long-term equilibrium bone remodeling will result in a well-fixed bone ingrowth phase that will last for years. Two factors are important to secure fixation. First, the implant must be fixed rigidly within the bone during the initial ingrowth period. Secondly, the local mechanical environment must promote a positive remodeling response of the supporting trabecular bone.