Figure 1

Question 1

Figure 1 is the radiograph of a 62-year-old woman who fell and sustained a left hip fracture. A radiograph is shown in Figure 1. Which of the following preoperative risk factors is associated with the highest postoperative mortality rate?

1. Fracture pattern
2. Chronic renal failure
3. Female gender
4. Coronary artery disease
5. Diabetes mellitus

PREFERRED RESPONSE: 2

DISCUSSION: In the study by Bhattacharyya and associates in 2002, they retrospectively reviewed over 43,000 in-patient orthopaedic procedures to identify preoperative risk factors associated with postoperative mortality. Their study identified five “critical” risk factors placing patients at increased risk for death. These included chronic renal failure, congestive heart failure, chronic obstructive pulmonary disease, hip fracture, and age of older than 70 years. Their study also demonstrated a linear increase in mortality observed with the increased number of risk factors. The risk factors of diabetes, gender, fracture pattern, coronary artery disease, peripheral vascular disease, septic arthritis, and rheumatoid arthritis did not achieve significance. Identification of patients with risk factors for mortality is important for individualizing treatment plans, accurate prognosis, and informed consent.

Question 2

A 37-year-old man fell from 24 feet and sustained a subarachnoid hemorrhage and closed femoral shaft fracture. What is most likely to lead to an adverse outcome?

1. Intraoperative hypotension
2. Temporizing external fixation
3. Elevated cerebral perfusion pressure
4. Immediate reamed intramedullary nailing
5. Skeletal traction with intramedullary nailing in 72 hours

PREFERRED RESPONSE: 1

DISCUSSION: In patients with femoral fractures and associated closed head injuries, there have been conflicting studies regarding timing of fracture care and eventual neurologic outcome. It is known that an episode of hypotension and elevated intracranial pressure will lower the cerebral perfusion pressure, which is known to be detrimental to the neurologic outcome. Intraoperative hypoxia may also worsen the neurologic outcome and increased fluid administration may elevate the intracranial pressure. If early fracture fixation is necessary, the intracranial pressure should be monitored and the cerebral perfusion pressure maintained during the procedure. Immediate reamed intramedullary nailing is appropriate if the patient is hemodynamically stable and the cerebral perfusion pressure is maintained. If not, external fixation would be appropriate treatment. Temporary skeletal traction may be appropriate if the intracranial pressure is labile and precludes the patient from going to the operating room.

Question 3

Figure 3a is the initial radiograph of a 19-year-old man who sustained a closed clavicle fracture. Figures 3b and 3c show postoperative radiographs. If the patient had been treated nonsurgically, which of the following would most likely occur?

1. Normal shoulder strength and function
2. Local sensory deficits
3. Fracture union
4. Infection
5. Malunion

PREFERRED RESPONSE: 5

DISCUSSION: Recent studies comparing surgical treatment with nonsurgical management in displaced clavicle fractures have revealed a decreased rate of malunion and nonunion with surgery. In addition, significant malunions can lead to functional deficits at the shoulder. Thus, with open reduction and internal fixation and anatomic or near-anatomic reduction, there should be a higher likelihood of normal shoulder strength and function. Infection and local sensory deficits would not be expected with nonsurgical management, whereas surgical treatment has a small risk of infection and a high likelihood of sensory deficits from iatrogenic damage to the supraclavicular nerves.

Question 4
What is the most common anatomic location of the lateral femoral cutaneous nerve?

1. Deep to the psoas muscle
2. Medial to the femoral vein
3. Under the inguinal ligament
4. Adjacent to the femoral nerve
5. Deep to the iliopectineal fascia

PREFERRED RESPONSE: 3

DISCUSSION: The lateral femoral cutaneous nerve most commonly originates from the lumbar plexus and runs on the surface of the iliacus muscle and enters the thigh by passing under the inguinal ligament before piercing the fascia lata. Its path can be variable.

Figures 5a and 5b are the radiographs of a 24-year-old obese woman who sustained a knee dislocation in a fall. Postreduction radiographs and an angiogram are shown in Figures 5c through 5e. Examination reveals a cold foot with no pedal pulses. After vascular repair and four-compartment fasciotomy is performed by a vascular surgeon, and while the patient is still in the operating room, you are contacted and asked to evaluate the patient. The knee is grossly unstable. What is the most appropriate initial orthopaedic management?

1. Spanning external fixation of the knee
2. Open lateral collateral ligament repair and delayed anterior cruciate ligament/posterior cruciate ligament/medial collateral ligament reconstruction
3. Application of a cylinder cast
5. Diagnostic knee arthroscopy

PREFERRED RESPONSE: 1

DISCUSSION: Knee dislocations are known to have a high risk for vascular injury. Although the specific treatment of various combinations of ligamentous injuries is controversial, the need for emergent revascularization is not. In this particular patient, after vascular repair, the most important initial concern is protection of the vascular repair. A spanning external fixator, especially in this patient with gross instability, will allow for easier assessment of vascular status, evaluation of fasciotomy wounds, and temporary stability of the knee. A cylinder cast can stabilize the knee but will not allow wound assessment or room for inevitable post-injury/postoperative swelling. Diagnostic knee arthroscopy is not necessary, and ligamentous repair/reconstruction should be delayed until the vascular repair is stable.

Question 6

Figures 6a and 6b are the radiographs of a thin 23-year-old man who sustained a closed injury to his left arm in a fall. He has no other injuries and his neurologic examination is normal. What is the most appropriate treatment?

1. Intramedullary nailing
2. Hanging arm cast for 6 weeks
3. Shoulder immobilizer for 4 to 6 weeks
4. Open reduction and internal fixation
5. Coaptation splinting with conversion to a fracture brace

PREFERRED RESPONSE: 5

DISCUSSION: The patient is a thin man with an isolated left humerus fracture. The fracture has bony apposition and should be amenable to closed treatment; therefore the most appropriate treatment is coaptation splinting with conversion to a fracture brace. A hanging arm cast is not recommended for a transverse fracture because of the propensity to distract the fragments, especially if left in place for a long period of time. A shoulder immobilizer is not an appropriate treatment for a humeral shaft fracture. A transverse fracture line is sometimes considered a relative indication for surgical treatment if the fragments are distracted, but in this patient, immediate surgical fixation is not warranted in the absence of other indications for surgical treatment.

Question 7

Figure 7 is the pelvic radiograph of a 33-year-old man involved in a high-speed automobile crash. Examination reveals a blood pressure of 90/50 mm Hg and a pulse rate of 120/min. Radiographs of the chest and lateral cervical spine are normal. A CT scan of the abdomen does not reveal any intra-abdominal bleeding. What is the most appropriate management for the pelvic fracture?

1. Angiography
2. Application of a pelvic binder
3. Anterior external fixation
4. Anterior external fixation with pelvic packing
5. Open reduction and internal fixation of the pubic symphysis

PREFERRED RESPONSE: 2

DISCUSSION: Since the patient has not had any mechanical stabilization to the pelvic ring, the first step in management should be application of a sheet or binder along with resuscitation. Pelvic binders have been shown to be effective in decreasing transfusion needs and are quick and simple to apply. Emergent external fixation, pelvic packing, or angiography is not indicated unless the patient is unresponsive to these initial measures. The order in which these measures are used is controversial and somewhat institution dependent. Repair of the pubic symphysis is indicated as part of the definitive treatment but should not be done prior to resuscitation with pelvic binder placement.

Question 8
What is the most common cause of death in a patient with the injury shown in Figure 8?

1. Visceral injury
2. Exsanguination
3. Closed head injury
4. Under-resuscitation
5. Disseminated intravascular coagulation

PREFERRED RESPONSE: 3

DISCUSSION: The most common identifiable cause of death in patients with lateral compression fractures is closed head injury. In contrast, the identifiable cause of death in patients with anteroposterior compression injuries is combined pelvic and visceral injury. Lateral compression injury results from a lateral impact to the pelvis that rotates the pelvis on the side of the impact toward the midline. The sacrotuberous and sacrospinous ligaments, as well as the internal iliac vessels, are shortened and are not subjected to tensile forces. Disruption of large named vessels (eg, internal iliac artery, superior gluteal artery) is relatively uncommon with lateral compression injuries.

Question 9

A 28-year-old woman with a history of systemic lupus erythematosus was involved in a motor vehicle crash. She sustained a closed left tibia fracture and underwent surgery. During surgery, the tourniquet was left inflated while the surgeon reamed the tibial canal to place the largest diameter nail that could be fit. At 6 weeks follow-up, there is evidence of massive bone necrosis. What event most likely led to the necrosis?

1. History of steroid use
2. History of systemic lupus erythematosus
3. Over reaming of the tibial canal
4. Reaming of the tibia with the tourniquet inflated
5. Reaming of the tibia with the knee in hyperflexion

PREFERRED RESPONSE: 3

DISCUSSION: Karunaker and associates showed in a canine model that there is no significant difference in the heat generated during reaming with and without a tourniquet. The factor that made the most difference was related to the size of the reamer used compared with the diameter of the isthmus. Giannoudis and associates performed a prospective randomized trial on 34 patients that evaluated the same thing as the first study with the same methodology, and the conclusions were again the same. The factor that generated the most heat was using large reamers (11 mm to 12 mm) in a patient with a small isthmus (8 mm to 9 mm). Systemic lupus erythematosus, steroid use, and knee flexion during reaming have not been shown to be associated with diaphyseal necrosis after reamed tibial nailing.

Figures 10a and 10b are the radiographs of a 33-year-old man who was involved in a high-speed motorcycle crash. He sustained an isolated injury to the right lower extremity. On the day of injury, he was treated with open reduction and internal fixation of the femoral neck and retrograde nailing of the femur. Radiographs are shown in Figures 10c through 10f. Alternative treatment with a cephalomedullary device alone would be more likely to lead to which of the following outcomes?

1. More postoperative pain
2. More rapid healing of the femoral neck fracture
3. Higher union rate of the femoral neck fracture
4. Higher union rate of the femoral shaft fracture
5. Higher rate of malreduction of one of the fractures

PREFERRED RESPONSE: 5

DISCUSSION: The patient has ipsilateral fractures of the femoral neck and femoral shaft. This is not an uncommon scenario, often found in high-energy injuries in younger patients. There is some controversy as to the best method of fixation with some authors recommending separate implants for the two fractures, and some recommending a single antegrade cephalomedullary nail for treatment of both fractures. The use of a single implant does not increase healing time of the femoral neck fracture or limit postoperative pain. However, the use of a single implant is associated with higher malreduction rates of either the shaft or neck component which could lead to increased rates of nonunion or malunion.

Figure 11a

Figure 11b

Question 11
Figures 11a and 11b show the radiographs of the open fracture of a 46-year-old man who injured his elbow on his nondominant arm in a motorcycle crash. On the day of injury, he underwent irrigation and débridement of the fracture. He was also treated with antibiotics. Which of the following definitive treatment methods will most likely lead to the best functional outcome?

1. Cast immobilization
2. Intramedullary screw fixation
3. Open reduction and plate fixation
4. Open reduction and internal fixation with tension band wiring
5. Fragment excision and triceps advancement

PREFERRED RESPONSE: 3

DISCUSSION: The patient has an open comminuted transolecranon fracture-dislocation. This occurs when the distal humerus is driven through the proximal ulna, and it is often associated with comminution of the olecranon and proximal ulna. The distal fragment translates anteriorly. Results of surgical treatment of transolecranon fracture-dislocations are best and most reliable when the fracture is reduced anatomically and plate fixation is used. Nonsurgical management is not indicated in this injury pattern. Excision of the comminuted fragments and advancement of the triceps will likely lead to persistent anterior instability of the elbow. Tension band wiring relies on cortical contact which will not be possible in this fracture. Intramedullary screw fixation is also not possible because of the significant comminution.

Question 12

Figures 12a through 12c show the radiographs of the closed fracture of a 24-year-old man who sustained an isolated injury to his left foot in a motorcycle crash. He was splinted and, on the following day, he underwent open reduction and internal fixation. Postoperative radiographs are shown in Figures 12d through 12f. What is the most likely complication of this injury?

1. Malunion
2. Nonunion
3. Osteomyelitis
4. Osteonecrosis
5. Posttraumatic arthritis

PREFERRED RESPONSE: 5
DISCUSSION: The patient has a talar neck fracture that is associated with several well-known complications. Posttraumatic arthritis is the most common complication and osteonecrosis is slightly less common. These two complications are often out of the control of the orthopaedic surgeon and do not seem to be influenced by the timing of fixation. Malunion and nonunion are relatively uncommon when an anatomic reduction and stable fixation can be obtained. Open reduction can help ensure the best possible reduction, and plate fixation may be a more stable method of fixation, especially useful in preventing collapse through areas of comminution. Osteomyelitis is rare in closed fractures.


Question 13
When comparing the results of open reduction and internal fixation (ORIF) versus antegrade intramedullary nailing (IMN) fixation of the humeral diaphysis in prospective randomized trials, which of the following statements is most accurate?

1. Union rates are higher with IMN.
2. Reoperation rates are higher with IMN.
3. Shoulder outcomes are similar for ORIF and IMN.
4. Infection rates are higher with ORIF.
5. Radial nerve complications are higher with ORIF.

PREFERRED RESPONSE: 2

DISCUSSION: There are relatively few comparative studies of the treatment of diaphyseal fractures of the humerus in the literature. In a meta-analysis of three prospective randomized trials comparing ORIF with IMN, open reduction and internal fixation showed a 90% risk reduction of shoulder impingement symptoms and a 75% risk reduction of reoperation. There is no difference in infection rate, nonunion rate, and radial nerve issues.

Question 14
Which inflammatory marker is most closely tied to a systemic inflammatory response following orthopaedic injury and treatment?

1. Interleukin 1 (IL-1)
2. Interleukin 6 (IL-6)
3. Interleukin 10 (IL-10)
4. Tumor necrosis factor, alpha
5. D-dimer

PREFERRED RESPONSE: 2

DISCUSSION: Significant basic science research has been done on identifying inflammatory markers associated with systemic inflammatory response following trauma and musculoskeletal injury. Although not yet clinically applicable, IL-6 has been identified as a marker that correlates well with musculoskeletal injury (ie, femur fracture) and treatment of these injuries (ie, intramedullary nailing). IL-1 and IL-10 do not correlate with treatment of musculoskeletal injury. Tumor necrosis factor, alpha and D-dimer, although often elevated following trauma, do not correlate with musculoskeletal treatment.

Question 15
Figures 15a and 15b are the radiographs of a 28-year-old man who fell from a height and sustained an isolated closed diaphyseal femur fracture that was treated with reamed antegrade femoral nailing 8 months ago. He now reports persistent pain during ambulation. He smokes one pack of cigarettes per day but is otherwise healthy. He denies any infectious history or symptoms, and laboratory studies show a normal WBC count, erythrocyte sedimentation rate, and C-reactive protein. What is the most appropriate treatment?

1. Bone graft in situ
2. External bone stimulation
3. Reamed antegrade exchange nailing
4. Reamed retrograde exchange nailing
5. Open biopsy to assess for infection followed by delayed surgical stabilization

PREFERRED RESPONSE: 3

DISCUSSION: The patient has an uninfected symptomatic nonunion of the femur after reamed antegrade nailing with an appropriately sized implant. The fracture is well aligned and has some callus response indicating reasonable vascularity. Auto-dynamization has occurred via fatigue failure of the distal interlocking screws but the patient remains symptomatic and the fracture line is evident, consistent with nonunion. Reamed exchange nailing is preferred because it allows for improved mechanics via a larger diameter nail and repeat interlock and improved biologics via reaming which is felt to elicit an inflammatory reaction and generate bone graft in situ. Unfortunately, the results of exchange nailing are not as good in patients who smoke and smoking cessation should be counseled and encouraged. The data on external bone stimulation on unhealed fractures of the femur with an intramedullary nail present are lacking. In light of a benign clinical examination and history and normal blood work parameters with reference to infection, open biopsy of the nonunion prior to definitive surgical treatment is unwarranted. The patient has mechanical instability and bone grafting in situ will not address this issue in terms of promoting progression to union or allowing for improved function and less pain.

Question 16
Figures 16a and 16b show the initial radiograph and CT scan after the application of a pelvic binder in a 24-year-old woman who sustained a pelvic ring injury in a motor vehicle accident. What does the fracture of the sacrum best indicate?

1. Pelvic instability  
2. Indication to repair the sacrum  
3. Higher likelihood of bowel injury  
4. Lower likelihood of neurologic injury  
5. Lower likelihood of internal bleeding

PREFERRED RESPONSE: 1

DISCUSSION: The radiograph and CT scan reveal a fracture of the lateral sacrum due to avulsion of the sacrospinous and sacrotuberous ligaments. These ligaments are disrupted in an unstable anteroposterior compression-type pelvic ring injury. Higher grade injuries have a higher risk of vascular and/or neurologic injuries.

Question 17
When attempting to treat a proximal tibial metadiaphyseal fracture with an intramedullary nail, what is the most common angular malalignment?

1. Varus alone
2. Valgus alone
3. Varus and procurvatum
4. Valgus and procurvatum
5. Valgus and recurvatum

PREFERRED RESPONSE: 4

DISCUSSION: Fractures of the proximal metadiaphysis of the tibia can be treated successfully with intramedullary nails but historic rates of malalignment are up to 84%. The typical deformity is valgus and procurvatum due to the metaphyseal bony anatomy, eccentric start point, deforming force of the patellar tendon, and implant factors such as the Herzog curve of the nail. An ideal starting point is mandatory and should be at the medial border of the lateral tibial eminence on a true AP view and very proximal and anterior on a true lateral view with appropriate coronal and sagittal trajectory of the entry reamer. A reduction should be obtained and maintained during reaming, implant insertion, and interlocking. This can be facilitated via a variety of techniques including intraoperative external fixation, percutaneous reduction clamps or joysticks, semi-extended positioning, blocking screws, and ancillary plate fixation.

Figures 18a through 18c show injuries sustained by a 22-year-old woman after falling 45 feet while mountain climbing. After being airlifted to the nearest trauma center, her arterial blood gas was 7.21, pO2 84, pCO2 48, and base arterial blood gas was 7.21, pO2 84, pCO2 48, and delta base -11 mmol/L. Her Hg is 8.7 and her resuscitation is ongoing. Based on this data, what would be the best management of her orthopaedic injuries?

1. External fixation of the pelvis, external fixation of the distal femur, and splinting of the humerus
2. External fixation of the pelvis, external fixation of the distal femur, and intramedullary nailing of the humerus
3. External fixation of the pelvis, open reduction and internal fixation of the distal femur, and splinting of the humerus
4. Open reduction and internal fixation of the pelvis, open reduction and internal fixation of the distal femur, and intramedullary nailing of the humerus
5. Open reduction and internal fixation of the pelvis, open reduction and internal fixation of the distal femur, and open reduction and internal fixation of the humerus

PREFERRED RESPONSE: 1

DISCUSSION: The patient is under-resuscitated and would benefit from minimally invasive stabilization of the pelvic ring and long bone fractures in a “damage-control” approach. External fixation of the pelvis and femur can be performed quickly and with minimal blood loss which should limit the “second hit” associated with more prolonged, invasive surgery. Upper extremity fractures are best managed acutely with splints in this clinical setting. Definitive fracture fixation should be delayed until the patient is adequately resuscitated.

Figure 19a

Figure 19b

Question 19
Figures 19a and 19b are the radiographs of a 32-year-old woman who has sustained multiple injuries after being struck by a motor vehicle while riding a bicycle. She is intubated on arrival and remains tachycardic and hypotensive. Pulses are hard to palpate but the right hand is somewhat cooler to touch than the left hand. She has a large open wound over the upper arm. What is the most important predictor of outcome with these injuries?

1. Open wound size
2. Open wound contamination
3. Time to débridement
4. Adequacy of débridement
5. Neurovascular status

PREFERRED RESPONSE: 5
DISCUSSION: The patient has lateral translation of the shoulder girdle on the chest radiograph as measured from the spinous process to the medial border of the scapula with resultant acromioclavicular widening consistent with the diagnosis of scapulothoracic dissociation. She also has an ipsilateral open fracture of the proximal humeral diaphysis. This represents an extremely high-energy injury to the upper extremity with a dismal prognosis. The overall mortality in the presence of scapulothoracic dissociation is 10%. Over 90% of patients will have neurologic injury which is often a complete and permanent brachial plexopathy, and a significant percentage will have associated limb-threatening vascular injuries. In the presence of a complete vascular and neurologic injury, amputation must be considered. While important, wound size and contamination, and time or adequacy of débridement will not likely drive the clinical outcomes in the presence of such a significant concomitant injury.


Question 20
Figures 20a and 20b are the radiographs of a 19-year-old woman who was involved in a motor vehicle accident. What mechanism of injury is most consistent with the injury?

1. Vertical shear
2. External rotation
3. Sagittal translation
4. Lateral compression
5. Anterior posterior compression

PREFERRED RESPONSE: 4
DISCUSSION: The radiographs show a lateral compression pelvic ring injury with a displaced superior ramus fracture, or tilt fracture. Tilt fractures are most commonly caused by a lateral compression mechanism. These injuries are often seen in female patients and careful examination, including vaginal examination, is required to rule out open fractures. Lateral compression results in internal rotation, not external rotation, of the pelvic ring. Tilt fractures are not commonly seen with anterior-posterior compression injuries or vertical shear injuries. Sagittal translation is not a term used to describe pelvic ring injuries.


Question 21

Figure 21 is the radiograph of a 45-year-old woman who was severely injured in a motorcycle crash. Her injuries include a traumatic subarachnoid hemorrhage, bilateral pneumothoraces with pulmonary contusions and flail chest, fracture-dislocation of the left hip, and open fractures of the right distal femur and proximal tibia. Antibiotics and tetanus are administered in the emergency department. The patient is intubated and bilateral chest tubes are placed. A closed reduction is performed on the left hip. After appropriate resuscitation, what is the most appropriate initial management of the right knee injury?

1. Skeletal traction
2. Irrigation and débridement of the open fractures
3. Irrigation and débridement and spanning external fixation of the knee
4. Open reduction and internal fixation of the proximal tibia and distal femur
5. Percutaneous screw fixation of the articular fragments with retrograde femoral nailing and antegrade tibial nailing

PREFERRED RESPONSE: 3
DISCUSSION: Although the radiographic evaluation is incomplete, the single lateral view shows a comminuted fracture of the distal femur with suspicion of intra-articular injury and an ipsilateral proximal tibia fracture. This is an open fracture that requires antibiotics, débridement, and skeletal stabilization. The fractures are complicated and the patient is polytraumatized; therefore, rapid but complete surgical débridement and simple stabilization of the knee with a spanning external fixator would be the most appropriate management. Definitive surgical stabilization will likely be complicated and is less desirable during the early post-injury period.


![Figure 22](image)

Question 22
Which of the following strategies is helpful to avoid the complication seen in Figure 22?

1. Fibular plating  
2. Blocking screws  
3. Medial starting point  
4. Nailing in the flexed position  
5. Cross Kirschner wire fixation prior to nail insertion

PREFERRED RESPONSE: 2
DISCUSSION: This is the classic deformity encountered during intramedullary nailing of a proximal one third tibia fracture: apex anterior angulation and anterior translation of the proximal segment. Blocking screws, nailing in the semi-extended position and a lateral starting point all may help avoid the malalignment seen with proximal tibial metaphyseal fractures. Fibular plating may help with distal tibial metaphyseal fracture alignment. Cross Kirschner wire stabilization is not used in adult fracture patterns. A temporary unicortical plate, external fixator, or distractor may be used instead to hold provisional reduction while the nail is inserted.


Question 23
Figure 23 is the radiograph of a 22-year-old woman who was involved in a motor vehicle collision. She reports isolated pain in her left shoulder. She is hemodynamically stable, respiring comfortably, and neurovascularly intact. Based on these findings, which of the following statements regarding treatment is most appropriate?

1. Union rates are in excess of 95% if treated nonsurgically.
2. A figure-of-8 brace is superior to a sling for nonsurgical management.
3. Open reduction and internal fixation increases the likelihood of a nonunion.
4. Open reduction and internal fixation results in improved functional outcomes.
5. Open reduction and internal fixation and nonsurgical management have equivalent outcomes at 1 year.

PREFERRED RESPONSE: 4
DISCUSSION: The patient has sustained an isolated, closed, transverse fracture of the middle third of the clavicle with greater than 100% displacement and greater than 2 cm of shortening. Whereas the traditional treatment of clavicle fractures has been overwhelmingly conservative, recent reports suggest that surgical fixation should be considered for certain injury patterns. The union rates of displaced clavicle fractures are more recently noted to be approximately 85%, which is lower than the traditional literature. In a prospective randomized trial of clavicle fractures with greater than 100% displacement, union rates were higher and functional outcomes were better at all time points up to 1 year after injury in the surgical group when compared with nonsurgical management.


Question 24
A 19-year-old man underwent intramedullary nailing of a closed tibia fracture 1 year ago and has never been pain free. While playing football, he was tackled and sustained the injury shown in Figure 24a. What is the best treatment option based on the radiographs seen in Figures 24b and 24c?

1. Circular fixator
2. Exchange nailing
3. Iliac crest bone graft
4. Straightening of the leg and casting
5. Removal of the nail and functional bracing

PREFERRED RESPONSE: 2
DISCUSSION: This is a young, healthy man with a tibial nonunion and a failed implant. He requires treatment for the nonunion. In the absence of bone loss and/or infection, the injury is best treated with removal of the bent nail and a reamed exchange nailing. Casting alone or functional bracing is not the best option in a patient with an atrophic nonunion. Use of circular fixators is an option; however, in a young, healthy patient with a fracture that has bony contact, the first line of treatment is exchange nailing.


Question 25
Figures 25a through 25c show the radiographs, including a stress radiograph, of a 58-year-old woman who twisted her ankle on a step. She has no history of diabetes or vascular disease. Examination reveals a closed injury with moderate swelling about the ankle. Her neurologic examination is normal. She has a strong dorsalis pedis pulse and tenderness over the lateral malleolus and the medial side of her ankle. What is the most appropriate management?

1. MRI scan of the ankle
2. Non-weight-bearing cast for 6 weeks
3. Removable walking boot and progressive weight bearing
4. Open reduction and internal fixation of the fibula
5. Open reduction and internal fixation of the fibula with medial ligament repair

PREFERRED RESPONSE: 3
DISCUSSION: The patient has a lateral malleolus fracture with an ankle mortise that is stable to a stress examination; therefore, surgical treatment is not indicated. In a stable lateral malleolus fracture, strict non-weight-bearing is not necessary, and a removable walking boot or walking cast can be used along with progressive weight bearing. The presence of tenderness or swelling medially at the ankle has been shown to be a poor indicator of medial-sided injury. The clinical utility of MRI scans in ankle fractures is controversial. Studies have used MRI scans to evaluate the competence of the deltoid ligament and have shown that the ligament may remain intact even with an increased medial clear space on a stress examination. In the patient, the stress examination does not show talar subluxation so the deltoid ligament is not incompetent.

Question 26

Figure 26 is the radiograph of a 33-year-old woman who was involved in a high-speed motor vehicle crash. Her initial blood pressure is 80/50 mm Hg and she has a pulse rate of 120 bpm. After hemodynamic stabilization and temporizing measures have been performed, the patient is cleared for surgery. What is the most appropriate method of definitive fixation?

1. External fixation
2. Open reduction and internal fixation of the pubic symphysis with a two-hole plate
3. Open reduction and internal fixation of the pubic symphysis with a two-hole plate and posterior triangular osteosynthesis
4. Open reduction and internal fixation of the pubic symphysis with a multi-hole plate
5. Open reduction and internal fixation of the pubic symphysis with a multi-hole plate and posterior plate osteosynthesis

PREFERRED RESPONSE: 4

DISCUSSION: The patient has sustained an anterior posterior compression (APC) grade II pelvic ring injury. Initial management should consist of pelvic volume reduction with pelvic binding or sheeting. Once the patient is hemodynamically stable, the decision for definitive management should be made. In a retrospective review of more than 200 patients, Sagi and Papp investigated plate osteosynthesis of the pubic symphysis. They found significantly fewer malunions in the multi-hole plate group and a trend toward fewer surgeries in the same group. Typically external fixation should be reserved for temporary fixation and not a definitive management in stable patients. Posterior fixation is reserved for injuries with disruption of the posterior ligamentous constraints, typically APC grade III injuries. Triangular osteosynthesis is a strategy for fixation of unstable vertical shear fractures that require fixation of the pelvis to the lumbar spine.

Question 27

Figure 27 is the radiograph of a 75-year-old woman with a 1-year history of left arm pain following a fall. What is the most appropriate management?

1. Thermal imaging
2. Metabolic/endocrine work-up
3. MRI of the arm
4. PET scan
5. Infection work-up

PREFERRED RESPONSE: 2

DISCUSSION: The patient should be evaluated for any correctable metabolic or endocrine abnormality that may exist prior to any surgical intervention. Infection in the absence of previous surgery is very unlikely. There are no radiographic findings suggestive of a malignancy; therefore, MRI and PET scans are not indicated. Thermal imaging is not in use in orthopaedics.

Question 28
Of the following variables, which has the strongest influence on external fixator stiffness?

1. Pin diameter
2. Pin spread
3. Bone quality
4. Stacking a second fixator bar
5. Distance from bone to fixator bar

PREFERRED RESPONSE: 1

DISCUSSION: Whereas all of the factors will have an impact on frame rigidity and stability, the single biggest factor is the pin diameter because it has an exponential effect.


Question 29
Figure 29 is the radiograph of a 30-year-old man who sustained an isolated tibial shaft fracture. What is the most common deformity with nonsurgical management?

1. Varus
2. Malrotation
3. Valgus
5. Valgus and recurvatum
4. Valgus and procurvatum

PREFERRED RESPONSE: 1
DISCUSSION: Studies have shown that approximately 25% of diaphyseal fractures of the tibia with intact fibulae will go onto varus malunion if treated nonsurgically. Limb-length discrepancies are also common. Here the fibula acts as a strut, preventing valgus collapse but predisposing to varus collapse. Valgus and procurvatum is the typical deformity in proximal tibial fractures.


Question 30
Figures 30a and 30b are the radiographs of a 61-year-old man with diabetes who fell from a ladder and sustained an isolated closed fracture. After realignment and splint application, what is the most appropriate next step in management?

1. CT scan
2. Hybrid external fixation
3. Ankle-spanning external fixation
4. Open reduction and internal fixation within 6 to 8 hours
5. Open reduction and internal fixation within 2 to 3 days

PREFERRED RESPONSE: 3
DISCUSSION: The patient has sustained a high-energy severely comminuted AO/OTA C2 fracture of the distal tibia. This injury is notably fraught with soft-tissue complications that can lead to disastrous clinical results. In general, a staged protocol is now preferred in an effort to avoid these complications and has shown substantial decreases in infection rates and wound healing problems. A CT scan is certainly appropriate for preoperative planning but should be obtained after frame application because the indirect reduction that is achieved improves one’s ability to understand the fracture characteristics and morphology. Hybrid external fixation has fallen out of favor because of its limited biomechanic rigidity and clinical results. Open reduction and internal fixation in the acute phase (6 to 8 hours) or sub-acute phase (2 to 3 days) is difficult.


Question 31
A starting point entry portal that is too lateral on a trochanteric femoral nail will result in what deforming force?

1. Varus
2. Valgus
3. Flexion
4. Extension
5. Excessive hoop stress

PREFERRED RESPONSE: 1

DISCUSSION: The trochanteric entry portal for femoral nail insertion is increasingly being used by orthopaedic surgeons both for cephalomedullary implants and standard femoral nailing. In contradistinction to the piriformis fossa, the tip of the trochanter is not co-linear to the diaphyseal isthmus and an errant start can lead to the introduction of malalignment and/or iatrogenic comminution at the fracture site. The desired starting point should be at the tip or slightly medial to the tip of the greater trochanter to avoid varus malalignment and blow out of the lateral wall.

Question 32
A 26-year-old man is involved in a high-speed motorcycle accident. He sustains a grade IIIB open tibia fracture. Examination reveals a large soft-tissue defect and an insensate foot. What is the expected outcome in this scenario?

1. Equal functional outcome when limb salvage is compared with amputation
2. Worse functional outcome with limb salvage than with primary amputation
3. Better functional outcome when amputation is compared with limb salvage
4. Amputation within 6 months of injury
5. Permanent loss of plantar sensation

PREFERRED RESPONSE: 1

DISCUSSION: The Lower Extremity Assessment Project data have shown that absent plantar sensation is not an indication for primary amputation. When looking at a comparison between an insensate salvage group and a sensate salvage group at 2 years follow-up, both groups had an equal proportion (55%) of normal plantar sensation and functionally both groups were equivalent. Absent plantar sensation at initial evaluation is not prognostic for long-term plantar sensory status or functional outcome.


Question 33
Which of the following clinical scenarios represents the strongest indication for locked plating technique in a 70-year-old woman?

1. Segmentally comminuted ulnar fracture
2. Simple diaphyseal fracture of the humerus
3. Transverse midshaft displaced clavicle fracture
4. Periprosthetic femur fracture distal to a well-fixed total hip arthroplasty
5. Schatzker 2 fracture of the tibia with severe joint depression and comminution

PREFERRED RESPONSE: 4
DISCUSSION: Locking screw fixation is a relatively new option in the armamentarium of orthopaedic surgeons treating fractures. The understanding of the biomechanics, implications to healing, and optimal indications and surgical techniques is still in evolution. A periprosthetic proximal femur fracture with a stable prosthesis is best treated with open reduction and internal fixation with locking proximal fixation with or without cerclage cables. Diaphyseal fractures treated with compression plating or bridge plating can be treated well with conventional implants unless osteoporosis is severe. An AO/OTA B-type partial articular fracture is also better suited to standard buttress plating with periarticular rafting lag screws. Locking fixation is not always required for a transverse displaced midshaft clavicle fracture.


Question 34
A 65-year-old woman with rheumatoid arthritis is involved in a motor vehicle accident. Her injuries include a right displaced femoral neck fracture, a left open tibial pilon fracture, a left open tibial plateau fracture, multiple rib fractures, and bilateral pulmonary contusions. Her vitals signs on admission are a heart rate of 115 bpm and a systolic blood pressure of 90 mm Hg. Laboratory studies show a hemoglobin of 10.0 g/dL and a delta base of -6.0 mmol/L. What finding in this patient is most significantly associated with increased mortality?

1. Heart rate
2. Base deficit
3. Hemoglobin
4. Urine output
5. Systolic blood pressure

PREFERRED RESPONSE: 2

DISCUSSION: The severity of injuries and the lack of physiologic reserve in this and other elderly patients often result in mortality. Base deficit has shown to be a reliable predictor of mortality even in normotensive elderly blunt trauma patients. Although tachycardia, low systolic blood pressure, and low hemoglobin may all contribute to these patients’ mortality, base deficit may be used as a predictor of mortality and a measure of resuscitation.
Question 35
A fracture of what portion of the coronoid is most often associated with a terrible triad injury?

1. Tip
2. Rim
3. Base
4. Anterolateral facet
5. Anteromedial facet

PREFERRED RESPONSE: 1

DISCUSSION: The most common pattern of coronoid fracture with a terrible triad injury is a transverse fracture of 2 mm to 3 mm of the tip. The mechanism of injury of a terrible triad injury is typically valgus and supination. These forces force the radial head against and then under the capitellum, resulting in a fracture of the radial head. The coronoid is then driven under the trochlea and sheared off as the valgus force continues. The lateral collateral ligament typically tears next.

A 45-year-old man sustained the injury shown in Figures 36a and 36b. The involved side is his dominant side. What is the most appropriate management?

1. Closed reduction
2. Arthroscopic labral repair
3. MRI to evaluate the rotator cuff
4. Stress radiographs to evaluate instability
5. Early motion in a structured physical therapy program

PREFERRED RESPONSE: 5

DISCUSSION: This minimally displaced (one-part) proximal humerus fracture is best treated with nonsurgical management. Early motion and physical therapy should be instituted to optimize functional results. No reduction is required. There is no indication for an acute MRI scan. If symptoms exist after healing, one may be obtained. Labral injuries are not typically associated with this type of injury. Instability is not associated with a one-part fracture and stress radiographs are not described.

Question 37
Which set of patient characteristics has the highest risk of developing osteonecrosis after an intracapsular femoral neck fracture?

1. 45-year-old woman with a displaced fracture
2. 55-year-old man with a nondisplaced fracture
3. 70-year-old woman with a nondisplaced fracture
4. 70-year-old man with a displaced fracture
5. 85-year-old woman with a displaced fracture

PREFERRED RESPONSE: 1

DISCUSSION: Loizou and associates prospectively studied 1,023 patients who sustained an intracapsular hip fracture that was treated with internal fixation using contemporary methods. The overall incidence of osteonecrosis was 6.6%. Osteonecrosis was less common for undisplaced (4.0%) than for displaced fractures (9.5%) and in men (4.9%) than women (11.4%) who had a displaced fracture. The incidence of osteonecrosis for those patients younger than 60 years and who sustained a displaced fracture was 20.6%, compared with 12.5% for those aged 60 to 80 years and 2.5% for those older than age 80 years. Barnes and associates reported that late segmental collapse was more common in displaced fractures in women younger than age 75 years than in those older than age 75 years.


Question 38
When compared with reamed intramedullary nailing for an unstable diaphyseal tibia fracture, unreamed nailing is associated with which of the following?

1. Longer surgical times
2. Higher infection rates
3. Lower functional outcome scores
4. Similar union rates in open fractures
5. Higher incidence of pulmonary complications

PREFERRED RESPONSE: 4
DISCUSSION: The Investigators Randomized Trial of Reamed versus Non-Reamed Intramedullary Nailing of Tibial Shaft Fractures (SPRINT) study, a large, randomized, controlled trial, has shown a benefit of reamed intramedullary (IM) nailing versus unreamed IM nailing for closed tibial shaft fractures with regard to reoperation rates. No such association exists for open tibial fractures; ie, union rates are the same for open fractures. The infection rates are the same, as is functional outcome, and surgical time is potentially shorter for unreamed nails. The potential pulmonary benefits from unreamed nailing have never been clinically proven.

Figures 39a and 39b are the radiographs of a 45-year-old man with diabetes who fell 12 feet from a ladder and sustained an isolated closed injury to his left leg. Examination revealed that he was neurovascularly intact and compartments were soft. A damage control knee spanning external fixator was applied and after 2 weeks in the frame, his blisters have resolved and his skin now wrinkles. What is the most appropriate treatment?

1. Conversion to a periarticular "hybrid" frame
2. Open reduction and internal fixation with a lateral nonlocking plate
3. Open reduction and internal fixation with a lateral locking plate
4. Open reduction and internal fixation with medial and lateral plates
5. Open reduction and internal fixation with posteromedial and lateral plates

PREFERRED RESPONSE: 5

DISCUSSION: The patient has sustained a severely comminuted bicondylar fracture of the tibial plateau. The mechanism and radiographs highlight the high-energy mechanism of the injury and should warrant aggressive monitoring for compartment syndrome which is relatively common in this scenario. A staged surgical approach is warranted with application of a spanning damage control external fixator to maintain length and alignment while the soft-tissue injury recovers and to allow for surveillance and examination of the limb. The radiographs reveal a comminuted bicondylar pattern with significant depression of the lateral articular surface and a split fracture with condylar widening. This element of the fracture will require direct elevation of the joint surface and reduction/buttress of the lateral condyle. This is best achieved with a lateral plate with subchondral rafting screws. The medial articular surface is coronally split and the posteromedial fragment is displaced. This fragment requires direct reduction and buttress via a separate posteromedial approach which is frequently performed prior to the lateral approach and fixation. A lateral buttress plate or a lateral locking plate alone does not reliably capture or adequately support the displaced posteromedial fragment. A medial and lateral plate construct is less soft-tissue friendly, particularly if inserted through a single incision. A medial plate would also fail to give direct buttress to the posteromedial fragment.

Question 40
A patient with an unstable pelvic ring injury has just undergone an emergent laparotomy and currently has a packed abdomen. Stabilization of the pelvic ring is performed with an anterior external fixator. What is an advantage of using an external fixator with pins in the iliac crest rather than pins in the anterior inferior iliac spine?

1. Greater pelvic ring stability
2. Lower risk of pin tract infection
3. Less reliance on fluoroscopy for pin placement
4. Better ability to control a posterior pelvic injury
5. Less likely to interfere with future incisions for definitive pelvic internal fixation

PREFERRED RESPONSE: 3

DISCUSSION: There are relative advantages to both types of these external fixators. A frame based on the iliac crest is oftentimes easier to place rapidly because it is less dependent on fluoroscopy. This is also advantageous in this clinical scenario because the patient may not be on a radiolucent table. A frame with pins in the anterior inferior iliac spines may be advantageous in that the pin sites will be away from any future needed incisions if an ilioinguinal approach is needed. There is, however, a higher risk of lateral femoral cutaneous nerve injury or intra-articular pin placement at the hip joint with this frame configuration. This technique is generally more dependent on fluoroscopy for pin placement. Some biomechanic studies have shown advantages to AIIS-based frames but this does not give a definite clinical advantage because neither frame alone is adequate to definitively treat an unstable associated posterior pelvic ring injury. There is no known difference in pin site infection rates between these frame types.

Question 41
What finding would most likely be present on an AP radiograph of a nondislocated elbow with an anteromedial coronoid fracture?

1. A “fleck” sign
2. The AP radiograph would appear normal
3. Equal joint spaces between the medial trochlea and the coronoid
4. Progressive narrowing of the joint space from lateral to medial between the medial trochlea and the coronoid
5. Progressive narrowing of the joint space from medial to lateral between the medial trochlea and the coronoid

PREFERRED RESPONSE: 4

DISCUSSION: Because of the fracture of the anteromedial portion of the coronoid, the medial side of the elbow is unsupported to varus stresses. As a result, the joint line will narrow from lateral to medial secondary to medial collapse of the joint. There is no “fleck” sign for this injury.

Question 42

Figures 42a and 42b are the AP pelvis and normal chest radiographs of a 40-year-old man who was a restrained driver in a high-speed motor vehicle crash. He reports right hip pain in the emergency department. He was awake and alert, normotensive, and tachycardic. Hemoglobin was 14 gm/dL. Thoracolumbar radiographs are normal. A closed reduction of the right hip was performed and the patient was monitored in the emergency department. One hour later, he was transported to the intensive care unit and, en route, he started to report chest pain and new onset of lower extremity weakness. He was noted to be tachycardic and hypotensive. Which of the following studies should be obtained?

1. CT scan of the head
2. CT scan of the pelvis
3. CT scan of the lumbar spine
4. CT angiography of the chest
5. Angiography of the right lower extremity

PREFERRED RESPONSE: 4

DISCUSSION: Posterior hip dislocation associated with a deceleration injury is associated with traumatic rupture of the thoracic aorta. Usually the chest radiograph reveals some abnormality such as mediastinal widening but this sign may be absent. This patient’s mental status is normal so an intracranial process is not a likely cause of the change in status. The patient is not reporting back pain. Posterior dislocation is not commonly associated with intrapelvic bleeding or lower extremity vascular injury. A high index of suspicion is necessary; however, in light of the patient’s chest pain and hypotension as well as lower extremity weakness (likely from spinal cord ischemia); therefore, the most appropriate study is CT angiography of the chest followed by prompt cardiothoracic surgical intervention.

Figure 43

Question 43

Figure 43 is the radiograph of a 22-year-old right-hand dominant man who sustained the injury shown 1 year ago. He now reports persistent pain with activity. Which of the following interventions would most reliably relieve the patient’s symptoms?

1. Functional bracing
2. Compression plating
3. Iliac crest bone grafting
4. Reamed intramedullary nailing
5. Internal electrical bone stimulation

PREFERRED RESPONSE: 2

DISCUSSION: This is a hypertrophic nonunion of the forearm. Vascularity to the fracture site has been preserved; however, there is too much mechanical instability leading to failure of healing. Compression plating alone is all that is necessary to achieve fracture site stability and union. Iliac crest bone grafting is needed in atrophic-type nonunions. Internal electrical bone stimulation is used as an adjunct occasionally, but again is usually reserved for atrophic nonunion types. This patient has failed to respond to nonsurgical management, and functional bracing will not provide enough mechanical stability to the nonunion site to promote union. A plate and screw device provides greater mechanical stability than a reamed intramedullary nail. Furthermore, use of a reamed intramedullary nail has never been described for the treatment of a nonunion of the forearm.


Question 44

Figures 44a and 44b are the radiograph and axial CT scan of a 24-year-old woman involved in a motor vehicle accident. The patient undergoes surgery and an intraoperative photograph is seen in Figure 44c. The finding indicated by the arrow is best described as which of the following?

1. Hip subluxation
2. Marginal impaction
3. Posterior wall fragment
4. Displacement of the transverse fracture
5. Osteochondral injury to the femoral head

PREFERRED RESPONSE: 2

DISCUSSION: The CT scan and the intraoperative photograph reveal a classic example of marginal impaction that is frequently seen with posterior wall acetabular fractures as a result of the hip dislocating and impacting a small rim of cartilage. Recognition of this injury is important because it requires special attention for restoration of articular congruency. Although hip subluxation, displacement of the transverse fracture, and osteochondral injury to the femoral head are all seen with this injury pattern, the arrow points to the marginal impaction.

Question 45
Which of the following is associated with increased fetal morbidity and mortality in acetabular fractures during pregnancy?

1. Fetal position
2. Surgical approach
3. Mechanism of injury
4. Fracture classification
5. Trimester of pregnancy

PREFERRED RESPONSE: 3

DISCUSSION: Fixation of pelvic and acetabular fractures in pregnancy is not contraindicated. However, both maternal and fetal morbidity and mortality is increased in this patient subset. Factors shown to be associated with increased fetal mortality include: injury severity, mechanism of injury, and maternal hemorrhage. Surgical approach, fracture classification, fetal position, and the trimester of pregnancy have not been shown to affect fetal morbidity or mortality.


Question 46
Which of the following is the major blood supply to the heel pad?

1. Lateral calcaneal artery
2. Lateral malleolar artery
3. Artery of the sinus tarsi
4. Artery of the tarsal canal
5. Medial calcaneal branch of the posterior tibial artery

PREFERRED RESPONSE: 5

DISCUSSION: The medial calcaneal branch of the posterior tibial artery is the major vascular supply to the heel pad. Heel pad avulsions are severe injuries associated with high-energy trauma and often carry a poor prognosis because of the potential for heel pad necrosis. The lateral calcaneal artery and the lateral malleolar artery, along with the lateral tarsal artery, provide perfusion to the lateral flap associated with a standard extensile approach to the calcaneus. The artery of the tarsal canal is a branch of the posterior tibial artery, and the artery of the sinus tarsi is a branch of the perforating peroneal artery. Both provide perfusion to the talus.

Question 47
Figures 47a and 47b are the radiograph and CT scan of a 45-year-old man who was involved in a high-speed motor vehicle accident. What is the most appropriate treatment?

1. Subtalar arthrodesis
2. Percutaneous screw fixation
3. Closed reduction and cast application
4. Open reduction and internal fixation
5. Non-weight-bearing and early range of motion

PREFERRED RESPONSE: 4

DISCUSSION: The radiograph and CT scan show a displaced talar neck fracture that is best treated with anatomic reduction and stable internal fixation. Neither non-weight-bearing and early range of motion nor closed reduction and cast application address the unstable fracture or restore articular congruity. The fracture is displaced with an interposed fragment in the fracture line and therefore requires open reduction prior to screw placement. Subtalar arthrodesis should be reserved for talar fractures with severe injury to the subtalar joint.

Question 48
Figures 48a and 48b are the initial radiograph and clinical photograph of a 21-year-old woman who sustained a severe mangled injury to her left foot in a rollover ATV crash. After multiple débridements, she underwent definitive transmetatarsal amputation with split-thickness skin graft. She did have intact plantar sensation. Figure 48c shows the clinical photograph 10 days after amputation. Her wounds healed without infection and she did not require further surgery. At 2 years after injury, which of these factors is most likely to be associated with improved level of satisfaction?

1. Female gender
2. Use of skin graft
3. Ability to return to work
4. Retained plantar sensation
5. Initial treatment by amputation

PREFERRED RESPONSE: 3

DISCUSSION: The LEAP study is a multicenter prospective study evaluating multiple aspects of reconstruction versus amputation in the treatment of mangled extremity injuries. With regard to patient satisfaction, treatment variables such as decision for reconstruction versus amputation, or initial presence or absence of plantar sensation have little impact. In addition, demographic factors such as age, gender, socioeconomic status, and education level do not predict patient satisfaction. Instead, the most important predictors of patient satisfaction at 2 years after injury include the ability to return to work, absence of depression, faster walking speed, and decreased pain.

Question 49

Which of the following is expected as a sequela with the use of a knee-spanning external fixator as a temporary method of stabilization for the injury shown in Figure 49?

1. Diminished distal pulses
2. An increased rate of pulmonary injury
3. Inability to access soft-tissue envelope
4. Transient compartmental pressure changes
5. Longer time to soft-tissue resolution for definitive surgery

PREFERRED RESPONSE: 4

DISCUSSION: The use of bridging external fixation about the knee for severe tibial plateau fractures is associated with all of the following: swelling reduction, improved blood flow, access to the soft-tissue envelope, with only transient increases in intracompartmental pressure during application. It has no effect on pulmonary injuries.

Question 50

Figure 50a is the radiograph of a 25-year-old man who fell off his bike, landed on his outstretched elbow, and sustained a closed fracture-dislocation of the elbow. After urgent closed reduction, he has no neurovascular compromise. Postreduction radiographs are shown in Figures 50b and 50c. What is the most appropriate management?

1. Transarticular screw fixation
2. Hinged external fixation and medial collateral ligament repair
3. Radial head excision, coronoid open reduction and internal fixation, and lateral collateral ligament repair
4. Open reduction and internal fixation of the coronoid, radial head arthroplasty, and lateral ulnar collateral ligament repair
5. Open reduction and internal fixation of the radial head, repair of the lateral collateral ligament, and excision of the coronoid fragment

PREFERRED RESPONSE: 4

DISCUSSION: The radiographs reveal a terrible triad injury of the elbow. This is a constellation of injuries involving an elbow dislocation, radial head fracture, and coronoid fracture and it is notorious for persistent instability and redislocation if treatment is inadequate. After initial closed reduction, surgical management is indicated to prevent or limit long-term complications. This involves repair or replacement of the injured radial head, reduction and fixation of the coronoid/anterior capsule complex, and lateral ligamentous repair. If there is persistent instability, then additional medial ligamentous repair should be undertaken. Nonsurgical management with bracing or cast immobilization is inadequate for this injury. Isolated treatment of either the coronoid or radial head, without addressing the other injury components is inadequate. Hinged external fixation is associated with a high complication rate and is generally reserved for salvage cases. The radial head should not be excised in an unstable elbow injury. Transarticular screw fixation is reserved for salvage situations.

Question 51
A 31-year-old man sustained an unstable closed left posterior hip dislocation in a motorcycle accident. A postreduction radiograph is shown in Figure 51a. 3-D CT scans are shown in Figures 51b and 51c. What is the optimal surgical approach that will allow for the most appropriate treatment?

1. Surgical dislocation
2. Watson-Jones approach
3. Smith-Peterson approach
4. Kocher-Langenbach approach
5. Extensile iliofemoral approach

PREFERRED RESPONSE: 1

DISCUSSION: The radiograph and CT scans show a posterior wall acetabular fracture with an associated femoral head fracture. As is the case in most of these injuries, the femoral head fracture is located on the anterior aspect of the femoral head. Surgical dislocation with a trochanteric flip osteotomy as described by Solberg and associates and Henle and associates allows for exposure and treatment of the posterior wall fracture as well as surgical dislocation for treatment of the femoral head fracture. A Smith-Peterson approach or Watson-Jones approach would allow for anterior exposure and may help to address the femoral head fracture, but not the posterior wall fracture. A Kocher-Langenbach approach would allow exposure of the posterior wall fracture, but not the femoral head fracture. An extensile iliofemoral approach is unnecessary for this injury pattern.

Question 52
What is the most common complication following surgery for a “terrible triad” elbow fracture-dislocation?

1. Arthritis
2. Infection
3. Re-dislocation
4. Restricted range of elbow motion
5. Posterior interosseous nerve (PIN) palsy

PREFERRED RESPONSE: 4

DISCUSSION: Recurrent instability, PIN palsy, infection, and posttraumatic arthritis have all been reported following these injuries; however, elbow contracture or loss of motion is nearly universal following these injuries.


Figure 53

Question 53
Figure 53 is the radiograph obtained at the time of transfer to the trauma center of a 41-year-old man who was involved in a motor vehicle accident. What is the most appropriate initial management?

1. MRI scan
2. CT scan of the pelvis
3. Application of skeletal traction
4. Closed reduction of the right hip
5. Open reduction and internal fixation

PREFERRED RESPONSE: 4
DISCUSSION: The radiograph reveals a displaced transverse posterior wall acetabular fracture, and the hip is dislocated. On recognition of a hip dislocation, the hip should be promptly reduced. A time to reduction of greater than 12 hours has been associated with adverse outcomes. Although skeletal traction and a CT scan are essential elements in this patient’s care, the hip should be reduced prior to these actions. An MRI scan is not indicated in this patient, particularly with the hip dislocated. The ultimate surgical treatment for this injury will be open reduction and internal fixation, but the patient should be stabilized, the hip reduced, and appropriate imaging obtained before taking the patient to surgery.


Question 54
Figures 54a and 54b are the radiographs of a 23-year-old man who fell from a height and sustained an isolated injury to his right leg. Which of the following is a useful surgical technique to optimize alignment during intramedullary nailing?

1. Move the starting point slightly medial
2. Move the starting point slightly lateral
3. Hyperflexion of the knee
4. Anterior blocking screw
5. Medial blocking screw

PREFERRED RESPONSE: 2
DISCUSSION: Fractures of the proximal metadiaphysis of the tibia can be treated successfully with intramedullary nails, but previous studies showed rates of malalignment of up to 84%. The typical deformity is valgus and procurvatum. An ideal starting point is mandatory and should be slightly lateral to the medial border of the lateral tibial eminence on a true AP view and very proximal and anterior on a true lateral view with appropriate coronal and sagittal trajectory of the entry reamer. A medial start point will exacerbate valgus deformity and should be avoided. A reduction should be obtained and maintained during reaming, implant insertion, and interlocking. This can be facilitated via a variety of techniques including intraoperative external fixation, percutaneous reduction clamps or joysticks, semi-extended positioning, blocking screws that are typically inserted posterior and lateral to the nail, and ancillary plate fixation. With careful attention to these techniques, more recent studies report low rates of malalignment.


Question 55
A 27-year-old man who was involved in a high-speed motor vehicle crash arrives at the trauma center with loss of consciousness, multiple posterior rib fractures, a left scapula body fracture, a left humerus fracture, bilateral femoral shaft fractures, and an open right ankle fracture-dislocation. Initial vital signs are a blood pressure of 88/50 mm Hg, a pulse of 120 bpm, and respirations of 22/min. His injury severity score is 28 and lactate levels are 2.7. CT scans of the head and abdomen are negative for hemorrhage, and after initial resuscitation the patient is cleared for surgery. Initial orthopaedic management should consist of débridement and irrigation of the right ankle with

1. external fixation, intramedullary nailing of bilateral femurs, and intramedullary nailing of the left humerus.
2. external fixation, external fixation of bilateral femurs, and splinting of the left humerus.
3. external fixation, external fixation of bilateral femurs, and open reduction and internal fixation of the left humerus.
4. open reduction and internal fixation, intramedullary nailing of bilateral femurs, and open reduction and internal fixation of the left humerus.
5. open reduction and internal fixation, external fixation of bilateral femurs, and intramedullary nailing of the left humerus.

PREFERRED RESPONSE: 2
DISCUSSION: The transition from early total care (ETC) to damage control orthopaedics has developed over the past 20 years in orthopaedic polytrauma situations. A vast number of studies over the past several years have investigated the timing and technique of orthopaedic intervention in the care of these patients and effects on outcomes. The goal is to avoid an iatrogenic second hit that can push a patient into adult respiratory distress syndrome (ARDS) or multiple organ failure (MOF). In a patient who is unstable, the algorithm shifts to damage control orthopaedics (DCO). In this patient, the minimum intervention to achieve orthopaedic stability is indicated; therefore, débridement and irrigation of open fractures, external fixation of lower extremity long bones, and splinting of upper extremity fractures is appropriate. There are several parameters that can help classify a patient’s condition and therefore guide the surgeon’s initial management (see Figure 55). Grade I is stable and the patient can be cleared for surgery for early total care. Grade II is borderline and these patients are found along a continuum. In general, the priority of each injury should be determined and the most important fixed first. The surgeon should continually check the patient’s status and proceed as long as the patient is stable. Once the patient shows signs of deteriorating status, DCO should be implemented for the remaining injuries. Grade III is unstable and DCO should be the initial course of action. Grade IV is in extremis with life-threatening injuries and DCO should be implemented if possible. In this scenario, answer choices 1 and 2 involve an ETC philosophy and would be inappropriate for this patient who is unstable with significant chest trauma. In answer choice 3, the humerus is not a higher priority than the femur fractures and should be one of the last fractures addressed surgically. Open reduction and internal fixation of the ankle fracture would not be indicated in an unstable patient.


Figures 56a and 56b are the radiographs of an 88-year-old woman who had a ground level fall. Examination reveals no neurovascular compromise, and the skin condition is good. The patient is otherwise in good health, does not take medication, and lives by herself. What is the most appropriate treatment?

1. Sling
2. Total elbow arthroplasty
3. Long-arm cast immobilization
4. Closed reduction, Kirschner wire fixation, and cast immobilization
5. Open reduction and internal fixation with medial and lateral column plates

PREFERRED RESPONSE: 2

DISCUSSION: Most distal humerus fractures are treated with open reduction and plate fixation. There is increasing evidence that in an elderly, osteoporotic patient with a comminuted or very distal fracture, total elbow arthroplasty is associated with better outcomes than open reduction and internal fixation. Nonsurgical management, ie, a sling or cast immobilization, is generally reserved for patients with significant medical conditions that preclude surgery. Kirschner wires and casting is the treatment of choice in children. In adults, however, the periosteum is not as robust and does not help in maintaining reduction. Stiffness is inevitable with cast immobilization.
Figure 57 is the radiograph of a 58-year-old woman who is right-hand dominant and has fallen on her flexed right elbow and is seen in the emergency department reporting isolated episodes of right elbow pain. Examination reveals that the skin is contused but intact, and her distal neurovascular examination is normal. What is the most appropriate treatment?

1. Percutaneous pinning
2. Closed reduction and extension casting
3. Fragment excision and triceps advancement
4. Open reduction and internal fixation with plate fixation
5. Open reduction and internal fixation with tension band wire construct

PREFERRED RESPONSE: 4
DISCUSSION: The patient has sustained an isolated, closed fracture of the olecranon without associated instability. The bone is radiographically osteopenic and the fracture is displaced, comminuted, and includes articular marginal impaction. Plate fixation is preferred in the presence of comminution or associated transolecranon or radiocapitellar instability. Displaced fractures are generally treated surgically in an effort to restore articular congruity, restore extensor function, and to allow for early mobilization in an effort to maximize functional outcomes. A tension band wire construct is a commonly used technique but is reserved for simple fracture patterns without comminution. Excision and triceps advancement can be considered in elderly, low-demand patients that have small unreconstructable fracture patterns without associated elbow instability.


Question 58
A 41-year-old man is involved in a high-speed motor vehicle crash and sustains a closed femoral midshaft fracture and a unilateral pulmonary contusion with a hemothorax, requiring placement of a chest tube. He has an initial blood pressure of 90/50 mm Hg. After receiving two liters of crystalloid, he has a blood pressure of 115/70 mm Hg and a heart rate of 90 bpm. He has normal mentation and does not require ventilator support. An arterial blood gas reveals that his delta base is -2 mmol/L. What is the most appropriate treatment for his femoral fracture?

1. Skeletal traction
2. Temporizing external fixation
3. Reamed intramedullary nailing
4. Unreamed intramedullary nailing
5. Open reduction and internal fixation

PREFERRED RESPONSE: 3

DISCUSSION: The patient responded to crystalloid resuscitation and hemodynamic parameters and the base deficit indicate that he is adequately resuscitated for definitive fracture care. In a resuscitated patient, a reamed nail is not detrimental in the setting of a pulmonary injury and is favorable for fracture union. An unreamed nail has a higher nonunion rate than a reamed nail for femoral fractures. In a skeletally mature patient with a midshaft fracture, an intramedullary nail is preferred to open reduction and internal fixation. In an adult patient, skeletal traction should be considered only as a temporary treatment prior to surgical fixation of the femoral fracture.

Question 59
A 20-year-old concert pianist sustained a diaphyseal radius fracture and underwent open reduction and internal fixation 3 years ago. She is thin and reports that the plate is irritating her after playing the piano for an hour or more. She undergoes elective plate removal of the 3.5 mm plate and 2 weeks later she refractures the radius. Which of the following statements is most accurate?

1. Diaphyseal plate removals are at higher risk of refracture.
2. Postoperative splinting increases the chance of refracture.
3. The patient would not have sustained a refracture if the plate was 4.5 mm.
4. The risk of fracture increased because the plate was removed within 5 years.
5. Waiting 5 years to remove the hardware would have decreased the risk of refracture.

PREFERRED RESPONSE: 1

DISCUSSION: The risk of refracture after hardware removal is multifactorial. Multiple variables have been looked at, such as protective splinting for 6 weeks after hardware removal, waiting 12 months or more prior to hardware removal, and the location of the fracture. The one variable that seems to correlate the most with the risk of refracture is a diaphyseal location of the initial fracture. Large fragment plates (4.5 mm), when removed, are at higher risk for refracture in the forearm.

Figures 60a and 60b are the radiographs of a 42-year-old man who was involved in a motorcycle crash. His vital signs are a pulse of 122 bpm, a blood pressure of 145/88 mm Hg, and a respiratory rate of 24/min. He has some facial trauma but his Glasgow coma scale score is 14. His delta base is -2 mmol/L. His primary and secondary surveys reveal no other injury. What is the most appropriate initial management?

1. Distal femoral traction for both injuries
2. External fixation of the pelvis and femur
3. External fixation of the pelvis and intramedullary nailing of the femur
4. Open reduction of the pelvis and external fixation of the femur
5. Nonsurgical management of the pelvis and intramedullary nailing of the femur

PREFERRED RESPONSE: 3

DISCUSSION: The patient is relatively hemodynamically stable and is a candidate for early surgical stabilization of his injuries. The femoral shaft fracture is best managed acutely with definitive intramedullary nailing. The rotationally unstable pelvic ring injury should be addressed at the time of femoral fracture fixation. In this patient, it is best managed acutely by anterior external fixation. Distal femoral traction would not be optimal for either injury.

Question 61

Figure 61 is the radiograph of a 34-year-old woman who was involved in a rollover motor vehicle accident. On arrival at the trauma center she is hypotensive and tachycardic. An abdominal CT scan reveals a spleen laceration. The patient remains hypotensive despite resuscitation and is taken to surgery for an emergent laparotomy and splenectomy. After surgery her delta base is -9 mmol/L. What is the most appropriate management of her pelvic ring injury?

1. Application of a pelvic binder
2. Application of skeletal traction
3. Open reduction and internal fixation
4. Placement of percutaneous iliosacral screws
5. Placement of an anterior pelvic external fixator

PREFERRED RESPONSE: 2

DISCUSSION: The patient has a displaced iliac wing and bilateral rami fractures with superior migration of the right hip. To prevent further deformity, the patient’s right hip should be placed into skeletal traction. A pelvic binder may worsen the deformity because of the iliac wing fracture. Anterior external fixation is problematic with an iliac wing fracture. Although the patient will eventually require open reduction and internal fixation and/or placement of iliosacral screws, she must be stabilized and resuscitated prior to this treatment.

Question 62
When planning pin placement for external fixation of the tibia, what is the maximum extent of the knee capsular reflection from the subchondral joint line?

1. 4 mm
2. 6 mm
3. 10 mm
4. 14 mm
5. 20 mm

PREFERRED RESPONSE: 4

DISCUSSION: Intracapsular pin placement is a concern for septic arthritis. Reid and associates and DeCoster and associates have demonstrated that the maximum distal extent of the knee capsule is 14 mm from the subchondral line and occurs in the posterolateral region. The recommended placement of external fixation pins is greater than 14 mm from the subchondral line of the proximal tibia.

Question 63

Figures 63a and 63b are the radiographs of a 24-year-old left-hand dominant man who felt a “snap” in the left mid-arm while arm wrestling. Examination reveals an isolated closed injury. He has significant pain and gross instability about the upper arm. His compartments are soft and he has good pulses with a well-perfused hand. He is unable to actively extend his wrist and fingers. Following splinting of the arm, his examination findings remain unchanged. What is the next most appropriate step in management?

1. Splintage followed by functional bracing
2. Intramedullary nailing with radial nerve exploration
3. Intramedullary nailing without radial nerve exploration
4. Open reduction and internal fixation with radial nerve exploration
5. Open reduction and internal fixation without radial nerve exploration

PREFERRED RESPONSE: 1

DISCUSSION: The patient has sustained an isolated, closed, comminuted fracture of the humeral diaphysis with an associated radial nerve palsy. In a report of 922 patients, Sarmiento and associates noted a nonunion rate of less than 2% with overall acceptable alignment and satisfactory functional results. Even in the presence of a radial nerve palsy, most humeral shaft fractures should be treated with functional bracing. Whereas open reduction and internal fixation and intramedullary nailing are viable treatment options, this fracture is acceptably aligned and is amenable to closed treatment. The absolute indications for surgical management include vascular injury, severe soft-tissue injury precluding closed treatment, compartment syndrome, open fracture, and associated ipsilateral forearm fracture, ie, floating elbow. Relative indications for surgical management include: segmental fracture, intra-articular extension, transverse fracture pattern with significant distraction, bilateral fracture, patient factors that preclude closed treatment such as head injury or morbid obesity, inability to maintain acceptable alignment via closed means, and polytrauma.

Question 64
Figures 64a and 64b are the radiographs of a 62-year-old woman who is seen in the emergency department after a fall to a flexed knee. She underwent posterior-stabilized total knee arthroplasty 6 years ago. She has no other injuries and was previously a community ambulatory without assistance. What is the most appropriate treatment?

1. Closed reduction and casting
2. Closed reduction and fracture bracing
3. Retrograde intramedullary nailing
4. Minimally invasive plate osteosynthesis
5. Revision total knee arthroplasty with distal femoral replacement

PREFERRED RESPONSE: 4
DISCUSSION: The patient has a displaced periprosthetic fracture just proximal to a posterior-stabilized total knee arthroplasty. Whereas distal bone stock is limited and there is evidence of radiographic osteopenia, there does not appear to be disruption of the bone-prosthetic interface and the prosthesis appears to be well fixed. Surgical fixation is indicated to restore alignment and allow for early range of motion and mobilization in an effort to optimize functional outcomes. Unless the patient is unable to tolerate surgical management, closed reduction and casting or functional bracing should be reserved for stable, minimally displaced or impacted fracture patterns. Whereas retrograde nailing is a viable treatment option, it can be difficult in the presence of a posterior-stabilized prosthetic design and distal fixation can be problematic in the setting of poor bone stock or quality. Minimally invasive plate osteosynthesis using modern-locking periarticular plates allows for indirect reduction techniques in an effort to optimize the biologic milieu and offers optimal biomechanical stability. Revisional total knee arthroplasty with a distal femoral replacement is not a good option for a young patient.


Question 65
A patient undergoes open reduction and internal fixation of a displaced radial neck fracture. What position should the forearm be in during the approach and during fixation?

1. Supinated during the approach and neutral for plate application
2. Neutral during the approach and pronated for plate application
3. Pronated during the approach and neutral for plate application
4. Pronated during the approach and pronated for plate application
5. Pronated during the approach and supinated for plate application

PREFERRED RESPONSE: 3

DISCUSSION: Pronating the forearm during the surgical approach decreases the danger to the posterior interosseous nerve by moving it away from the surgical field. Placing the plate straight lateral with the forearm in neutral rotation puts the plate in the safe zone that does not articulate with the proximal radioulnar joint to prevent impingement of the plate during forearm rotation.

Question 66
A 45-year-old man sustained bilateral femur fractures in a motorcycle accident. On admission to the emergency department, the patient is unconscious with a heart rate of 120 bpm and a systolic blood pressure of 80 mm Hg. A chest radiograph reveals bilateral pulmonary contusions. After resuscitation with 2 L of crystalloid, the patient’s heart rate is 115 bpm, the systolic blood pressure is 90 mm Hg, and the patient’s delta base is -10 mmol/L. What is the most appropriate treatment for the femoral fractures at this point?

1. External fixation
2. Percutaneous plating
3. Reamed antegrade intramedullary nailing
4. Reamed retrograde intramedullary nailing
5. Unreamed antegrade intramedullary nailing

PREFERRED RESPONSE: 1

DISCUSSION: The patient is in shock, has pulmonary contusions, and needs further resuscitation. Damage control orthopaedics (ie, external fixation of the femoral fractures) is rapid, safe, and assists in patient resuscitation. Although the patient may ultimately undergo definitive treatment with reamed intramedullary nailing or percutaneous plating, to do so at this time would not further assist resuscitation and may increase pulmonary dysfunction. Unreamed intramedullary nailing is not indicated in this patient.

Question 67
What approach should be chosen for the injury seen in Figure 67?

1. Stoppa
2. Hardinge
3. Ilioinguinal
4. Watson Jones
5. Kocher-Langenbeck

PREFERRED RESPONSE: 5

DISCUSSION: The injury shown is a transverse plus posterior wall fracture of the acetabulum. The anterior and posterior columns are fractured as one piece, the ischiopubic segment, and need to be reduced along with the posterior wall. The Kocher-Langenbeck approach will allow visualization of the transverse component through the joint and also direct exposure of the posterior wall. The ilioinguinal approach would not allow visualization or access to the posterior wall. The Stoppa, Watson Jones, and the Hardinge approaches do not allow adequate visualization of the posterior column which is needed to reduce the posterior wall. The other option is the extended iliofemoral approach which would allow excellent visualization and ability to reduce this fracture.

Question 68

Figures 68a and 68b are the radiographs of a 58-year-old right-hand dominant woman who fell from a standing height directly onto her left shoulder and now reports left shoulder pain and is unable to elevate her arm. She has a normal sensory examination. The patient refuses any type of surgical intervention. What factor will have the greatest impact on her outcome at 1 year?

1. Age
2. Bone quality
3. Hand dominance
4. Initial angulation of fracture
5. Use of a physical therapy program

PREFERRED RESPONSE: 1

DISCUSSION: In a review of over 1,000 proximal humerus fractures, Court-Brown and McQueen looked at outcomes of impacted varus fractures. These accounted for 13% of the fractures in their review. All impacted varus fractures, with the exception of two, were treated nonsurgically and were followed for 1 year. They determined that the age of the patient was the major factor in overall outcome. Good results can be expected with younger patients, but results deteriorate with advancing age. In regards to angulation of the fracture, they found no correlation between increased varus angulation and shoulder function. Most patients had good or excellent results no matter how much final varus was achieved. They also noted that physical therapy did not have a significant impact on outcome. In their study, poor results in patients who lacked therapy were more related to the advanced age of the patients. Hanson and associates prospectively evaluated nonsurgical management of 124 proximal humerus fractures for 1 year. They found that displacement of the fracture only gradually influenced the constant scores and that the DASH revealed the patients on average had not fully recovered at 1 year. They also noted that 97.6% of employed patients were able to return to work and that employed patients on average had significantly lower differences in side-to-side constant and DASH scores. Solid bony union was seen in 93% at 1 year and fracture consolidation was seen in 98%. The predicted risk of delayed and nonunion was 7% with smoking increasing the nonunion risk by 5.5 times.

Figure 69

Question 69
Figure 69 is the radiograph of a 52-year-old right-hand dominant man who fell while skiing. He was initially treated at a mountainside clinic where he was placed in a sling. He now reports moderate shoulder pain but has no other complaints. What is the most appropriate management?

1. Hemiarthroplasty
2. Total shoulder arthroplasty
3. Open reduction and internal fixation
4. Sling for 6 to 8 weeks followed by mobilization
5. Sling followed by early mobilization within 2 to 3 weeks

PREFERRED RESPONSE: 3

DISCUSSION: The patient sustained a four-part valgus impacted fracture of the proximal humerus with a significantly increased head-shaft angle and resultant displacement of the greater and lesser tuberosities. In an effort to restore anatomic alignment and optimize functional outcomes, open reduction and internal fixation is indicated. A valgus impacted pattern has been noted to have improved outcomes and lower rates of osteonecrosis. In addition, this patient has adequate bone stock and all efforts should be made to salvage his shoulder. A sling will not change the overall alignment and is therefore not the most appropriate treatment option. Hemiarthroplasty is reserved for unreconstructable patterns, and total shoulder arthroplasty would only be considered in the acute scenario if there was significant preexisting glenoid wear or inflammatory arthropathy.

Question 70
Pelvic packing for a hemodynamically unstable patient with a pelvic ring fracture is best described by which of the following techniques?

1. Placing a pelvic external fixator followed by packing the pelvis with lap pads via a subumbilical incision
2. Placing lap pads for packing via a subumbilical incision in the angiography suite
3. Placing lap pads for packing using the lateral window of the ilioinguinal approach (anterior approach to the internal iliac fossa)
4. Packing the retroperitoneum with lap pads after exploration of the abdomen by the general surgeons
5. Direct exploration of the pelvic vasculature via a midline incision followed by packing with lap pads

PREFERRED RESPONSE: 1

DISCUSSION: For the technique of pelvic packing patients are placed supine on an operating room table. For rotationally and/or vertically unstable fracture patterns, an external fixator is then placed to stabilize the pelvis so that the volume of the pelvis is decreased and the packing has counterforce acting against it. An approximately 6 cm to 8 cm midline incision is made extending upwards from the pubic symphysis and heading toward the umbilicus. The rectus fascia is then divided in the midline. The bladder is retracted to one side and three lap pads are packed deep to the pelvic brim. The bladder is retracted to the other side and three more lap pads are placed on that side as well. The first sponge is placed at the level of the sacroiliac joint, the second anterior to the first sponge, and the third in the retropubic space lateral and just deep to the bladder. All should be placed below the level of the pelvic brim. The fascia is then closed. If the patient is hemodynamically unstable after stabilization, then packing of the pelvis angiography should be considered.

Question 71
A previously healthy man who weighs 70 kg (154 lb) sustains an acute blood loss of 2 liters after a motorcycle crash. Which of the following statements about physiologic parameters is unique to this amount of blood loss?

1. Pulse pressure will be widened.
2. Urine output will be at the lower limits of normal.
3. Tachycardia will be present, but with no change in systolic blood pressure.
4. Systolic blood pressure will be decreased with a narrowed pulse pressure.
5. Systolic blood pressure will be maintained with an elevated diastolic blood pressure.

PREFERRED RESPONSE: 4

DISCUSSION: The normal adult blood volume is approximately 7% of body weight. For example, a man weighing 70 kg has a circulating blood volume of approximately 5 liters. A blood loss of 2 liters places the patient in a class IV hemorrhage of more than 40% blood volume loss. Signs and symptoms of class IV hemorrhage include marked tachycardia of greater than 140 bpm, a significant decrease in blood pressure, and a very narrow pulse pressure. Urinary output is negligible, and mental status is markedly depressed. The skin is cold and pale. Physiologic parameters associated with a class II hemorrhage include: urine output that is at the lower limits of normal; the presence of tachycardia but with no change in the systolic blood pressure; and maintenance of the systolic blood pressure with an elevated diastolic blood pressure. A widened pulse pressure correlates with a class I hemorrhage.

RECOMMENDED READING(S): American College of Surgeons Committee on Trauma, eds. ATLS: Advanced Trauma Life Support for Doctors. 8th ed. Chicago, IL: American College of Surgeons;2008:69-85.
Question 72

Figures 72a through 72d are the radiographs and CT scans of a 45-year-old man who fell 10 feet from a ladder and sustained an injury to the right knee. Examination reveals no open wounds and the skin was in good condition with moderate swelling and no fracture blisters. The patient is neurovascularly intact. What is the most appropriate treatment?

1. Hinged knee brace and non-weight-bearing for 6 weeks
2. Percutaneous screw fixation
3. Open reduction and internal fixation with a laterally applied nonlocking plate
4. Open reduction and internal fixation with posteromedial and lateral plates via one anterior approach
5. Open reduction and internal fixation with posteromedial and lateral plates via dual incisions

PREFERRED RESPONSE: 5

DISCUSSION: The patient has a bicondylar tibial plateau fracture with metadiaphyseal separation, depressed lateral articular surface, and a medial articular coronal split. This fracture is ideally treated with open reduction and internal fixation. A nonlocking lateral plate may not be able to protect against varus collapse through the metaphysis as well as a locking plate. However, neither plate can reliably deal with reduction and reliable fixation of the medial articular fracture. Recent studies have shown the relative frequency of the so-called “posteromedial fragment,” and have recommended supplemental fixation of the medial articular surface because standard lateral implants may not be able to gain screw purchase in the posteromedial bone. Other studies have shown good fracture reduction and maintenance of reduction with low complication rates using the two-incision technique with double plating. Placing dual plates via one anterior incision is associated with soft-tissue complications.

Figure 73a  Figure 73b  Figure 73c

Question 73
Figures 73a through 73c are the radiographs of a 57-year-old woman who twisted her ankle stepping off a curb and now has lateral foot pain. Examination reveals intact skin and point tenderness over the base of the fifth metatarsal. What is the most appropriate treatment?

1. Fragment excision
2. Intramedullary screw fixation
3. Non-weight-bearing cast for 6 weeks
4. Percutaneous Kirschner wire fixation
5. Immediate weight bearing with a postoperative shoe

PREFERRED RESPONSE: 5

DISCUSSION: The patient has an avulsion fracture of the fifth metatarsal base. Unlike a true Jones-type fracture, this is amenable to immediate weight bearing. Intramedullary screw fixation may be indicated in select patients with a Jones fracture but not with this fracture type. Fragment excision can be considered in the presence of a symptomatic nonunion of this fracture, but is not indicated acutely. Percutaneous pinning is not indicated.

Question 74
Which of the following factors is associated with improved outcomes following surgery for hip fractures?

1. Immediate surgical intervention
2. Early discharge to a skilled nursing facility
3. Choosing spinal versus general anesthesia for surgery
4. Choosing total hip arthroplasty instead of hemiarthroplasty for a displaced femoral neck fracture
5. Correction of metabolic abnormalities prior to surgical intervention

PREFERRED RESPONSE: 5

DISCUSSION: Many studies have looked at patient outcomes following hip fracture surgery. While early surgery in these patients is recommended, medical optimization prior to surgical intervention is warranted in all cases. Anesthetic type and discharge status have not been proven to alter patient outcomes. Total hip arthroplasty has improved function at 1 year compared with hemiarthroplasty; no changes in mortality have been reported.

Figures 75a through 75e are the CT scans and radiographs of a 56-year-old man who is a restrained driver involved in a motor vehicle accident in which his car is struck at 35 mph. He has pain to the right buttock and groin regions. Examination reveals that he is neurologically intact and has no evidence of other injuries. What is the most appropriate management at this time?

1. Anterior pelvic external fixation
2. Iliosacral screw fixation on the right side
3. Open reduction and internal fixation of the sacrum
4. Bed rest for 1 to 2 weeks, followed by non-weight-bearing on the right side for 4 weeks
5. Immediate mobilization and weight bearing as tolerated on the right lower extremity

PREFERRED RESPONSE: 5

DISCUSSION: The patient has a lateral compression-type pelvic fracture with an incomplete fracture of the sacrum. This is a stable pattern that will tolerate immediate weight bearing with little risk of displacement. Anterior pelvic external fixation is occasionally indicated for a lateral compression-type pelvic fracture to reduce a severe internal rotation deformity, but that is not present in this patient. Iliosacral screw fixation may be indicated if the patient has pain that prevents mobilization with this injury or in the case of a sacral fracture that is complete or comminuted, which can indicate a higher risk of displacement.


Question 76

How is the fracture pattern shown in Figures 76a through 76c best classified?

1. Moore 1
2. Moore 3
3. Schatzker 3
4. Schatzker 6
5. OTA type 41C

PREFERRED RESPONSE: 2

DISCUSSION: This fracture is best classified as a “rim avulsion pattern”: Moore type 3. A Moore 1 is a posteromedial shear fracture associated with subluxation of the tibiofemoral joint. This classification is useful for fractures associated with knee instability and patterns that do not fit into the Shatzker classification. A Shatzker 3 is a pure depression type, and a type 6 has metaphyseal-diaphyseal dissociation. OTA type C are complete articular fractures.


Figures 77a and 77b are the radiographs of a 45-year-old man who fell into a ditch and sustained a twisting injury to the left lower extremity. Examination in the emergency department reveals normal neurologic function, no skin compromise, and palpable pedal pulses. The patient has no other complaints and has an otherwise normal examination. What additional imaging study is recommended?

1. MRI of the left knee
2. Arterial duplex of the left leg
3. CT scan of the left ankle
4. CT scan of the chest, abdomen, and pelvis
5. CT scan of the cervical, thoracic, and lumbar spine

PREFERRED RESPONSE: 3

DISCUSSION: Spiral distal tibia fractures are frequently associated with intra-articular fracture extension, usually involving the posterior malleolus. This may or may not be visible on the radiographs. A CT scan of the ankle is recommended to identify this associated injury. This is especially important when considering intramedullary nail fixation of the distal tibia fracture because a previously nondisplaced intra-articular fracture may become displaced as the nail is inserted to its final depth. Anteroposterior screw fixation prior to nailing may be useful in these cases. With the patient’s history, there is no indication of thoracic, abdominal, pelvic, or spinal trauma. There are no signs of vascular injury and preoperative MRI is not indicated.

Question 78
Long-term alendronate (Fosamax) use for osteoporosis has been associated with which of the following?

1. Scurvy
2. Detached retina
3. Uterine carcinoma
4. Osteonecrosis of the femoral head
5. Diaphyseal femoral insufficiency fractures

PREFERRED RESPONSE: 5

DISCUSSION: Alendronate is a bisphosphonate that inhibits the ruffled border of the osteoclast. When used long term, this class of medication prevents the normal bone remodeling process. Long-term use has recently been shown to be associated with insufficiency fractures of the femur. Osteonecrosis of the jaw has been described but not in other anatomic locations. Scurvy occurs because of a lack of vitamin C and use of bisphosphonates is not associated with uterine cancer or a detached retina.

Figures 79a and 79b are the radiographs of a 78-year-old right-hand dominant man who fell at home and sustained an isolated injury to his right shoulder. He lives alone and is independent with his activities of daily living. Examination reveals a closed injury and a normal neurologic examination. What is the most appropriate management?

1. Shoulder hemiarthroplasty
2. Hanging arm cast for 6 to 8 weeks
3. Shoulder immobilizer for 6 weeks, followed by range-of-motion exercises
4. Open reduction and internal fixation of the proximal humerus with a locking plate
5. Sling, followed by pendulum exercises with elbow range of motion within 1 to 2 weeks

PREFERRED RESPONSE: 5

DISCUSSION: The patient has an isolated proximal humerus fracture in acceptable alignment, thus surgical treatment is not indicated. Multiple studies have shown the benefits of earlier mobilization and therapy in patients who are treated nonsurgically for proximal humerus fractures. A hanging arm cast can be used in proximal humerus fractures, but typically would not be recommended for a length of 6 to 8 weeks because a prolonged time in a hanging arm cast has the disadvantage of immobilizing the elbow during that time as well.

Question 80

A 38-year-old woman is polytraumatized in a motor vehicle crash. She has multiple injuries including a unilateral femur fracture. The patient is felt to be borderline and, although she is currently stable, she could potentially deteriorate quickly. Which of the following parameters has been suggested as an indicator of which patients would benefit from damage control?

1. Normothermia
2. Hemoglobin of less than 9 g/dL
3. Unilateral lung contusion evident on CT only
4. Injury severity score of greater than 40 without thoracic injury
5. Injury Severity Score of less than 18 with a pulmonary contusion

PREFERRED RESPONSE: 4

DISCUSSION: Polytraumatized patients can be classified as stable, unstable, borderline, or in extremis. Management of the borderline patient is controversial because it is unclear which patients can safely undergo early definitive surgical stabilization of fractures, and which patients would benefit from temporizing “damage control” stabilization to allow adequate resuscitation and physiologic stabilization prior to definitive treatment. Although the question of damage control versus early total care is unresolved, there are several clinical parameters that have been suggested for use in deciding who should be treated with early damage control. These include Injury Severity Score of greater than 40, Injury Severity Score of greater than 20 with thoracic trauma, multiple injuries with severe pelvic/abdominal trauma and hemorrhagic shock, bilateral femoral fractures, pulmonary contusion noted on radiographs, hypothermia of less than 35 degrees C), and a head injury with an Abbreviated Injury Score of 3 or greater. A hemoglobin of 9 g/dL is not included in these suggested parameters.

Question 81
A 37-year-old man is evaluated in the emergency department after a motor vehicle accident at 40 mph. He reports low back and buttock pain and numbness in his perineum. After initial radiographic evaluation of his pelvis, he is advised to attempt weight bearing but is unable to because of severe pain. A CT scan of the pelvis is ordered. The radiographs and CT scan are shown in Figures 81a through 81d. What study should be obtained next?

1. CT scan of the abdomen
2. Judet views of the pelvis
3. MRI scan of the lumbar spine
4. Lateral radiograph of the sacrum
5. Electromyography of the lumbosacral plexus

PREFERRED RESPONSE: 4

DISCUSSION: The patient has a U-type fracture of the sacrum. The best way to visualize this fracture is with a lateral view of the sacrum or sagittal reformatted images of the CT scan. Standard pelvic radiographs often miss this injury. A high index of suspicion must be maintained for a transverse fracture component (H- or U-type fracture) in a patient with bilateral sacral injuries, especially without any anterior pelvic ring fractures. This injury occurs by a different mechanism than pelvic ring disruptions, thus the sacrum will fracture oftentimes without associated anterior pelvic injuries. These injuries have a high rate of associated neurologic injury. Treatment of these injuries varies based on neurologic compromise and displacement.

Question 82
Figures 82a and 82b are the radiographs of a 52-year-old woman who fell down the stairs and sustained an acute hemarthrosis of the elbow. What is the most common complication following surgical treatment of this injury?

1. Elbow contracture
2. Complex regional pain syndrome
3. Posterior interosseous nerve palsy
4. Bridging heterotopic ossification of the elbow
5. Elbow instability requiring ligamentous reconstruction

PREFERRED RESPONSE: 1

DISCUSSION: The patient has a displaced capitellum fracture that requires surgical intervention. Whereas complex regional pain syndrome, posterior interosseous nerve palsy, bridging heterotopic ossification of the elbow, and elbow instability requiring ligamentous reconstruction are seen as sequelae of various traumatic elbow injuries, elbow contracture is frequently seen following this specific injury.

Question 83
The vessel that is exposed crossing the interval used for an anterior approach to the hip between the tensor fascia lata and the sartorius muscle is a branch of what artery?

1. Deep femoral artery (profunda)
2. Superficial femoral artery
3. Superior gluteal artery
4. Descending recurrent femoral artery
5. External iliac

PREFERRED RESPONSE: 1

DISCUSSION: The ascending branch of the lateral femoral circumflex artery crosses the surgical field between the tensor fascia lata and the sartorius muscles and has to be ligated during this approach. It is a branch of the profunda femoris artery.

Question 84

Three years following repair of a subtrochanteric femur fracture, a 26-year-old man has a draining sinus shown in Figure 84a. Radiographs are shown in Figures 84b and 84c. Management should consist of which of the following?

1. Hip disarticulation
2. Infectious diseases consultation and long-term suppressive antibiotics
3. Incision and drainage, removal of hardware, excision of heterotopic bone, and culture-directed antibiotics
4. Excision of heterotopic bone and radiation therapy to prevent recurrence
5. Excision of heterotopic bone and administration of nonsteroidal anti-inflammatory drugs to prevent recurrence

PREFERRED RESPONSE: 3

DISCUSSION: This is a case of chronic osteomyelitis with infected hardware and a healed fracture. Limb salvage should be attempted in the patient. The presence of a chronic draining sinus requires surgical débridement. Removal of the implant and as much of the infected heterotopic bone will reduce the bacterial load. Culture-directed antibiotics are started after deep cultures are obtained. Infectious diseases consultation is obtained following surgical intervention. Long-term suppressive antibiotics are not the treatment of choice in healthy patients who can tolerate a surgical procedure.

Question 85
Which of the following is the best predictor of mortality after a patient has sustained a pelvic ring injury?

1. Gender
2. Comorbidities
3. Fracture pattern
4. Use of angiography
5. Shock on presentation

PREFERRED RESPONSE: 5

DISCUSSION: Starr and associates demonstrated that age and shock on presentation were predictors of mortality after pelvic ring injury. Smith and associates showed that the amount of blood transfusions in the first 24 hours was also predictive of mortality. Gender, fracture pattern, use of angiography, and comorbidities do not correlate directly with mortality.


Question 86
What is the best way to determine whether a radial head implant is too thick intraoperatively?

1. Visually assess the radiocapitellar joint.
2. Visually assess widening of the lateral ulnohumeral joint.
3. Assess widening of the radiocapitellar joint on an AP radiograph.
4. Assess the elbow for concentric reduction on a lateral radiograph.
5. Assess widening of the medial ulnohumeral joint on an AP radiograph.

PREFERRED RESPONSE: 2

DISCUSSION: Widening of the medial ulnohumeral joint on an AP radiograph is only visible after overlengthening of the radial head by 6 mm or more. At least in this cadaver study, the most sensitive method was to visually assess the lateral aspect of the ulnohumeral joint with the radial head resected and then with the trial radial head in place. This method allows detection of any overlengthening.

Question 87

Figures 87a and 87b are the radiographs of an 18-year-old pedestrian who was struck by a car. During intramedullary nailing, it is difficult to maintain proper alignment. Poller blocking screws placed in the proximal fragment at which position(s) relative to the nail can help prevent the typical deformity?

1. Anterior only
2. Anterior and medial
3. Anterior and lateral
4. Posterior and medial
5. Posterior and lateral

PREFERRED RESPONSE: 5

DISCUSSION: This is a proximal one third tibial shaft fracture. Typically nailing of this fracture creates a valgus and procurvatum malalignment that must be addressed. This can be difficult when using an intramedullary nail in the wide metaphyseal bone of the proximal tibia. To help direct and center the nail in the metaphysis, blocking screws can be used. Blocking screws should be placed where the nail should not travel. If the nail was passed with the proximal fragment in this position, it would occupy the lateral and posterior aspects of the metaphyseal fragment. To prevent this, blocking screws should be placed in the lateral and posterior aspects of the proximal fragment.

Question 88
What mechanism of injury is most likely to cause a fracture of the anteromedial facet of the coronoid?

1. Extension and axial load
2. Varus and posteromedial rotation
3. Valgus and posteromedial rotation
4. Varus and posterolateral rotation
5. Valgus and posterolateral rotation

PREFERRED RESPONSE: 2

DISCUSSION: The mechanism of injury in a fracture of the anteromedial facet of the coronoid is typically a varus and posteromedial rotation force on the forearm which is the opposite of a terrible triad injury. First, the lateral collateral ligament is injured and then the medial coronoid is compressed against and then under the medial trochlea.

Question 89

Figure 89a is the radiograph of a 24-year-old man who was involved in a motor vehicle accident. A closed reduction is performed and a post-reduction CT scan is shown in Figure 89b. What is the next most appropriate step in management?

1. Total hip arthroplasty
2. Removal of loose bodies
3. Protected weight bearing
4. Assessment of hip stability
5. Open reduction and internal fixation

PREFERRED RESPONSE: 4

DISCUSSION: The radiograph and CT scan show a posterior hip dislocation with an associated posterior wall acetabular fracture. The next step in management is assessment of hip instability. As suggested by Tornetta, assessment of hip instability with dynamic stress views is helpful to determine which posterior wall fractures are unstable and therefore require open reduction and internal fixation. Although protected weight bearing may be correct if the hip is stable, stability needs to be determined first. The CT scan reveals a small fragment in the cotyloid fossa. However, in this location, the presence of a loose body alone does not require surgical treatment. Hip instability needs to be assessed before determining if this fracture should be treated with open reduction and internal fixation. Total hip arthroplasty is not appropriate for a 24-year-old patient with a small posterior wall acetabular fracture.

Question 90
Figures 90a and 90b are the radiographs of the right leg of a 30-year-old man who sustained a crush injury to his right chest, abdomen, and right leg after being pinned under a hydraulic jack. He has a blood pressure of 170/90 mm Hg. He is intubated and sedated secondary to his pulmonary injury. Six hours later he has a swollen lower leg. Examination reveals significant swelling but palpable pulses. Compartment pressures ranged from 32 to 41 mm Hg. What is the next step in management?

1. MRI of right leg
2. Venous doppler of right leg
3. Four-compartment fasciotomy
4. Follow-up examination the next day
5. Serial examinations with compartment pressures

PREFERRED RESPONSE: 5

DISCUSSION: The patient is at risk for a compartment syndrome. Management should consist of close follow-up with serial examinations and repeat compartment pressure measurements as long as the patient cannot give a good clinical examination. MRI scan of the leg is not needed acutely because the scenario is suggestive of a crush injury and the most likely problem is muscle injury. Venous doppler, although important to discern the possibility of a venous occlusion, is not the most pressing issue. Four-compartment fasciotomy may become necessary but based on the available data is not indicated at this time. The current pressure difference between the diastolic blood pressure and his compartment pressure is almost 50 mmHg, suggesting the microcirculation is open.

Question 91

Figure 91 is the radiograph of a 20-year-old man who kicked a door while intoxicated. At the emergency department, his leg is placed into a long-leg cast. After 2 hours, he reports increasing pain, numbness, and tingling in his toes. What is the most appropriate initial treatment?

1. Elevate leg on pillows
2. Administer IV morphine
3. Observation of the patient
4. Bivalve and spread the cast
5. Apply ice to the lower extremity

PREFERRED RESPONSE: 4

DISCUSSION: The patient appears to have some indications of a compartment syndrome: increasing pain and signs of nerve compression. Tibia fractures also should heighten the suspicion for a compartment syndrome. Two basic mechanisms of compartment syndrome are that an increase in volume occurs in an enclosed space or there is a decrease in size of the space. In this situation, both are likely occurring; post-fracture swelling is occurring within a closed space and if a cast is in place that may constrict the space even more. One way to increase the available space for swelling would be to bivalve and spread the cast. If the extremity has been casted, then it is vitally important that the cast be removed so that all external compression of the compartment has been eliminated. In the face of compartment syndrome, elevation of the limb, masking the pain with morphine, application of ice, or observation alone are all inappropriate.

Figure 92

Question 92

Figure 92 is the radiograph of a 45-year-old man who was thrown from his horse and now reports groin pain. Which of the following is the most common long-term sequelae of this injury?

1. Gait abnormality
2. Sexual dysfunction
3. Chronic low back pain
4. Quadriceps weakness
5. Posttraumatic osteoarthritis

PREFERRED RESPONSE: 2

DISCUSSION: The radiograph reveals an anterior posterior compression injury to the pelvic ring which is commonly seen after horseback riding injuries. In a large series of patients with this type of injury, 18 of 20 patients had sexual dysfunction after sustaining this injury. Posttraumatic osteoarthritis of the sacroiliac joints may occur, but is less common in this type of injury. Chronic low back pain, gait abnormalities, and quadriceps weakness are not typically seen with this type of injury.

Question 93
A 23-year-old woman is involved in a motorcycle accident. She sustains bilateral femur fractures (Abbreviated Injury Score [AIS]=3), an intra-abdominal injury (AIS=3), facial fractures (AIS=2), and a pulmonary injury (AIS=2). What is her Injury Severity Score (ISS)?

1. 13
2. 18
3. 22
4. 27
5. 35

PREFERRED RESPONSE: 3

DISCUSSION: The ISS is calculated as the sum of the squares of three highest AIS scores from the six body regions, thus this patient’s ISS score is 22. The ISS does correlate with mortality, but the ISS does not score multiple injuries to the same body region, hence the bilateral femur fractures score the same as a unilateral fracture. The New Injury Severity Score (NISS) was developed because of this shortcoming of the ISS. The ISS is used in studies to characterize patient injury severity, with a value of 18 or above indicating polytrauma in many studies.

Question 94

Figure 94 is the initial lateral radiograph of the foot of a 55-year-old woman who felt a pop in her left foot as she stepped off the curb. She subsequently had severe heel pain and could not bear weight. Examination in the emergency department revealed a bony prominence over the posterior aspect of the heel with blanching of the surrounding skin. What is the most appropriate orthopaedic management?

1. Immediate cast immobilization with maximum plantar flexion
2. Immediate surgical treatment with percutaneous reduction and screw fixation
3. Immediate open reduction and internal fixation via an extensile lateral approach
4. Short leg splint, elevation, and delayed open reduction and internal fixation
5. Short leg splint, elevation, and conversion to cast immobilization when soft-tissue swelling has resolved

PREFERRED RESPONSE: 2

DISCUSSION: The patient has a calcaneal tuberosity fracture, similar to the tongue-type fracture except the fracture line exits posterior to the posterior facet. The Achilles tendon is attached to the displaced fragment and pulls the fragment proximally. These are relatively uncommon fractures, but have the same (or greater) potential as tongue-type fractures for soft-tissue compromise and necrosis. Immediate management with reduction and fixation is indicated to prevent heel ulceration and secondary complications such as deep infection. Fracture fixation generally does not require an extensile approach or plate fixation, and may benefit from decreasing the forces acting on the displaced fragment by supplemental gastrocnemius recession.

Question 95
A 24-year-old man is involved in a motor vehicle accident at 60 mph. He sustains multiple injuries including an intra-abdominal injury requiring a splenectomy and a closed right femoral shaft fracture. Which variable will best indicate the patient’s resuscitation status when deciding whether to proceed with definitive care of the fracture at the conclusion of the laparotomy?

1. Heart rate
2. Hematocrit
3. Base deficit
4. Urine output
5. Systolic blood pressure

PREFERRED RESPONSE: 3

DISCUSSION: A metabolic parameter such as the base deficit or lactate level has been shown to better reflect the resuscitation status and survival after trauma. Normalization of hemodynamic parameters does not accurately reflect the resuscitation status and a patient can be in compensated shock (occult tissue hypoperfusion) despite normalization of the heart rate and blood pressure. The use of temporizing measures with delayed definitive fracture treatment has been shown to decrease systemic complications in these patients with occult hypoperfusion.

Question 96
A 27-year-old woman who was an unrestrained driver in a head-on collision sustained the following injuries: bilateral supracondylar femur fractures, a left talus fracture, multiple left metatarsal fractures, a right distal radius fracture, and a left open elbow fracture-dislocation. Which of the following serologic inflammatory markers drawn in this patient has been shown to be a reliable measure of systemic inflammatory response, correlating with injury severity and outcome?

1. IL-6
2. IL-8
3. IL-10
4. C-reactive protein
5. Tumor necrosis factor-alpha

PREFERRED RESPONSE: 1

DISCUSSION: In response to trauma, the body demonstrates a systemic inflammatory response that varies in intensity according to the severity of the injuries sustained. Increased production of proinflammatory cytokines serves to activate the host immune system. The activation of systemic inflammatory response may lead to remote end organ damage with neutrophil demargination and disruption of the vascular endothelium. Disturbances in microcirculation exacerbate local tissue hypoxia, and parenchymal necrosis may ensue. Furthermore, the systemic inflammatory response serves as the basis for the development of adult respiratory response distress syndrome (ARDS) and multiple organ failure following trauma. Several serologic inflammatory markers have been investigated for their potential usefulness in measuring and monitoring the inflammatory response to a major trauma. These markers include IL-1, IL-6, IL-8, IL-10, and C-reactive protein and tumor necrosis factor-alpha. For many of these markers, serum concentration is noted to increase following severe trauma, but the extent and duration of elevation have been too variable to allow for clinical application. IL-6 has been shown to be a reliable measure of systemic inflammatory response, correlating with injury severity and outcome. It has been recommended that measurement of IL-6 concentration be traced to evaluate the severity of the inflammatory response. In this way, it may be possible to clarify the risks associated with secondary procedures such as fracture fixation and to determine when these procedures should be performed.

Question 97
Figures 97a and 97b are the radiographs of a 27-year-old man involved in a motorcycle crash who sustained a right proximal humerus fracture. Which of the following is most associated with osteonecrosis?

1. Intact medial hinge
2. Metaphyseal head extension of fracture of less than 8 mm
3. Tobacco use
4. Age
5. Angular displacement of the head of 30 degrees

PREFERRED RESPONSE: 2

DISCUSSION: Hertel and associates demonstrated factors that are predictive of osteonecrosis of the humeral head after fracture. Factors shown to be predictive of osteonecrosis include: fractures consisting of four fragments, angular displacement of the head (greater than 45 degrees), the amount of displacement of the tuberosities (displacement of greater than 10 mm), glenohumeral dislocation, and head-split components. Factors associated with good prognosis include: length of the metaphyseal head extension (calcar segments of greater than 8 mm), the integrity of the medial hinge, and the basic fracture pattern. When the above criteria (anatomic neck, short calcar, disrupted hinge) were combined, positive predictive values of up to 97% could be obtained for osteonecrosis. However, the degree to which this osteonecrosis impacts long-term outcome is unclear and should not be the only indication for proximal humeral arthroplasty.

Question 98
Clinical staging of osteomyelitis using the Cierny-Mader classification system takes into account which of the following factors?

1. Age and gender of patient
2. Fracture type and type of bacteria
3. Host status and extent of infected bone
4. Immune status and chronicity of infection
5. Bacterial resistance and source of infection

PREFERRED RESPONSE: 3

DISCUSSION: The Cierny-Mader classification system takes into account three types of patients with osteomyelitis: (A) healthy, (B) those with comorbidities, and (C) a host in whom treatment will lead to greater morbidity than the infection. Furthermore, the disease is addressed based on its complexity: type I-medullary, type II-superficial, type III-localized, and type IV-diffuse.

Question 99

Figures 99a and 99b are the radiographs of a 76-year-old woman who sustained an injury to her dominant arm in a fall. Which of the following is the most common complication seen following treatment with a locked plate and screw construct?

1. Osteomyelitis
2. Osteonecrosis
3. Posttraumatic osteoarthritis
4. Deltoid heterotopic ossification
5. Screw penetration of the articular surface

PREFERRED RESPONSE: 5

DISCUSSION: The most common complication reported following use of a locked plate construct for a displaced proximal humerus fracture is screw penetration of the humeral head (16% to 30%). Heterotopic ossification can be seen following proximal humerus fracture and repair and is associated with a deltoid split approach. The rate of osteonecrosis following a valgus impacted three-part fracture is 5% to 10%. Posttraumatic osteoarthritis is not seen frequently following surgical repair of these fractures. Infection is uncommon after this surgery, and chronic osteomyelitis is rare.

Question 100
A 63-year-old woman with osteopenia is struck by a motor vehicle and sustains a Schatzker 2 (AO/OTA Type B) fracture of the lateral tibial plateau. She has 1.5 cm of joint depression and 7 mm of condylar widening. What is the most appropriate surgical fixation for this injury?

1. Lateral nonlocking plate
2. Percutaneous screws
3. External fixation
4. Lateral locking plate
5. Medial and lateral plating

PREFERRED RESPONSE: 1

DISCUSSION: The patient has a significantly displaced partial articular fracture of the tibial plateau. Surgical treatment is preferred in an effort to restore the axis of the knee, achieve an articular reduction, and allow for repair of commonly associated soft-tissue injuries such as meniscal tears. This requires direct reduction, and fixation should provide subarticular support, interfragmentary compression, and buttress. This is best achieved with an undercontoured lateral nonlocking plate. Screws alone are unlikely to be adequately stable in this patient. Locking plates do not provide buttress effect when used in pure locking mode. In addition, locking plates add significant incremental cost to the procedure.

RESPONSES FOR QUESTIONS 101 THROUGH 104

1. Open reduction and internal fixation with absolute stability
2. Open reduction and internal fixation with relative stability
3. Closed reduction with casting
4. Reamed locked intramedullary nailing
5. External fixation

For each of the following fractures choose the best method for definitive fixation.

Question 101
A 25-year-old man fell off a golf cart and injured his right forearm. The radiographs show both a radial shaft and an ulna fracture. The fractures are highly comminuted, and there is a small laceration of about 1 cm over the fracture site.

PREFERRED RESPONSE: 2

Question 102
A 45-year-old man was skiing when he sustained a direct blow to the lateral side of his left knee. Radiographs reveal a left split depression tibial plateau fracture.

PREFERRED RESPONSE: 1

Question 103
A 19-year-old woman was involved in a high-speed motor vehicle accident. She has an obvious deformity of her right thigh. Radiographs reveal a transverse mid-shaft femur fracture.

PREFERRED RESPONSE: 4

Question 104
A 22-year-old woman injured her ankle when she fell off a ladder. Radiographs reveal a displaced large posterior malleolus fracture of about 45% of the joint.

PREFERRED RESPONSE: 1
DISCUSSION FOR QUESTIONS 101 THROUGH 104:

Basic understanding of fracture care requires a fundamental knowledge of the principles regarding absolute and relative stability. Compression plating and anatomic reduction of articular fractures are examples of absolute stability. Bridge plating, external fixation, casting, and intramedullary nailing are all examples of relative stability. Both bone forearm fractures have long been treated with open reduction and internal fixation even in the light of open wounds. Results have been excellent with plate fixation. Recently, intramedullary nails that are contoured and locked have been used in the treatment of both bone forearm fractures, but they are not reamed. It is well established that with restoring the proper radial bow, length, and alignment, optimal function can be achieved. Open reduction and internal fixation allows this achievement. In cases where comminution exists, absolute stability may have to be sacrificed so as to not strip small comminuted bone fragments. Therefore, a bridging technique is worthwhile. External fixation can be used as a temporary technique until the soft tissues are more amenable to definitive fixation. Cast treatment is not indicated in adult forearm fractures. Locking nails for forearm use are not reamed. With regards to articular fractures, anatomic reduction and rigid stabilization are required to achieve the best results and allow for fracture healing. This environment also allows for the best chance of the cartilage repair process to form “hyaline-like” cartilage. Open reduction and internal fixation with absolute stability is the mainstay of treatment for partial articular fractures such as split depression tibial plateau fractures and posterior malleolus fractures involving greater than about 25% to 30% of the joint. The gold standard for the treatment of a closed femur fracture is a reamed intramedullary locked nail. Results are uniformly excellent. This can be done without stripping of the soft tissues such as in open reduction and internal fixation. External fixation can be used as a temporary device in patients in extremis for damage control reasons.

RECOMMENDED READING(S) FOR QUESTIONS 101 THROUGH 104:


END OF SERIES
Figure 105

CLINICAL SITUATION FOR QUESTIONS 105 THROUGH 107

Figure 105 is the radiograph of a 72-year-old woman who fell down the steps and injured her left leg. Because she was unable to get up on her own or reach a telephone, she was not discovered until 24 hours after the incident and was then brought to the emergency department by ambulance. The patient is a community ambulator, who drives and lives alone. Her medical history includes hypertension, type 2 diabetes mellitus, and hypothyroidism. She takes enalapril, levothyroxine, and rosiglitazone. She is obese (BMI>30). Examination reveals that the left lower extremity is shortened and externally rotated. She has pain with movement of the extremity. There is no other bony tenderness in either the upper or contralateral lower extremity.

Question 105
Which of the following imaging studies must be obtained for this patient?

1. Duplex scan of both lower extremities
2. MRI scan of the hip
3. Traction internal rotation radiograph of the hip
4. Frog lateral of the hip
5. CT scan of the abdomen and pelvis

PREFERRED RESPONSE: 1
Question 106
What is the most appropriate protocol for surgical management of this patient?

1. Must be performed within the first 24 hours
2. Should be delayed until a stress test is performed
3. May occur only following optimization of medical conditions
4. Must be postponed until normalization of the BMI
5. A delay of several days after admission results in greater technical ease

PREFERRED RESPONSE: 3

Question 107
Treatment of the patient’s injury is best accomplished by which of the following?

1. Cephalomedullary nail
2. Closed reduction and percutaneous pinning
3. Open reduction and internal fixation
4. Total hip arthroplasty
5. Hemiarthroplasty

PREFERRED RESPONSE: 4

DISCUSSION FOR QUESTIONS 105 THROUGH 107:
This scenario is a common one for the presentation of a displaced intracapsular hip fracture. Injured elderly patients not found for an extended period of time prior to hospital admission are at greater risk for the development of a venous thromboembolism and should have a screening Doppler. Whereas a traction-internal rotation radiograph is valuable in further delineating the fracture pattern, it is not necessary in making the diagnosis. The frog lateral radiograph should be avoided in hip fracture management because it causes unneeded pain and risks displacement if none exists. An MRI scan is not indicated in a displaced fracture, but may be useful in diagnosing nondisplaced fractures. A CT scan is not warranted in the absence of clinical signs of intra-abdominal trauma or a high-energy mechanism. Surgical treatment is warranted in this ambulatory, independent patient. Whereas many studies have looked at optimal timing of surgery, no definitive time frame has been elucidated. Most authors agree that surgery is urgent and should follow optimization of all comorbid medical conditions. Technical aspects of the surgery are not dependent on time from injury. Given that this is a displaced femoral neck fracture in an elderly patient, the options of fracture repair, which include intramedullary nailing, closed reduction and pinning, and open reduction and internal fixation, are associated with high rates of complications and revision surgery. Of the two arthroplasty choices, total hip arthroplasty has been shown to yield the best clinical and functional results with a lower rate of reoperation. Hemiarthroplasty is reserved for low functioning or minimally ambulatory patients.
RECOMMENDED READINGS FOR QUESTIONS 105 THROUGH 107:

END OF SERIES

CLINICAL SITUATION FOR QUESTIONS 108 THROUGH 110
A 23-year-old man was injured in a high-speed motorcycle accident. He sustained bilateral pulmonary contusions, a closed left femoral fracture, an open, comminuted, contaminated, diaphyseal left tibia fracture without bone loss, and a small subdural bleed. His blood pressure in the trauma bay was 85/50 mm Hg and did not respond to initial volume resuscitation. He has a heart rate of 122/min and a core temperature of 34.7°C.

Question 108
What is the optimal initial treatment for his orthopaedic injuries?

1. Irrigation and débridement of the open fracture and reamed intramedullary nailing of the femoral and tibial fractures
2. Irrigation and débridement of the open fracture, reamed intramedullary nailing of the femur, and external fixation of the tibia
3. Irrigation and débridement of the open fracture and external fixation of both fractures
4. Irrigation and débridement of the open fracture, a reamed femoral nail, and an unreamed tibial nail
5. Irrigation and débridement of the open fracture in the ICU and a calcaneal traction pin

PREFERRED RESPONSE: 3
Question 109
Definitive fixation of the tibia is ideally

1. uniplanar external fixation.
2. a reamed intramedullary nail.
3. an unreamed intramedullary nail.
4. either a reamed or an unreamed intramedullary nail.
5. bridge plating.

PREFERRED RESPONSE: 4

Question 110
Four months after injury, the tibia is showing evidence of slow healing on radiographs. What is the optimal treatment for this potential nonunion?

1. Convert to circular external fixation
2. Exchange nailing and autograft
3. Exchange nailing and bone morphogenetic protein
4. Tibial plate
5. Observation until 6 months after injury

PREFERRED RESPONSE: 5

DISCUSSION FOR QUESTIONS 108 THROUGH 110:
This patient is unstable and is not a good candidate for Early Total Care (ETC) and therefore should be managed by the tenets of Damage Control Orthopaedics (DCO). Débridement and external fixation is preferable for this patient. Intramedullary nails would be a component of ETC. Calcaneal traction is not considered ideal because it does not allow the patient to travel as easily. The S.P.R.I.N.T. study concluded that while reamed nails may offer benefit in closed fractures, there was no difference between reamed or unreamed nails in the treatment of open fractures of the tibia. Uniplanar external fixation and tibial plating are not considered the best options for open tibia fractures. Additional findings of the S.P.R.I.N.T. study conclude that delaying surgical intervention for at least 6 months after injury may reduce the need for reoperation.
RECOMMENDED READINGS FOR QUESTIONS 108 THROUGH 110:

END OF SERIES