UNIT TERMINAL OBJECTIVE
4-1 At the completion of this unit, the Paramedic student will be able to integrate the principles of kinematics to enhance the patient assessment and predict the likelihood of injuries based on the patient's mechanism of injury.

COGNITIVE OBJECTIVES
At the completion of this unit, the Paramedic student will be able to:

4-1.1 List and describe the components of a comprehensive trauma system. (C-1)
4-1.2 Describe the role of and differences between levels of trauma centers. (C-3)
4-1.3 Describe the criteria for transport to a trauma center. (C-1)
4-1.4 Describe the criteria and procedure for air medical transport. (C-1)
4-1.5 Define energy and force as they relate to trauma. (C-1)
4-1.6 Define laws of motion and energy and understand the role that increased speed has on injuries. (C-1)
4-1.7 Describe each type of impact and its effect on unrestrained victims (e.g., “down and under,” “up and over,” compression, deceleration). (C-1)
4-1.8 Describe the pathophysiology of the head, spine, thorax, and abdomen that result from the above forces. (C-1)
4-1.9 List specific injuries and their causes as related to interior and exterior vehicle damage. (C-1)
4-1.10 Describe the kinematics of penetrating injuries. (C-1)
4-1.11 List the motion and energy considerations of mechanisms other than motor vehicle crashes. (C-1)
4-1.12 Define the role of kinematics as an additional tool for patient assessment. (C-1)

AFFECTIVE OBJECTIVES
None identified for this unit.

PSYCHOMOTOR OBJECTIVES
None identified for this unit.
DECLARATIVE

I. Introduction
   A. Epidemiology of trauma
      1. A leading cause of death for people 1-44 years of age
      2. 140,000 unexpected deaths per year
      3. Automobile related deaths are > 40,000
      4. Penetrating trauma may exceed blunt in near future
      5. Pre-incident, incident, post-incident phase
   B. History
      1. Complete and accurate history of incident will identify possibility for 95% of the
dlg injuries present
      2. Incident site
         a. Indications of severity of injury
      3. Major factors of tissue injury
      4. Amount of energy exchanged
      5. Anatomical structures potentially involved

II. Trauma systems
   A. Components
      1. Injury prevention
      2. Prehospital care
         a. Treatment
         b. Transportation
         c. Trauma triage guidelines
      3. Emergency department care
      4. Interfacility transportation - if necessary
      5. Definitive care
      6. Trauma critical care
      7. Rehabilitation
      8. Data collection/ trauma registry
   B. Trauma centers
      1. Levels
      2. Qualifications
         a. Essential
         b. Desired
      3. Role
   C. Transport considerations
      1. Level of receiving facility
      2. Mode of transport
         a. Ground transport
            (1) If appropriate facility can be reached within reasonable time
            (2) To a more accessible landing zone for air medical transport
         b. Air medical transport
            (1) Indications
            (2) Contraindications
            (3) Procedure
III. Energy

A. Physical laws

1. Newton’s first law of motion
   a. A body at rest or a body in motion will remain in that state until acted upon by an outside force
   b. In a vehicle traveling at 50 mph, the occupant is also traveling at 50 mph
   c. When the car stops, the occupant continues to travel at 50 mph until some force acts on the occupant

2. Conservation of energy
   a. Energy cannot be created nor destroyed
   b. It can be changed in form
   c. Energy can be absorbed producing deformation of substance

3. Kinetic energy (KE)
   a. KE = ½ the mass of the object multiplied by the velocity (speed) of the object squared (Mass/2 x V²)
   b. Velocity (V) influences KE more than mass
   c. Greater speed means more energy generated

4. Force
   a. Force = Mass x Acceleration
   b. Force = Mass x Deceleration
   c. Mass x Acceleration = Force = Mass x Deceleration
   d. Simply put, to accelerate a bullet from a the muzzle of a weapon requires the force from the explosion of the gunpowder; once the bullet is set in motion by this explosion, an equal amount of tissue destruction must occur inside the body to stop it as was used to start it

5. Energy law summary
   a. Motion is created by force (energy exchange)
   b. Force (energy exchange) must stop this motion
   c. If such energy exchange occurs inside the body tissue damage is produced

B. Energy exchange

1. Cavitation
   a. Energy exchange produces particle motion
   b. Temporary cavity
      (1) Short lived
      (2) Produced by stretching
      (3) Dependent on the elasticity of the object involved
      (4) Produces particle compression at the limits of the cavity
   c. Permanent cavity
      (1) Visible when the energy exchange has been completed
      (2) Produced by compression and destruction

2. Interaction between two bodies
   a. At least one must be in motion
   b. Both can be in motion

3. Dependent on number of particles involved in the interface of the interaction
   a. Density of the interacting bodies
      (1) Air density (few particles)
      (a) Lung
(b) Intestinal tract

(2) Water density (more particles)
   (a) Vascular system
   (b) Liver
   (c) Spleen
   (d) Muscle

(3) Solid density (thick particles)
   (a) Bone
   (b) Asphalt
   (c) Steel

b. Area on interaction
   (1) Shape of object
   (2) Position of object
   (3) Fragmentation of object

C. Types of trauma based on ingress
   1. Blunt
      a. Tissue not penetrated
      b. Cavitation away from site of impact
      c. Cavitation in direction of impact
   2. Penetrating
      a. Tissue penetrated
      b. Cavitation at 90° to bullet pathway
         (1) Tissue inline to penetration is crushed

IV. Blunt trauma
A. Vehicle collisions
   1. Frontal
   2. Lateral
   3. Rear
   4. Rotational
   5. Roll over
B. Occupant collisions
   1. Frontal impacts
      a. Down and under
         (1) Feet impact floor pan
         (2) Knees impact dash
            (a) Tibia impact
               i) Knee dislocation
               ii) Popliteal artery disruption
               iii) Knee support disruption
            (b) Femur impact
               i) Femur fracture
               ii) Acetabular posterior fracture dislocation
         (3) Torso rotates
            (a) Steering column
            (b) Dash
            (c) Windshield
      b. Up and over
1. Head impact
   (a) Windshield
   (b) Roof
   (c) Mirror

2. Chest impact
   (a) Steering column
   (b) Dash

3. Abdominal impact
   (a) Steering column
   (b) Dash

2. Lateral impacts
   a. Vehicle moves into and impacts body
      (1) Chest
      (2) Pelvis
      (3) Body moves laterally
         (a) Neck
             i) Rotates
             ii) Lateral flexion
             iii) Combination

3. Rear impacts
   a. Vehicle seat pushes body
      (1) All body parts in contact with seat move
      (2) Body parts not in contact dragged along with torso
   b. Secondary impact if vehicle hits another object
      (1) Similar to frontal impact

4. Rotational impacts
   a. Part of vehicle stops; the rest remains in motion
   b. Combination of frontal and lateral impacts

5. Roll over
   a. Difficult to predict the body impacts

C. Organ collisions
   1. Two types of injury from blunt trauma
      a. Compression
      b. Change in velocity
         (1) Acceleration
            (a) Shear
            (b) Avulsion
         (2) Deceleration
            (a) Shear
            (b) Avulsion
   2. Organ collisions with different vehicular collisions
      a. Frontal impacts
         (1) Head
            (a) Compression
               i) Skull fractures
               ii) Cerebral contusion
Deceleration

i) Opposite end separation

ii) Hemorrhage

iii) Brain stem stretch

(2) Neck

(a) Compression

i) Vertebral body

a) Compression fracture

b) Hyperextension injury
   - Posterior element compression
   - Anterior body separation

c) Hyperflexion injury
   - Anterior body compression
   - Posterior element separation

(b) Shear

i) Not significant

(3) Thorax

(a) Chest wall

i) Compression

a) Fracture rib(s) - producing single rib fractures, flail chest, and/or pneumothorax

ii) Shear

a) Fracture thoracic spine

(b) Heart

i) Compression

a) Contusion

b) Rupture

ii) Shear

a) Not significant

(c) Aorta

i) Compression

a) Not significant

ii) Shear

a) Junction arch and descending portions

b) Aortic origin at the aortic valve

c) At the diaphragm

(d) Lung

i) Compression

a) Pneumothorax

b) Rib fracture and penetration

ii) Shear

a) Not significant

(4) Abdomen

(a) Abdominal cavity

i) Diaphragm

a) Compression tears

b) Shear - not significant
ii) Abdominal wall  
   a) Compression tears  
   b) Shear - not significant
(b) Liver  
i) Compression  
   a) Burst type injuries  
   ii) Shear  
   a) Tears from Ligamentum Teres  
   b) Avulsion of liver from inferior vena cava at the hepatic veins
(c) Spleen  
i) Compression  
   a) Burst  
   ii) Shear  
   a) Avulsion of pedicle
(d) Gastrointestines  
i) Compression  
   a) Rupture  
   ii) Shear  
   a) Avulsion of mesenteric vessels from aorta or vena cava  
   b) Tears along mesenteric vessels  
   c) Avulsion of vessels from intestine
(e) Gall bladder  
i) Compression  
   a) Rupture  
   ii) Shear  
   a) Avulsion from liver  
   b) Avulsion of cystic duct

b. Lateral impacts  
(1) Head  
   (a) Compression  
      i) Similar to frontal except lateral head and on the side of the impact to the vehicle  
   (b) Shear  
      i) Shear of brain and vessels opposite side of the impact
(2) Cervical spine  
   (a) Compression  
      i) Minimal unless head hits the top of the passenger compartment or the support for the windows  
   (b) Shear  
      i) Two fold mechanism  
      ii) Rotation  
      a) Center of gravity of the head is anterior to the pivot point of the head and the spine at the odontoid process; as lateral
impact occurs the torso and then the C-spine is pushed under the head; the head rotates in relative position to the body, toward the impact

b) The center of gravity of the head is also cephalad to the point of support at the cervical spine; as the lateral forces push the torso away from the point of impact the motion of the head produces lateral flexion of the head

c) The combination of these two forces is lateral flexion of the neck opening the facets opposite the side of impact and rotation of the vertebral bodies in relation to each other; the result is jumped facets and if the force is great enough significant torsion of the spinal cord

(3) Thorax
(a) Compression
i) Impact of the door into the thorax
   a) Lateral ribs - fractures and flail chest
   b) Lung - pneumothorax
   c) Spleen or liver - lacerations and hemorrhage

(b) Shear
   i) Lateral motion of the thoracic spine as the torso is pushed away from the impact
   ii) Thoracic aorta moves with the spine
   iii) Arch and heart do not move until traction on the arch
   iv) Shear forces tear the aorta at the junction of the movable arch and the descending aorta that is attached to the thoracic spine

(4) Abdomen
(a) Compression
   i) Liver or spleen depending of the side of the impact
   ii) Kidneys depending of the side of the impact
   iii) Diaphragm similar to frontal impact

(b) Shear
   i) Abdominal aorta moves with the lumbar spine
      a65535 Shear of the renal vessels
      b65535 Shear of the splenic vessels

(5) Pelvis
(a) Compression
   i) Impact on the femur
      a65535 Femoral head driven through the acetabulum
Fracture of the ileum
Sacro-iliac joint fracture
Fracture of the other bones of the pelvis

(6) Extremities
(a) Compression
i Clavicle compressed between the humerus and the sternum
ii Lateral compression of the humerus

(1) Rear impact
(0) Physics
(a) Energy (velocity) imparted to the rear
i Moves all attached parts of the vehicle
ii Occupants in direct contact with vehicle move also
iii Parts of the occupants not in direct contact do not move until pulled along

a65535 Newton’s first law of motion
b65535 Unrestricted body parts will be separated or at least stretched by this differential velocity
iv The force of the energy exchange depends on the differential energy of the two vehicles and the exchange of energy between the two

(2) Head
(a) Compression
i Into structures behind the seat
ii Energy of compression depends on the force of the change of energy between the vehicle and the impact into the head

(b) Shear
i Separation of the brain and skull in front

(3) Neck
(a) Compression
i Unrestrained occupant into the top of the passenger compartment or into the rear seat

(b) Shear
i Head restraint not in the correct position to move the head forward with the motion of the vehicle
ii Neck hyperextended over the malpositioned head restraint; usually only ligamentous and tendon stretch and no fractures

(4) Torso
(a) As most of the torso is in contact with the seat and springs of the seat only minimal differential energy is exchanged onto the body parts
(b) Unless there is rebound when the vehicle hits another vehicle there is little injury to the torso in the rear impact collision

(5) Extremities
(a) The extremities move with the torso and receive very little differential exchange with rear impacts

d0 Rotational impacts
(1) In the pure rotational impact, one part of the vehicle hits an immovable object, while the rest continues in motion (Newton’s first law of motion)
(2) As the one part stops and the rest of the vehicle continues to move the vehicle moves around the fixed point
(3) The motion to the occupant is a combination of two motions
(a) Frontal and lateral
(b) Rear and lateral
(4) The injuries are combinations of the two motions with emphasis on the initial impact motion

e0 Roll over
(1) In a roll over the pattern of injuries is very difficult as the unrestrained occupant can hit all parts of the vehicle

f0 Ejection
(1) If the force is such and the occupant is unrestrained then ejection is possible
(2) The major injuries occur inside of the vehicle and on the way out rather than afterward on impact the ground or some other object
(3) Since the major part of the injuries occur on the way out, the Paramedic can better predict the injuries by thinking of the first part of the collision rather than the latter portion

D0 Restraints
1 Restraints are systems for absorbing the energy of the impact before the occupant hits something hard and limiting the distance the body has to travel thus helping to decrease velocity (speed)

2 Belt restraint
a0 Contrary to popular belief the belt restraints work on lateral impacts as well as in frontal impacts (they are not quite as effective in lateral impacts because the hard parts of the passenger compartment is closer on the sides than in the front therefore the belt systems do not have as much distance to be effective)

b0 The benefit of the belt restraint can be seen on any Sunday at the automobile race track

c0 Lap belts
(1) Benefits
(a) Hold the lower torso in close approximation to the seat and away from the dash or steering column
(b) Prevent
   (i) Forward motion of the lower torso in frontal collisions
ii Moves the torso with the vehicle and away from the impact in lateral impact collisions

iii Prevents multiple impacts in rollover collisions

iv Prevents ejection

(c) Attached to the floor behind the occupant at a 45° angle to the floor

(d) Prevents forward motion of the pelvis by supporting the anterior part of the pelvis

(e) No impingement on the soft intra-abdominal contents

(2) Limitations

(a) Upper torso is not supported

(b) If positioned above the anterior iliac spine, the belt stops the forward motion of the body against the lumbar spine with the intra-abdominal organs crushed between the belt and the spine

(c) High position can fracture or dislocate the lumbar spine

(d) Increased intra-abdominal pressure can rupture the diaphragm

d0 Shoulder restraints

(1) Benefits

(a) Prevents

i Forward motion of the upper torso in frontal impact collisions

ii Hyper flexion of the upper torso around the lap belts preventing spinal injuries

(b) Moves the upper torso with the vehicle in lateral impact collisions

(2) Limitations

(a) If worn without the lap belt neck injuries can occur

(b) Lessened benefit if the seat is very close to the dash or steering column

e0 Air bags

(1) Benefits

(a) Supplemental protection

(b) Frontal impact protection only with frontal bags

(2) Limitations

(a) Minimally effective alone

(b) Can produce significant injuries if too close to the occupant

i Bag expansion

ii Protective cover into the face or chest

(c) Projects standing children into the seat producing cervical spine fractures

(d) Facial and forearm abrasions

(e) Deployed air bag may hide structural damage to the vehicle that may aid in assessment

f0 Child safety seats

(1) Age and types
(2) Proper use
(3) Injury patterns
(4) Proper use with airbags

E0 Motorcycle collisions
1 Frontal impact
   a0 Bike stops
   b0 Occupant continues forward
   (1) Impacts parts of the bike
       (a) Face
       (b) Chest
       (c) Abdomen
       (d) Upper legs (femur)
   (2) Ejected over the bike
       (a) Into vehicle
       (b) Onto ground
       (c) Into objects in the pathway
   (3) Injuries
       (a) C-spine fractures
       (b) Torso
          i Compression injuries
             a65535 Solid organ crush
                    b65535 Hollow organ rupture (e.g. lungs)
          ii Deceleration (sheer injuries)
             a65535 Aorta
                    b65535 Pedicled organs
       (c) Compound tibia/ fibula fractures

2 Angular impact
   a0 Collapse of bike onto vehicle
   (1) Legs trapped between bike and vehicle
   (2) Open fracture and/or dislocations
   b0 Lateral motion of torso into vehicle
   c0 Injuries
   (1) Cervical spine
      (a) Similar to lateral impact in vehicle
   (2) Torso
      (a) Compression
         i Lateral chest
         ii Lateral abdomen
      (b) Deceleration
         i Aorta
         ii Pedicled organs

3 Protection
   a0 Head
   (1) Helmet
      (a) 300% increase brain injury without helmet
      (b) Spine
          i Small protection
No increase

b0 Skin
   (1) Leathers
   (2) Very protective during slides on asphalt

c0 Ankles and feet
   (1) Strong boots

F0 Pedestrian versus motor vehicle
1 Injuries patterns depends on
   a0 Height
   b0 Body area facing impact
2 Three phases
   a0 Vehicle pedestrian impact
      (1) Legs
         (a) Feet stay in place on asphalt
         (b) Legs pushed by bumper
         (c) Torso moves after the legs
      (2) Torso
         (a) Pelvis
         (b) Crushed by front of vehicle
         (c) Lateral or posterior angulation
            i Lumbar fractures
            ii Thoracic fractures
   b0 Pedestrian rotates onto hood
      (1) Impact onto torso
         (a) Compression injuries
         (b) Acceleration (shear) injuries
      (2) Cervical spine
         (a) Severe flexion or lateral flexion
         (b) Torsion
         (c) Fractures and dislocations
   c0 Pedestrian rolls off onto the ground (asphalt)
      (1) Beside vehicle
         (a) Impact into the ground as fall from height
      (2) In front of vehicle
         (a) Run over by the vehicle
         (b) Dragged by the vehicle

G0 Falls
1 Factors
   a0 Height of fall
   b0 Surface of the impact
   c0 Objects struck during the fall
   d0 Body part of first impact
2 Feet first
   a0 Impact onto calcaneus
   b0 Continued motion of the torso
      (1) Ankles, knees, femur
      (2) Acetabulum, pelvis
      (3) Spine
### Head first

**a0** Compression

- (1) Skull fracture
- (2) Brain
  - (a) Contusion
  - (b) Laceration
- (3) Spine

**b0** Deceleration (shear)

- (1) Aorta
- (2) Kidney
- (3) Other

### Parallel to ground

**a0** Compression

- (1) All parts of the impact

### Penetrating injuries

**A0** Energy exchange

1. Number of particles involved
   
   **a0** Density of tissue
   
   - (1) Gas
     - (a) Lung
     - (b) Gastrointestinal tract
   - (2) Liquid
     - (a) Blood vessels
     - (b) Muscle
     - (c) Solid organs
       - (i) Spleen
       - (ii) Liver
       - (iii) Kidney
       - (iv) Other
   - (3) Solid
     - (a) Bone

**b0** Area of interaction

- (1) Deformation of bullet
- (2) Tumble
- (3) Fragmentation

### Cavitation

**a0** Permanent
(1) Visible when examined  
(2) Crushed tissue  

b0 Temporary  
(1) Compression wave of tissue particles  
(2) Away from the pathway of the bullet  
(3) Lasts only a few microseconds  
(4) Tissue damage produced by stretch

3 Available energy  
a0 \[ KE = \frac{M}{2} x V^2 \]  
(1) Velocity more important than the mass  
b0 Mass \times acceleration = FORCE = mass \times deceleration  
(1) Then energy used to place the mass in motion must be completely exchanged into the body tissues to stop the mass  
c0 Energy potential  
(1) Continuum of energy increase  
(2) Can be broken down into artificial but workable groups  
(3) Energy  
(a) Low energy objects  
i) Hand driven  
a65535 Knife  
b65535 Ice pick  
c65535 Ax  
d65535 Other  
ii) Minimal cavitation  
iii) Damage only by cutting edge  
(b) Medium energy  
i) Muzzle velocity > 1500 feet/second  
ii) Hand guns, low power rifle  
iii) Small projectile  
iv) Cavitation 6-10 x bullet frontal area  
(c) High energy  
i) Muzzle velocity < 1500 feet/second  
ii) Military high velocity small caliber weapons  
a65535 Examples (M16, AK 47/74)  
b65535 Other  
iii) Cavitation 20-30 x frontal area of missile  
(d) Implications of soft body armor

B0 Anatomy  
1 Organs injured  
2 Pathway of missile  
a0 Entrance wound  
(1) Hole is crushed inward  
(2) Round or oval shaped  
(3) Rim  
(a) Dark  
(b) 1-2 mm width  
(c) Produced by grease and other substance on the bullet  
(4) Abrasion
Blast

A0  Introduction
1  The blast effect is broken down into three phases depending on the type of force that occurs during that phase
2  Each phase has a different energy pattern

B0  Phases

1  Primary
   a0  Pressure wave of the blast
       (1)  Major effect on gas containing organs
            (a)  Organ systems
                 i  Lungs
                 ii  Intestinal tract
            (b)  Pathology
                 i  Rupture of the organ
            (c)  Air emboli
       b0  Heat wave
           (1)  Burns on unprotected part of body
           (2)  Skin burns
           (3)  Eye burns

2  Secondary
   a0  Struck by flying particles
       (1)  Glass
       (2)  Bricks
       (3)  Wood
       (4)  Metal
   b0  Pathology
       (1)  Compression
       (2)  Lacerations

3  Tertiary
   a0  Patient becomes flying object
       (1)  Impact into other objects
       (2)  Similar to falls

(a)  Produced by spinning of the bullet
(b)  Largest with greatest contact of skin
   i  Larger when impact is at an angle
(5)  Burn
   (a)  Flame from barrel
   (b)  End of weapon 4-6 inches from the skin

b0  Exit wound
   (1)  Pushed outward
   (2)  Stellate or slit

Blast
UNIT TERMINAL OBJECTIVE
4-2 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and assessment findings to formulate a field impression and implement the treatment plan for the patient with shock or hemorrhage.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-2.1 Describe the epidemiology, including the morbidity/mortality and prevention strategies, for shock and hemorrhage. (C-1)
4-2.2 Discuss the anatomy and physiology of the cardiovascular system. (C-1)
4-2.3 Predict shock and hemorrhage based on mechanism of injury. (C-1)
4-2.4 Discuss the various types and degrees of shock and hemorrhage. (C-1)
4-2.5 Discuss the pathophysiology of hemorrhage and shock. (C-1)
4-2.6 Discuss the assessment findings associated with hemorrhage and shock. (C-1)
4-2.7 Identify the need for intervention and transport of the patient with hemorrhage or shock. (C-1)
4-2.8 Discuss the treatment plan and management of hemorrhage and shock. (C-1)
4-2.9 Discuss the management of external hemorrhage. (C-1)
4-2.10 Differentiate between controlled and uncontrolled hemorrhage. (C-3)
4-2.11 Differentiate between the administration rate and amount of IV fluid in a patient with controlled versus uncontrolled hemorrhage. (C-3)
4-2.12 Relate internal hemorrhage to the pathophysiology of compensated and decompensated hemorrhagic shock. (C-3)
4-2.13 Relate internal hemorrhage to the assessment findings of compensated and decompensated hemorrhagic shock. (C-3)
4-2.14 Discuss the management of internal hemorrhage. (C-1)
4-2.15 Define shock based on aerobic and anaerobic metabolism. (C-1)
4-2.16 Describe the incidence, morbidity, and mortality of shock. (C-1)
4-2.17 Describe the body’s physiologic response to changes in perfusion. (C-1)
4-2.18 Describe the effects of decreased perfusion at the capillary level. (C-1)
4-2.19 Discuss the cellular ischemic phase related to hemorrhagic shock. (C-1)
4-2.20 Discuss the capillary stagnation phase related to hemorrhagic shock. (C-1)
4-2.21 Discuss the capillary washout phase related to hemorrhagic shock. (C-1)
4-2.22 Discuss the assessment findings of hemorrhagic shock. (C-1)
4-2.23 Relate pulse pressure changes to perfusion status. (C-3)
4-2.24 Relate orthostatic vital sign changes to perfusion status. (C-3)
4-2.25 Define compensated and decompensated hemorrhagic shock. (C-1)
4-2.26 Discuss the pathophysiological changes associated with compensated shock. (C-1)
4-2.27 Discuss the assessment findings associated with compensated shock. (C-1)
4-2.28 Identify the need for intervention and transport of the patient with compensated shock. (C-1)
4-2.29 Discuss the treatment plan and management of compensated shock. (C-1)
4-2.30 Discuss the pathophysiological changes associated with decompensated shock. (C-1)
4-2.31 Discuss the assessment findings associated with decompensated shock. (C-1)
4-2.32 Identify the need for intervention and transport of the patient with decompensated shock. (C-1)
4-2.33 Discuss the treatment plan and management of the patient with decompensated shock. (C-1)
4-2.34 Differentiate between compensated and decompensated shock. (C-3)
4-2.35 Relate external hemorrhage to the pathophysiology of compensated and decompensated hemorrhagic shock. (C-3)
4-2.36 Relate external hemorrhage to the assessment findings of compensated and decompensated hemorrhagic shock. (C-3)
4-2.37 Differentiate between the normotensive, hypotensive, or profoundly hypotensive patient. (C-3)
4-2.38 Differentiate between the administration of fluid in the normotensive, hypotensive, or profoundly hypotensive patient. (C-3)
4-2.39 Discuss the physiologic changes associated with the pneumatic anti-shock garment (PASG). (C-1)
4-2.40 Discuss the indications and contraindications for the application and inflation of the PASG. (C-1)
4-2.41 Apply epidemiology to develop prevention strategies for hemorrhage and shock. (C-1)
4-2.42 Integrate the pathophysiological principles to the assessment of a patient with hemorrhage or shock. (C-3)
4-2.43 Synthesize assessment findings and patient history information to form a field impression for the patient with hemorrhage or shock. (C-3)
4-2.44 Develop, execute and evaluate a treatment plan based on the field impression for the hemorrhage or shock patient. (C-3)

AFFECTIVE OBJECTIVES
None identified for this unit.

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-2.45 Demonstrate the assessment of a patient with signs and symptoms of hemorrhagic shock. (P-2)
4-2.46 Demonstrate the management of a patient with signs and symptoms of hemorrhagic shock. (P-2)
4-2.47 Demonstrate the assessment of a patient with signs and symptoms of compensated hemorrhagic shock. (P-2)
4-2.48 Demonstrate the management of a patient with signs and symptoms of compensated hemorrhagic shock. (P-2)
4-2.49 Demonstrate the assessment of a patient with signs and symptoms of decompensated hemorrhagic shock. (P-2)
4-2.50 Demonstrate the management of a patient with signs and symptoms of decompensated hemorrhagic shock. (P-2)
4-2.51 Demonstrate the assessment of a patient with signs and symptoms of external hemorrhage. (P-2)
4-2.52 Demonstrate the management of a patient with signs and symptoms of external hemorrhage. (P-2)
4-2.53 Demonstrate the assessment of a patient with signs and symptoms of internal hemorrhage. (P-2)
4-2.54 Demonstrate the management of a patient with signs and symptoms of internal hemorrhage. (P-2)
DECLARATIVE

I. Pathophysiology, assessment, and management of hemorrhage
   A. Hemorrhage
      1. Epidemiology
         a. Incidence
         b. Mortality/ morbidity
         c. Prevention strategies
      2. Pathophysiology
         a. Location
            (1) External
               (a) Controlled
               (b) Uncontrolled
            (2) Internal
               (a) Trauma
               (b) Non-trauma
                  i) Common sites
                  ii) Uncommon sites
               (c) Controlled
               (d) Uncontrolled
         b. Anatomical type
            (1) Arterial
            (2) Venous
            (3) Capillary
         c. Timing
            (1) Acute
            (2) Chronic
         d. Severity
            (1) Amounts of blood loss tolerated by
               (a) Adults
               (b) Children
               (c) Infants
         e. Physiological response to hemorrhage
            (1) Clotting
            (2) Localized vasoconstriction
         f. Stages of hemorrhage
            (1) Stage 1
               (a) Up to 15% intravascular loss
               (b) Compensated by constriction of vascular bed
               (c) Blood pressure maintained
               (d) Normal pulse pressure, respiratory rate, and renal output
               (e) Pallor of the skin
               (f) Central venous pressure low to normal
            (2) Stage 2
               (a) 15-25% intravascular loss
               (b) Cardiac output cannot be maintained by arteriolar constriction
               (c) Reflex tachycardia
               (d) Increased respiratory rate
               (e) Blood pressure maintained
               (f) Catecholamines increase peripheral resistance
               (g) Increased diastolic pressure
(h) Narrow pulse pressure  
(i) Diaphoresis from sympathetic stimulation  
(j) Renal output almost normal  

(3) Stage 3  
(a) 25-35% intravascular loss  
(b) Classic signs of hypovolemic shock  
   i) Marked tachycardia  
   ii) Marked tachypnea  
   iii) Decreased systolic pressure  
   iv) 5-15 ml per hour urine output  
   v) Alteration in mental status  
   vi) Diaphoresis with cool, pale skin  

(4) Stage 4  
(a) Loss greater than 35%  
(b) Extreme tachycardia  
(c) Pronounced tachypnea  
(d) Significantly decreased systolic blood pressure  
(e) Confusion and lethargy  
(f) Skin is diaphoretic, cool, and extremely pale  

3. Assessment  
   a. Bright red blood from wound, mouth, rectum or other orifice  
   b. Coffee ground appearance of vomitus  
   c. Melena  
   d. Hematochezia  
   e. Dizziness or syncope on sitting or standing  
   f. Orthostatic hypotension  
   g. Signs and symptoms of hypovolemic shock  

4. Management  
   a. Airway and ventilatory support  
   b. Circulatory support  
      (1) Bleeding from nose or ears after head trauma  
         (a) Refrain from applying pressure  
         (b) Apply loose sterile dressing to protect from infection  
      (2) Bleeding from other areas  
         (a) Control bleeding  
            i) Direct pressure  
            ii) Elevation if appropriate  
            iii) Pressure points  
            iv) Tourniquet  
            v) Splinting  
            vi) Packing of large gaping wounds with sterile dressings  
            vii) PASG  
         (b) Apply sterile dressing and pressure bandage  
      (3) Transport considerations  
      (4) Psychological support/ communication strategies  

II. Shock  
A. Epidemiology  
   1. Mortality/ morbidity  
   2. Prevention strategies
3. Pathophysiology
   a. Perfusion depends on cardiac output (CO), systemic vascular resistance (SVR) and transport of oxygen
      (1) \[ CO = HR \times SV \]  
         (a) HR - heart rate  
         (b) SV - stroke volume  
      (2) \[ BP = CO \times SVR \]  
      (3) Hypoperfusion can result from  
         (a) Inadequate cardiac output  
         (b) Excessive systemic vascular resistance  
         (c) Inability of red blood cells to deliver oxygen to tissues  
   b. Compensation for decreased perfusion  
      (1) Occurrence of event resulting in decreased perfusion, e.g., blood loss, myocardial infarction, loss of vasomotor tone or tension pneumothorax  
      (2) Baroreceptors sense decreased flow and activate vasomotor center  
         (a) Normally stimulated between 60-80 mm Hg systolic (lower in children)  
         (b) Located in carotid sinuses and aortic arch  
         (c) Arterial pressure drop decreases stretch  
            i) Nerve impulse through Vagus and Hering's nerve to glossopharyngeal nerve  
            ii) Impulse transmitted to vasomotor center  
            iii) Frequency of inhibitory impulses decreases  
            iv) Increase in vasomotor activity  
            v) Sympathetic nervous system stimulated  
               (iv) Decrease in systolic less than 80 mmHg stimulates vasomotor center to increase arterial pressure  
      (3) Chemoreceptors are stimulated by decrease in PaO$_2$ and increase in PaCO$_2$  
      (4) Sympathetic nervous system  
      (5) Adrenal medulla glands secrete epinephrine and norepinephrine  
         (a) Epinephrine  
            i) Alpha 1  
               a) Vasoconstriction  
               b) Increase in peripheral vascular resistance  
               c) Increased afterload from arteriolar constriction  
            ii) Alpha 2 regulated release of alpha 1  
            iii) Beta 1  
               a) Positive chronotropy  
               b) Positive inotropy  
               c) Positive dromotropy  
            iv) Beta 2  
               a) Bronchodilation  
               b) Gut smooth muscle dilation  
         (b) Norepinephrine  
            i) Primarily alpha 1 and alpha 2  
               a) Vasoconstriction  
               b) Increase in peripheral vascular resistance  
               c) Increased afterload from arteriolar constriction
(6) Arginine vasopressin (AVP)
   (a) Also known as antidiuretic hormone (ADH)
   (b) Released from anterior pituitary gland
   (c) Effects
      i. Increases free water absorption in distal tubule and collecting ducts of kidney
      ii. Decreases urine output
      iii. Splanchnic vascular constriction

(7) Renin-angiotensin system
   (a) Renin released from kidney arteriole
   (b) Renin and angiotensinogen combine in renal arteriole to produce angiotensin I
   (c) Angiotensin I converted to angiotensin II by angiotensin converting enzyme
   (d) Effects of angiotensin II
      i. Potent vasoconstrictor
      ii. Sodium reabsorption decreases urine output
      iii. Positive inotrope and chronotrope

(8) Aldosterone
   (a) Defends fluid volume
   (b) Secreted by cells of adrenal cortex in response to stress
   (c) Promotes sodium reabsorption and water retention in kidney
   (d) Reduces urine output

(9) Insulin
   (a) Secretion is diminished by circulating epinephrine
   (b) Impaired effect on peripheral tissue
   (c) Contributes to hyperglycemia seen following injury and volume loss

(10) Glucagon
    (a) Stimulated to be released by epinephrine
    (b) Promotes
       i. Liver glycogenolysis
       ii. Gluconeogenesis
       iii. Amino acid uptake for conversion into glucose
       iv. Transfer of fatty acid into mitochondria

(11) ACTH (adrenocorticotropic hormone)-cortisol system
    (a) ACTH release stimulates the release of cortisol from the adrenal cortex of kidney
    (b) Cortisol increases glucose production by inhibiting enzymes that break down glucose

(12) Growth hormone
    (a) Secreted by anterior pituitary gland
    (b) Early effects of growth hormone
       i. Promotes uptake of glucose and amino acids in muscle
       ii. Stimulates protein synthesis

(13) Failure of compensation to preserve perfusion

(14) Preload decreases

(15) Cardiac output decreases

(16) Myocardial blood supply and oxygenation decrease
    (a) Myocardial perfusion decreases
    (b) Cardiac output decreases further
Coronary artery perfusion decreases  
Myocardial ischemia  
Capillary and cellular changes  
Ischemia  
Minimal blood flow to capillaries  
Cells go from aerobic to anaerobic metabolism  
Stagnation  
Precapillary sphincter relaxes in response to  
Lactic acid  
Vasomotor center failure  
Increased carbon dioxide  
Postcapillary sphincters remain constricted  
Capillaries engorge with fluid  
Anaerobic metabolism continues, increasing lactic acid production  
Aggregation of red blood cells and formation of microemboli  
Potent vasodilator  
Destroys capillary cell membrane  
Plasma leaks from capillaries  
Interstitial fluid increases  
Distance from capillary to cell increases  
Oxygen transport decreases secondary to increased capillary-cell distance  
Myocardial toxin factor released by ischemic pancreas  
Washout  
Postcapillary sphincter relaxes  
Hydrogen, potassium, carbon dioxide, thrombosed erythrocytes wash out  
Metabolic acidosis results  
Cardiac output drops further  
Stages of shock  
Compensated or nonprogressive  
Characterized by signs and symptoms of early shock  
Arterial blood pressure is normal or high  
Treatment at this stage will typically result in recovery  
Decompensated or progressive  
Characterized by signs and symptoms of late shock  
Arterial blood pressure is abnormally low  
Treatment at this stage will sometimes result in recovery  
Irreversible  
Characterized by signs and symptoms of late shock  
Arterial blood pressure is abnormally low  
Even aggressive treatment at this stage does not result in recovery  
Etiologic classifications  
Hypovolemic  
Hemorrhage  
Plasma loss  
Fluid and electrolyte loss  
Endocrine
(2) Distributive (vasogenic)
   (a) Increased venous capacitance
   (b) Low resistance, vasodilation
(3) Cardiogenic
   (a) Myocardial insufficiency
   (b) Filling or outflow obstruction (obstructive)
(4) Spinal neurogenic shock
   (a) Refers to temporary loss of all types of spinal cord function distal to injury
      i. Flaccid paralysis distal to injury site
      ii. Loss of bladder and bowel control
      iii. Priapism
      iv. Loss of thermoregulation
   (b) Does not always involve permanent primary injury
(5) Spinal shock
   (a) Also called spinal vascular shock
   (b) Temporary loss of the autonomic function of the cord at the level of injury which controls cardiovascular function
   (c) Presentations includes
      i. Loss of sympathetic tone
      ii. Relative hypotension
      a65535 Systolic pressure 80 - 100 mmHg
      iii. Skin is pink, warm and dry
      a65535 Due to cutaneous vasodilation
      iv. Relative bradycardia
   (d) Occurrence is rare
   (e) Shock presentation is usually the result of hidden volume loss
      i. Chest injuries
      ii. Abdominal injuries
      iii. Other violent injuries
   (f) Treatment
      i. Focus primarily on volume replacement
4 Assessment - hypovolemic shock due to hemorrhage
(1) Early or compensated
   (a) Tachycardia
   (b) Pale, cool skin
   (c) Diaphoresis
   (d) Level of consciousness
      i. Normal
      ii. Anxious or apprehensive
   (e) Blood pressure maintained
   (f) Narrow pulse pressure
      i. Pulse pressure is the difference between the systolic and diastolic pressures, i.e., pulse pressure = systolic - diastolic
      ii. Pulse pressure reflects the tone of the arterial system and is more sensitive to changes in perfusion than the systolic or diastolic alone
   (g) Positive orthostatic tilt test
   (h) Dry mucosa
   (i) Complaints of thirst
(j) Weakness
(k) Possible delay of capillary refill

(2) Late or progressive
(a) Extreme tachycardia
(b) Extreme pale, cool skin
(c) Diaphoresis
(d) Significant decrease in level of consciousness
(e) Hypotension
(f) Dry mucosa
(g) Nausea
(h) Cyanosis with white waxy looking skin

Differential shock assessment findings
(1) Shock is assumed to be hypovolemic until proven otherwise
(2) Cardiogenic shock
(a) Differentiated from hypovolemic shock by one or more of the following
   i Chief complaint (chest pain, dyspnea, tachycardia)
   ii Heart rate (bradycardia or excessive tachycardia)
   iii Signs of congestive heart failure (jugular vein distention, rales)
   iv Dysrhythmias
(b) Distributive shock
(c) Differentiated from hypovolemic shock by presence of one or more of following
   i Mechanism that suggests vasodilation, e.g., spinal cord injury, drug overdose, sepsis, anaphylaxis
   ii Warm, flushed skin, especially in dependent areas
   iii Lack of tachycardia response (not reliable, though, since significant number of hypovolemic patients never become tachycardic)
(d) Obstructive shock
   i Differentiated from hypovolemic shock by presence of signs and symptoms suggestive of
      ii Cardiac tamponade
      iii Tension pneumothorax

Management/ treatment plan

<table>
<thead>
<tr>
<th>(a0)</th>
<th>Airway and ventilatory support</th>
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<tbody>
<tr>
<td>(1)</td>
<td>Ventilate and suction as necessary</td>
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<td>(2)</td>
<td>Administer high concentration oxygen</td>
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<td>(3)</td>
<td>Reduce increased intrathoracic pressure in tension pneumothorax</td>
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<tr>
<th>(b0)</th>
<th>Circulatory support</th>
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<tbody>
<tr>
<td>(1)</td>
<td>Hemorrhage control</td>
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<td>(2)</td>
<td>Intravenous volume expanders</td>
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<tr>
<td>(a)</td>
<td>Types</td>
</tr>
<tr>
<td>i</td>
<td>Isotonic solutions</td>
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<td>ii</td>
<td>Hypertonic solutions</td>
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<td>iii</td>
<td>Synthetic solutions</td>
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<td>iv</td>
<td>Blood and blood products</td>
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<td>v</td>
<td>Experimental solutions</td>
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<tr>
<td>vi</td>
<td>Blood substitutes</td>
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</table>
(b) Rate of administration
   i  External hemorrhage that can be controlled
   ii  External hemorrhage that can not be controlled
   iii  Internal hemorrhage
      a65535  Blunt trauma
      b65535  Penetrating trauma
(3) Pneumatic anti-shock garment
   (a) Effects
      i  Increased arterial blood pressure above garment
      ii  Increased systemic vascular resistance
      iii  Immobilization of pelvis and possibly lower extremities
      iv  Increased intra-abdominal pressure
   (b) Mechanism
      i  Increases systemic vascular resistance through direct
          compression of tissues and blood vessels
      ii  Negligible autotransfusion effect
   (c) Indications
      i  Hypoperfusion with unstable pelvis
      ii  Conditions of decreased SVR not corrected by other
          means
      iii  As approved locally, other conditions characterized by
          hypoperfusion with hypotension
      iv  Research studies
   (d) Contraindications
      i  Advanced pregnancy (no inflation of abdominal
          compartment)
      ii  Object impaled in abdomen or evisceration (no inflation
          of abdominal compartment)
      iii  Ruptured diaphragm
      iv  Cardiogenic shock
      v  Pulmonary edema
(4) Needle chest decompression of tension pneumothorax to improve
    impaired cardiac output
(5) Recognize the need for expeditious transport of suspected cardiac
    tamponade for pericardiocentesis

c0  Pharmacological interventions
(1) Hypovolemic shock
   (a) Volume expanders
(2) Cardiogenic shock
   (a) Volume expanders
      (b) Positive cardiac inotropes
      (c) Vasoconstrictor
      (d) Rate altering medications
(3) Distributive shock
   (a) Volume expanders
      (b) Positive cardiac inotropes
      (c) Vasoconstriction
      (d) PASG
(4) Obstructive shock
   (a) Volume expanders
(5) Spinal shock
   (a) Volume expanders

d0 Psychological support/communication strategies

e0 Transport considerations
   (1) Indications for rapid transport
   (2) Indications for transport to a trauma center
   (3) Considerations for air medical transportation

Integration
UNIT TERMINAL OBJECTIVE
4-3 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement the treatment plan for the patient with soft tissue trauma.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-3.1 Describe the incidence, morbidity, and mortality of soft tissue injuries. (C-1)
4-3.2 Describe the layers of the skin, specifically: (C-1)
   a. Epidermis and dermis (cutaneous)
   b. Superficial fascia (subcutaneous)
   c. Deep fascia
4-3.3 Identify the major functions of the integumentary system. (C-1)
4-3.4 Identify the skin tension lines of the body. (C-1)
4-3.5 Predict soft tissue injuries based on mechanism of injury. (C-1)
4-3.6 Discuss the pathophysiology of wound healing, including: (C-1)
   1. Hemostasis
   2. Inflammation phase
   3. Epithelialization
   4. Neovascularization
   5. Collagen synthesis
4-3.7 Discuss the pathophysiology of soft tissue injuries. (C-2)
4-3.8 Differentiate between the following types of closed soft tissue injuries: (C-3)
   a. Contusion
   2. Hematoma
   3. Crush injuries
4-3.9 Discuss the assessment findings associated with closed soft tissue injuries. (C-1)
4-3.10 Discuss the management of a patient with closed soft tissue injuries. (C-2)
4-3.11 Discuss the pathophysiology of open soft tissue injuries. (C-2)
4-3.12 Differentiate between the following types of open soft tissue injuries: (C-3)
   a. Abrasions
   2. Lacerations
   3. Major arterial lacerations
   4. Avulsions
   5. Impaled objects
   6. Amputations
   7. Incisions
   8. Crush injuries
   9. Blast injuries
   10. Penetrations/ punctures
4-3.13 Discuss the incidence, morbidity, and mortality of blast injuries. (C-1)
4-3.14 Predict blast injuries based on mechanism of injury, including: (C-2)
   a. Primary
   2. Secondary
3. Tertiary

4-3.15 Discuss types of trauma including: (C-1)
   a. Blunt
   2. Penetrating
   3. Barotrauma
   4. Burns

4-3.16 Discuss the pathophysiology associated with blast injuries. (C-1)

4-3.17 Discuss the effects of an explosion within an enclosed space on a patient. (C-1)

4-3.18 Discuss the assessment findings associated with blast injuries. (C-1)

4-3.19 Identify the need for rapid intervention and transport of the patient with a blast injury. (C-1)

4-3.20 Discuss the management of a patient with a blast injury. (C-1)

4-3.21 Discuss the incidence, morbidity, and mortality of crush injuries. (C-1)

4-3.22 Define the following conditions: (C-1)
   1. Crush injury
   2. Crush syndrome
   3. Compartment syndrome

4-3.23 Discuss the mechanisms of injury in a crush injury. (C-1)

4-3.24 Discuss the effects of reperfusion and rhabdomyolysis on the body. (C-1)

4-3.25 Discuss the assessment findings associated with crush injuries. (C-1)

4-3.26 Identify the need for rapid intervention and transport of the patient with a crush injury. (C-1)

4-3.27 Discuss the management of a patient with a crush injury. (C-1)

4-3.28 Discuss the pathophysiology of hemorrhage associated with soft tissue injuries, including: (C-2)
   1. Capillary
   2. Venous
   3. Arterial

4-3.29 Discuss the assessment findings associated with open soft tissue injuries. (C-1)

4-3.30 Discuss the assessment of hemorrhage associated with open soft tissue injuries. (C-1)

4-3.31 Differentiate between the various management techniques for hemorrhage control of open soft tissue injuries, including: (C-3)
   a. Direct pressure
   2. Elevation
   3. Pressure dressing
   4. Pressure point
   5. Tourniquet application

4-3.32 Differentiate between the types of injuries requiring the use of an occlusive versus non-occlusive dressing. (C-3)

4-3.33 Identify the need for rapid assessment, intervention and appropriate transport for the patient with a soft tissue injury. (C-2)

4-3.34 Discuss the management of the soft tissue injury patient. (C-2)
4-3.35 Define and discuss the following: (C-1)
   a. Dressings
      1. Sterile
      2. Non-sterile
      3. Occlusive
      4. Non-occlusive
      5. Adherent
      6. Non-adherent
      7. Absorbent
      8. Non-absorbent
      9. Wet
      10. Dry
   2. Bandages
      1. Absorbent
      2. Non-absorbent
      3. Adherent
      4. Non-adherent
   3. Tourniquet

4-3.36 Predict the possible complications of an improperly applied dressing, bandage, or
tourniquet. (C-2)

4-3.37 Discuss the assessment of wound healing. (C-1)
4-3.38 Discuss the management of wound healing. (C-1)
4-3.39 Discuss the pathophysiology of wound infection. (C-1)
4-3.40 Discuss the assessment of wound infection. (C-1)
4-3.41 Discuss the management of wound infection. (C-1)
4-3.42 Integrate pathophysiological principles to the assessment of a patient with a soft tissue injury. (C-3)
4-3.43 Formulate treatment priorities for patients with soft tissue injuries in conjunction with: (C-3)
   a. Airway/ face/ neck trauma
   2. Thoracic trauma (open/ closed)
   3. Abdominal trauma

4-3.44 Synthesize assessment findings and patient history information to form a field impression for the patient with soft tissue trauma. (C-3)
4-3.45 Develop, execute, and evaluate a treatment plan based on the field impression for the patient with soft tissue trauma. (C-3)

**AFFECTIVE OBJECTIVES**
At the completion of this unit, the paramedic student will be able to:

4-3.46 Defend the rationale explaining why immediate life-threats must take priority over wound closure. (A-3)
4-3.47 Defend the management regimens for various soft tissue injuries. (A-3)
4-3.48 Defend why immediate life-threatening conditions take priority over soft tissue management. (A-3)
4-3.49 Value the importance of a thorough assessment for patients with soft tissue injuries. (A-3)
4-3.50 Attend to the feelings that the patient with a soft tissue injury may experience. (A-2)
4-3.51 Appreciate the importance of good follow-up care for patients receiving sutures. (A-2)
4-3.52 Understand the value of the written report for soft tissue injuries, in the continuum of patient care. (A-2)

**PSYCHOMOTOR OBJECTIVES**
At the completion of this unit, the paramedic student will be able to:

4-3.53 Demonstrate the assessment and management of a patient with signs and symptoms of soft tissue injury, including: (P-2)

1. Contusion
2. Hematoma
3. Crushing
4. Abrasion
5. Laceration
6. Avulsion
7. Amputation
8. Impaled object
9. Penetration/ puncture
10. Blast
DECLARATIVE

I. Introduction
   A. Epidemiology
      1. Incidence
      2. Mortality/ morbidity
      3. Risk factors
      4. Prevention strategies
   B. Body substance isolation review
      1. Risks from exposure to body substances
         a. Bloodborne pathogens
            (1) HIV
            (2) HBV
            (3) Other bloodborne pathogens
         b. Other body substances posing risk
      2. Relationship to body substance isolation
         a. Universal precautions
            (1) Gloves
            (2) Hand washing
            (3) Protective eyewear
            (4) Masks
            (5) Gowns
            (6) Handling and disposal of sharps
         b. Disposal of contaminated materials
   C. Anatomy and physiology review
      1. Layers
         a. Cutaneous layer
            (1) Epidermis
               (a) Stratum germinativum (Basal Layer)
               (b) Stratum corneum
            (2) Dermis
               (a) Fibroblasts
               (b) Macrophages
               (c) Mast cells
               (d) Lymphocytes
               (e) Papillary dermis
               (f) Reticular dermis
         b. Subcutaneous layer (superficial fascia)
            (1) Loose connective tissue
            (2) Fat
               (a) Insulation
               (b) Protection from trauma
c. Deep fascia
   (1) Thick, dense layer of fibrous tissue
   (2) Support and protect underlying structures

2. Functions
a. Protection against mechanical trauma
b. Regulation of body temperature
c. Sensory function
   (1) Pain
   (2) Touch
   (3) Heat
   (4) Cold
d. Protection against bacterial invasion
e. Maintenance of fluid balance

3. Skin tension lines
a. Static tension
   (1) Constant force due to taut nature of skin
   (2) Effects on scar formation
   (3) Consideration in wound debridement and revision
   (4) Consideration in foreign body removal
b. Dynamic tension
   (1) Caused by underlying muscle contraction
   (2) Effects on scar formation
   (3) Consideration in wound debridement and revision
   (4) Consideration in foreign body removal

4. Process of normal wound healing
a. Hemostasis of wound healing
   (1) Injury causes changes in normal skin anatomy
   (2) Reflex vasoconstriction for up to 10 minutes
   (3) Clotting process begins
b. Inflammatory phase
   (1) Role of granulocytes
   (2) Role of lymphocytes
   (3) Role of macrophages
c. Epithelialization phase
   (1) Wound healing within 12 hours
   (2) Healing through re-establishment of skin layers
d. Neovascularization
   (1) Role of new vessel formation
   (2) Neovascularization as soon as 3 days after, lasting a total of 21 days
   (3) New vessel formation
e. Collagen synthesis
(1) Role of fibroblasts in collagen synthesis
(2) Time factors involved with collagen fibers
(3) Process of collagen lysis and wound healing
(4) Time table for the healing and tensile strength of wound

5. Alteration of wound healing
   a. Anatomic factors
      (1) Body region
      (2) Static skin tension
      (3) Dynamic skin tension
      (4) Pigmented skin
      (5) Oily skin
   b. Concurrent drug use
      (1) Corticosteroids
      (2) NSAID
      (3) Penicillin
      (4) Colchicine
      (5) Anticoagulants
      (6) Antineoplastic agents
   c. Medical conditions and diseases
      (1) Advanced age
      (2) Severe alcoholism
      (3) Acute uremia
      (4) Diabetes
      (5) Hypoxia
      (6) Severe anemia
      (7) PVD
      (8) Malnutrition
      (9) Advanced cancer
      (10) Hepatic failure
      (11) Cardiovascular disease
   d. High risk wounds
      (1) Bites (human and animal)
      (2) Foreign bodies
      (3) Wounds contaminated with organic matter
      (4) Injection wounds
      (5) Wounds with significant devitalized tissue
      (6) Crush wounds
      (7) Any wound in immunocompromised patients
      (8) Any wound in patients with poor peripheral circulation

6. Abnormal scar formation
   a. Keloid
(1) Excessive accumulation of scar tissue that extends beyond original wound borders
(2) More common in darkly pigmented individuals
(3) Most common locations
   (a) Ears
   (b) Upper extremities
   (c) Lower abdomen
   (d) Sternum
b. Hypertrophic scar formation
   (1) Excessive accumulation of scar tissue confined within the original wound borders
   (2) More common in areas of high tissue stress, such as flexion creases across joints
c. Wounds requiring closure
   (1) Cosmetic regions (face, lip, eyebrow, etc.
   (2) Gaping wounds
   (3) Wounds over tension areas
   (4) Degloving injuries
   (5) Ring injuries
   (6) Skin tearing

II. Pathophysiology and assessment of soft tissue injuries
A. Identification of closed soft tissue injuries
   1. Contusion
      a. Epidermis remains intact
      b. Cells damaged and blood vessels in dermis are torn
      c. Swelling and pain typically present - may occur up to 24 to 48 hours later
      d. Blood accumulation causes ecchymosis
   2. Hematoma
      a. Collection of blood beneath skin
      b. Larger amount of tissue damage as compared to contusion
      c. Larger vessels are damaged
      d. May lose one or more liters of blood in confined space
   3. Crush injuries
      a. Crushing force applied to body area
      b. Can cause internal organ rupture
      c. Associated with severe fractures
      d. Overlying skin may remain intact, but internal bleeding may be severe, with shock

B0 Identification of open soft tissue injuries
1. Abrasions
a0 Outermost layer of skin is damaged by shearing forces
b0 Painful injury
c0 Superficial
d0 No blood, or very little oozing of blood
(1) Contamination should be expected

2 Lacerations
a0 Break in skin of varying depth
b0 May be linear (regular) or stellate (irregular)
c0 Jagged wound ends that bleed freely
d0 May occur in isolation or together with other types of soft tissue injury
e0 Caused by forceful impact with a sharp object
f0 Bleeding may be severe

3 Incisions
a0 Break in skin of varying depth
b0 Similar to laceration except wound ends are smooth and even, not jagged
c0 Tend to heal better than lacerations
d0 Caused by very sharp objects, such as knife, sharp metal, or scalpel

4 Avulsion
a0 Flap of skin or tissue torn loose or pulled completely off
b0 Avulsed tissue may or may not be viable

5 Amputations
a0 Involves the extremities or other body parts
b0 Jagged skin and/or bone edges are typically present at site of amputation
c0 Massive bleeding may be present or bleeding may be limited
d0 Three types of amputations
(1) Complete
(2) Partial
(3) Degloving

6 Crush injuries
a0 Causes of injuries
(1) Collapse of masonry or steel structures
   (a) Earthquakes
   (b) Tornadoes
   (c) Construction accidents
(2) Collapse of earth
   (a) Mudslides
   (b) Earthquakes
(3) Motor vehicle collisions
(4) Warfare injuries
(5) Industrial accidents
(6) Any prolonged compression in a chronic situation
   (a) Unconscious person lying on an extremity
   (b) Prolonged application of PASG
   (c) Improperly applied casts

b0 Crush injuries - definitions
(1) Crush injury - injury sustained from a compressive force
    sufficient to interfere with the normal metabolic function
    of the involved tissue
(2) Crush syndrome - traumatic rhabdomyolysis; “smiling death”
(3) Systemic manifestations of crush injuries consisting of
    rhabdomyolysis, electrolyte and acid-base abnormalities,
    hypovolemia (shock), and acute renal failure
(4) Compartment syndrome - local manifestations of muscle
    ischemia resulting from compressive forces on a closed
    space

Pathophysiology of crush syndrome
(1) Damage to soft tissue and internal organs
(2) May cause painful, swollen, deformed extremities
(3) External bleeding may be minimal or absent
(4) Internal bleeding may be severe
(5) Reperfusion phenomenon - systemic effects and even
    microvascular injury occur after the affected tissue is
    reperfused
(6) Oxygen free radicals
(7) Xanthine oxidase - xanthine oxidase requires two substrates
    - hypoxanthine and oxygen on reperfusion; oxygen is
    supplied so xanthine oxidase uses oxygen as an electron
    acceptor generating the oxygen free radical - oxygen
    superoxide
(8) Lipid peroxidation - pressure stretch myopathy
(9) High intracellular calcium levels

d0 Rhabdomyolysis
(1) Destruction of muscle
(2) Influx from extracellular fluid into muscle cells
    (a) Water
    (b) NaCl
    (c) Ca++
(3) Eflux from muscle to extracellular fluid
    (a) K+
    (b) Purines from disintegrating cell nuclei
(c) Phosphate
(d) Lactic acid
(e) Myoglobin
(f) Thromboplastin
(g) Creatine kinase & creatinine

4 Consequences - all contribute to development of renal failure
(a) Hypovolemia - adds to cardiotoxicity
(b) Hypocalcemia - adds to cardiotoxicity
(c) Hyperkalemia - adds to cardiotoxicity
(d) Hyperuricemia
(e) Hyperphosphatemia
(f) Metabolic acidosis
(g) Possible DIC
(h) Increased levels of serum creatine and creatinine

Pathophysiology of compartment syndrome
1 Tissue pressure rises above capillary hydrostatic pressure resulting in ischemia to muscle
2 Edema of muscle cells develop
3 Prolonged ischemia (> 6 to 8 hours) leads to tissue hypoxia and anoxia, and ultimately cell death
4 Direct soft tissue trauma adds to the edema and ischemia

Renal failure pathogenesis
1 Hypovolemia
2 Obstructed renal tubules by casts
3 Nephrotoxic agents
4 Other factors

Crush injury clinical presentation
1 General
(a) Alert to unresponsive
(b) Affected limb may appear almost normal
2 Local signs and symptoms
(a) Flaccid paralysis and sensory loss that are unrelated to peripheral nerve distribution
(b) May mimic spinal cord injury
(c) Early - rigor of the joint distal to the involved muscles, wooden texture of the affected skin and muscles, and loss of voluntary muscle contraction
(d) Varying combinations of pain, swelling, sensory changes, weakness, and pain on passive stretching of muscles
(e) May have pulses present and warm skin
7. Blast injuries
   a0 Causes of blast injuries
      (1) Natural gas or gasoline explosions
      (2) Firework explosions
      (3) Dust within a grain elevator
      (4) Terrorism (bombs)
   b0 Primary injuries
      (1) Initial air blast
      (2) Compression injuries to air filled organs
         (a) Ruptured ear drum
         (b) Sinuses
         (c) Lungs
         (d) Stomach
         (e) Intestines
   c0 Secondary injuries due to flying debris striking victim
   d0 Tertiary injuries
      (1) Victim is thrown from the blast and strikes an object
      (2) All can lead to superficial and deep internal injuries

8. Punctures/ penetrations
   a0 Caused by a foreign object that enters the body
   b0 Bleeding is minimal or absent if extremity injury
   c0 Bleeding may be severe if abdominal or thoracic injury
   d0 Underlying damage can be extensive
      (1) Thoracic
         (a) Simple pneumothorax
         (b) Open pneumothorax
         (c) Tension pneumothorax
         (d) Hemothorax
         (e) Pericardial tamponade
         (f) Penetrating heart wound
         (g) Rupture of esophagus
         (h) Rupture of aorta
         (i) Rupture of diaphragm
         (j) Rupture of mainstem bronchus
      (2) Abdominal
(a) Solid organ damage
(b) Hollow organ damage
(c) Peritonitis
   i Bacterial
   ii Chemical
(d) Evisceration

9 Increased risk of infection/ complications

9 Impaled objects
   a0 Specific type of puncture wound
   b0 Instrument that caused injury remains impacted in wound

10 Major arterial lacerations
   a0 Any of these injuries can involve major arterial lacerations
   b0 Bleeding often will be severe
   c0 Spurting, bright red blood flow
   d0 Artery may spasm which may decrease blood flow
   e0 Can result in shock and death if severe enough blood loss

III Management principles for soft tissue injuries

A0 Treatment priorities

1 Emphasize scene survey to protect yourself and crew
   a0 Have the police ruled out the presence of another bomb or device?
   b0 Have the police apprehended the perpetrator?

2 Treat for hypoperfusion (shock)

3 Consider the power of the explosion

4 Internal and external injuries are possible (refer to specific units on specific injuries encountered)

5 Be aware of possibility of multiple trauma

6 Treatment priorities for patient with a soft tissue injury
   a0 Treatment of life-threatening injury should occur prior to isolated soft tissue trauma
      (1) Life-threatening airway deficit
      (2) Life-threatening breathing deficit
      (3) Life-threatening circulatory deficit

7 Methods of hemorrhage control based on injury severity
   a0 Direct pressure
      (1) General description
         (a) Quickest/ efficient means
      (2) Pressure applied directly to wound
         (a) Dressing and gloved hand
         (b) Gloved hand
      (3) Physiology of intervention
         (a) Limit additional significant blood loss
(b) Promote localized clotting

(4) Indications
(a) Mild hemorrhage
(b) Profuse hemorrhage

(5) Contraindications - none

(6) Assessment of intervention
(a) Positive hemorrhage control
(b) Prevention of additional significant blood loss

(7) Considerations
(a) Never remove dressing once in place
   i Restart bleed
   ii Additional injury
(b) Positive hemorrhage control
   i Secure in place with bandage
(c) Negative hemorrhage control
   i Continue direct pressure
   ii Apply additional dressing
   iii Elevation of extremity with direct pressure

b0 Elevation
(1) General description
(a) Used concurrent with direct pressure
(b) Extremity involvement only
(c) Elevation of extremity

(2) Physiology of intervention
(a) Wound above level of heart
(b) Gravity decreases blood pressure in extremity
(c) Slow hemorrhage
(d) Promote localized clotting

(3) Indications
(a) Control of hemorrhage
(b) Failure of direct pressure to control hemorrhage

(4) Contraindications
(a) Possible musculoskeletal injury to involved extremity
(b) Object impaled in involved extremity
(c) Possible spinal injury

(5) Assessment of intervention
(a) Positive hemorrhage control
(b) Prevention of additional significant blood loss

(6) Considerations
(a) Positive control - continue elevation
(b) Negative control
Pressure dressing

(1) General description
   (a) Dressing firmly wrapped with self adhering roller bandage
   (b) Continuous mechanical pressure
      i  Over injury site
      ii Above injury site
      iii Below injury site

(2) Physiology of intervention
   (a) Limit additional significant blood loss with continuous pressure
   (b) Promote localized clotting

(3) Indications
   (a) Hemorrhage control
   (b) Failure of other methods to control hemorrhage
      i  Direct pressure
      ii  Elevation

(4) Contraindications - none

(5) Assessment of intervention
   (a) Positive control of hemorrhage
   (b) Prevent additional significant blood loss

(6) Considerations
   (a) Check distal pulse after application
      i  Positive pulse - leave in place
      ii Negative pulse - adjust to establish circulation
      iii Some arterial bleeds will stop circulation needed for pulse
   (b) Certain body regions not conducive to direct pressure
   (c) If bleeding continues adjust with more pressure

Pressure points

(1) General description
   (a) Site where main artery lies near surface
   (b) Direct compression applied to site
      i  Brachial artery
      ii  Femoral artery

(2) Physiology of intervention
   (a) Decrease blood flow to extremity
   (b) Limit additional significant blood loss
   (c) Promote localized clotting

(3) Indications
(a) Need for hemorrhage control
(b) Failure of other methods of hemorrhage control
   i  Direct pressure
   ii  Elevation
   iii  Pressure dressings
(4) Contraindications - none
(5) Assessment of intervention
   (a) Positive hemorrhage control
   (b) Prevention of additional significant blood loss
(6) Considerations
   (a) Skill needed to locate pressure points
   (b) Distal wounds difficult to control with pressure points
   (c) Proper application
      i  Considerable force needed
      ii  Loss of distal pulses

Tourniquet application
(1) General description
   (a) Last resort
   (b) Tourniquet placed between heart and wound
   (c) Tourniquet placed within 2" of wound
(2) Physiology of intervention
   (a) Restriction of blood flow to and from extremity
   (b) Prevent additional significant blood loss
   (c) Promote localized clotting
(3) Indications
   (a) Control of profuse hemorrhage
   (b) Last resort after failure of other methods
      i  Direct pressure
      ii  Elevation
      iii  Pressure dressings
      iv  Pressure points
(4) Contraindications - bleeding controllable by other methods
(5) Assessment of intervention
   (a) Positive control of hemorrhage
   (b) Prevention of additional significant blood loss
(6) Considerations
   (a) Last resort technique
   (b) Used only on wounds to extremities
   (c) Never apply directly to knee or elbow
   (d) Once in place never loosen
      i  Emboli
      ii  Restart bleed
Tourniquet shock

(e) Never use wire/ string/ rope

IV Review of bandaging and dressing material used in conjunction with soft tissue trauma

A0 Dressings

1 Sterile
   a0 Has gone through process to eliminate bacteria from dressing material
   b0 Used when infection is a concern

2 Non-sterile
   a0 Has not gone through process of sterilization
   b0 Used when infection is not a concern

3 Occlusive
   a0 Does not allow passage of air through dressing
   b0 Useful for wounds involving thorax and major vessels
      (1) Negative pressure may cause air to enter thorax or vessel
      (2) Occlusive dressing may prevent pneumothorax and air embolism
      (3) Be aware of the possibility of developing tension pneumothorax

4 Non-occlusive
   a0 Allows air to pass through dressing
   b0 Useful for most standard open soft tissue injuries

5 Adherent
   a0 Dressing may adhere to wound surface by incorporating wound exudate into dressing mesh
   b0 May assist in controlling acute bleeding

6 Non-adherent
   a0 Allows passage of wound exudate so that dressing will not adhere to wound surface
   b0 Will not damage surface of wound when removed
   c0 Used after wound closure

B0 Complications of improperly applied dressings

1 Hemodynamic
   a0 Hemorrhage
   b0 Exsanguination
   c0 Ischemia

2 Structural - immediate and distal
   a0 Vessels
   b0 Nerves
   c0 Tendons
d. Muscles
e. Integument/ tissue
f. Organ

3. Patient discomfort

C. Basic concepts of open wound dressing

1. Assessment
   a. Cleansing
   b. Irrigation
   c. Debridement
   d. Definitive care as appropriate

2. Non-adherent based dressing
   a. Function/ description
   b. Indications
   c. Contraindications
   d. Considerations
   e. Technique
      (1) Location
      (2) Application/ implementation

3. Absorbent gauze sponges
   a. Function/ description
   b. Indications
   c. Contraindications
   d. Considerations
   e. Technique
      (1) Location
      (2) Application/ implementation

4. Gauze wrappings
   a. Function/ description
   b. Indications
   c. Contraindications
   d. Considerations
   e. Technique
      (1) Location
      (2) Application/ implementation

5. Taping
   a. Function/ description
   b. Indications
   c. Contraindications
   d. Considerations
   e. Technique
      (1) Location
      (2) Application/ implementation
V. Management of specific soft tissue injuries not requiring closure

A. Dressing and bandaging specific soft tissue injuries
   1. General principles
      a. Dressing application
      b. Antibacterial ointment
      c. Immobilization
      d. Bandaging
   2. Injury location
      a. Scalp dressings
      b. Facial dressings
      c. Ear or mastoid dressings
      d. Neck dressings
      e. Shoulder dressings
      f. Truncal dressings
      g. Groin, hip, and upper dressings
      h. Hand and finger dressings
      i. Elbow and knee dressings
      j. Ankle, knee, and foot dressings
   3. Open wounds that should be dressed, bandaged and then transported for further evaluation
      a. Wound with neural compromise
      b. Wound with vascular compromise
      c. Wound with muscular compromise
      d. Wound with tendon/ligament compromise
      e. Wound with heavy contamination
      f. Wound with cosmetic complications
      g. Wound with foreign body complication
   4. Any other soft tissue trauma can be dressed and bandaged
      a. Consider transport versus patient discharge on-scene

B. Evaluation
   1. Overview
      a. Treat and release
      b. Treat and refer
      c. Treat and transport
   2. Tetanus vaccine
      a. Overview
      b. Tetanus vaccine preparation
      c. Immunization recommendations
      d. Allergic/hypersensitive reactions
   3. Patient instructions
      a. Verbal
      (1) Overview of written
(2) Patient counseling
b. Written
(1) Protection and care of wound area
(2) Dressing change and follow-up
(3) Wound cleansing recommendations
(4) Signs of wound infection

C. Potential and seriousness of wound infection
1. Description
   a. Common complication
   b. Serious complication
   c. Goal
      (1) Prevent from infection
      (2) Protect from infection
2. Mechanism
   a. Interruption in stratum corneum
   b. Non sterile external environment
   c. Integumentary microflora
3. Risk factors
   a. Wound characteristics
   b. Wound mechanism
   c. Technical elements
   d. General patient condition
4. Complication of wound infection
   a. General patient recovery
   b. Localized
   c. Systemic
   d. Ancillary conditions

D. Wound infection causal factors
1. Time
   a. Cleansing
   b. Repair
2. Mechanism
3. Location
4. Severity
   a. Complications
   b. Tissue damage
5. Contamination
6. Preparation
7. Cleansing
8. Technique of repair
9. General patient condition
VI. Special considerations regarding soft tissue injuries

A. Treatment priorities for patients with soft tissue injuries in conjunction with other life-threatening injuries
   1. Assess for and treat any existing critical injuries to
      a. Airway
         (1) Obstructed airway
         (2) Concurrent immobilization of spine
      b. Breathing
         (1) Inadequate breathing
      c. Circulation
         (1) Hypoperfusion
         (2) Hemorrhage
   2. Life-threatening injuries are managed prior to isolated soft tissue trauma
   3. Institute appropriate emergency medical care for life-threatening injuries
      a. Life-threatening airway trauma
      b. Life-threatening head trauma
      c. Life-threatening thoracic trauma
      d. Life-threatening abdominal trauma

B. Emergency medical care of patients with penetrating impalations, chest, and abdominal injuries
   1. Penetrating chest injury
   2. Open wound to the abdomen
   3. Impaled object
      a. Assessment
         (1) Location
         (2) Complications
      b. Treatment
         (1) Stabilization

C. Treatment priorities for patients with amputations and avulsion
   1. Avulsion
      a. Assessment
      b. Emergency care of avulsion
         (1) Airway, ventilation, and circulation
         (2) Stabilize affected area
         (3) Dress and bandage wound appropriately
         (4) Package avulsed area, if complete avulsion, for transport
         (5) Immediate and safe transport to appropriate facility
   2. Amputations
      a. Assessment
      b. Emergency care of amputations
         (1) Airway, ventilation, and circulation
         (2) Stabilize injured area
3. Crush injuries
   a. Treatment should be started before the patient arrives in the ED
   b. Goals
      1. Prevent sudden death
      2. Prevent renal failure
      3. Salvage limbs
      4. Institute as early as possible (in the field before the patient is extricated)
      5. ABCs as always
   c. Fluid therapy for hypovolemia
      1. Consider bolus of 1-1.5 liters
      2. Up to 12 liters may be needed in the first 24 hours
   d. Alkalization of the urine
      1. Consider adding sodium bicarbonate to IV fluid at one amp per liter to start
      2. The goal is to maintain urine Ph > 6.5
      3. Controls hyperkalemia and acidosis to prevent acute myoglobinuria renal failure (changes the structure of myoglobin so it passes through the renal tubules)
      4. If done in the emergency department, irrelevant to out-of-hospital
   e. Maintain urine output
      1. Goal of diuresis of at least 300 cc per hour
      2. Consider Mannitol (10 g or 20% solution to each liter of IV fluid)
      3. Loop diuretics such as Lasix are not recommended as they may acidify the urine
      4. The “ideal fluid” for crush injury is D5 1/2 normal saline with one amp sodium bicarbonate and 10 g or 20% solution of mannitol
      5. Treats hypovolemia
      6. Corrects acidosis
      7. Treats hyperkalemia, thus preventing sudden cardiac dysrhythmias
      8. Prevents renal failure
   f. Further treatment of hyperkalemia
      1. Forced alkaline diuresis may be adequate
(2) CaCl is not indicated unless there is a danger of hyperkalemia dysrhythmia

(3) Consider insulin/glucose for severe hyperkalemia (25cc D50W followed by 10 units regular insulin IV)

g. Other considerations for management - physician may come to the scene prior to extrication

1. Amiloride
   a. K+ sparing diuretic
   b. Inhibits Na-Ca exchange - protection against “Ca++ paradox”
   c. Administer before reperfusion - before crushed limb is extricated
      i. Free radical scavengers

2. Catalase (H2O2 ----> H2O and O2)

3. Mannitol - scavenges hydroxyl free radicals

4. Allopurinol (xanthine oxidase inhibitor)
   a. May prevent reperfusion induced injury in ischemic skeletal muscle and organs such as the kidneys
   b. Would have to administer before extrication or as soon as possible afterwards

5. Hospital use of hemodialysis
   a. Role in patient who ultimately develops renal failure
   b. Can prevent permanent renal damage in patient who is not septic
   c. Prevention is the key - delays in IV fluid therapy leads to acute renal failure

4. Local injury treatment is controversial

5. Closed crush injury
   a. Use of a tourniquet prior to release of crushed limb may be beneficial
   b. Compartment syndrome
      1. If intracompartmental pressure > 40mm Hg or > diastolic pressure - 30 mm Hg, fasciotomy is recommended by many if accompanied by clinical signs and symptoms
      2. Concern of increasing tissue necrosis requiring disfiguring debridement and increased risk of sepsis in those injuries older than 8 hours old
      3. Early fasciotomy can preserve limb, avoid Volkmann’s contracture and preserve cutaneous sensation
      4. Medical direction may consider a field fasciotomy

6. Open crush injuries
a. Wound care required - thorough cleansing, debridement, prophylactic antibiotics, administration of tetanus prophylaxis
b. ED surgical consultation

7. Amputation
   a. Field - increased risk of infection/sepsis, but may be necessary for extrication
   b. In-hospital - for severely injured limb

8. Hyperbaric oxygen treatment
   a. Shown to decrease tissue necrosis
   b. Can inhibit lipid peroxidation form oxygen free radicals (via increased levels of superoxide dismutase)
   c. Decreases muscle edema
   d. Most useful if done early

D. Documentation/record keeping for patients with soft tissue trauma
   1. Document patency of airway, ventilation, and circulation and any interventions administered
   2. Document patient assessment thoroughly
   3. Document general description of wound as to size, location, depth, associated complications
      a. Neurovascular status
      b. Joint injury
      c. Infection
   4. Document past medical history, medications, and allergies to medications
   5. Document all treatment/interventions rendered
   6. Document patient's response(s) to treatment rendered
   7. Document patient's understanding of procedure
UNIT TERMINAL OBJECTIVE
4-4 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement the management plan for the patient with a burn injury.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-4.1 Describe the anatomy and physiology pertinent to burn injuries. (C-1)
4-4.2 Describe the epidemiology, including incidence, mortality/ morbidity, risk factors, and prevention strategies for the patient with a burn injury. (C-1)
4-4.3 Describe the pathophysiological complications and systemic complications of a burn injury. (C-1)
4-4.4 Identify and describe types of burn injuries, including a thermal burn, an inhalation burn, a chemical burn, an electrical burn, and a radiation exposure. (C-1)
4-4.5 Identify and describe the depth classifications of burn injuries, including a superficial burn, a partial-thickness burn, a full-thickness burn, and other depth classifications described by local protocol. (C-1)
4-4.6 Identify and describe methods for determining body surface area percentage of a burn injury including the "rules of nines," the "rules of palms," and other methods described by local protocol. (C-1)
4-4.7 Identify and describe the severity of a burn including a minor burn, a moderate burn, a severe burn, and other severity classifications described by local protocol. (C-1)
4-4.8 Differentiate criteria for determining the severity of a burn injury between a pediatric patient and an adult patient. (C-3)
4-4.9 Describe special considerations for a pediatric patient with a burn injury. (C-1)
4-4.10 Discuss considerations which impact management and prognosis of the burn injured patient. (C-1)
4-4.11 Discuss mechanisms of burn injuries. (C-1)
4-4.12 Discuss conditions associated with burn injuries, including trauma, blast injuries, airway compromise, respiratory compromise, and child abuse. (C-1)
4-4.13 Describe the management of a burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (C-1)
4-4.14 Describe the epidemiology of a thermal burn injury. (C-1)
4-4.15 Describe the specific anatomy and physiology pertinent to a thermal burn injury. (C-1)
4-4.16 Describe the pathophysiology of a thermal burn injury. (C-1)
4-4.17 Identify and describe the depth classifications of a thermal burn injury. (C-1)
4-4.18 Identify and describe the severity of a thermal burn injury. (C-1)
4-4.19 Describe considerations which impact management and prognosis of the patient with a thermal burn injury. (C-1)
4-4.20 Discuss mechanisms of burn injury and conditions associated with a thermal burn injury. (C-1)
4-4.21 Describe the management of a thermal burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/ communication strategies. (C-1)
4-4.22 Describe the epidemiology of an inhalation burn injury. (C-1)
4-4.23 Describe the specific anatomy and physiology pertinent to an inhalation burn injury. (C-1)
4-4.24 Describe the pathophysiology of an inhalation burn injury. (C-1)
4-4.25 Differentiate between supraglottic and infraglottic inhalation injuries. (C-3)
4-4.26 Identify and describe the depth classifications of an inhalation burn injury. (C-1)
4-4.27 Identify and describe the severity of an inhalation burn injury. (C-1)
4-4.28 Describe considerations which impact management and prognosis of the patient with an inhalation burn injury. (C-1)
4-4.29 Discuss mechanisms of burn injury and conditions associated with an inhalation burn injury. (C-1)
4-4.30 Describe the management of an inhalation burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/communication strategies. (C-1)
4-4.31 Describe the epidemiology of a chemical burn injury and a chemical burn injury to the eye. (C-1)
4-4.32 Describe the specific anatomy and physiology pertinent to a chemical burn injury and a chemical burn injury to the eye. (C-1)
4-4.33 Describe the pathophysiology of a chemical burn injury, including types of chemicals and their burning processes and a chemical burn injury to the eye. (C-1)
4-4.34 Identify and describe the depth classifications of a chemical burn injury. (C-1)
4-4.35 Identify and describe the severity of a chemical burn injury. (C-1)
4-4.36 Describe considerations which impact management and prognosis of the patient with a chemical burn injury and a chemical burn injury to the eye. (C-1)
4-4.37 Discuss mechanisms of burn injury and conditions associated with a chemical burn injury. (C-1)
4-4.38 Describe the management of a chemical burn injury and a chemical burn injury to the eye, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/communication strategies. (C-1)
4-4.39 Describe the epidemiology of an electrical burn injury. (C-1)
4-4.40 Describe the specific anatomy and physiology pertinent to an electrical burn injury. (C-1)
4-4.41 Describe the pathophysiology of an electrical burn injury. (C-1)
4-4.42 Identify and describe the depth classifications of an electrical burn injury. (C-1)
4-4.43 Identify and describe the severity of an electrical burn injury. (C-1)
4-4.44 Describe considerations which impact management and prognosis of the patient with an electrical burn injury. (C-1)
4-4.45 Discuss mechanisms of burn injury and conditions associated with an electrical burn injury. (C-1)
4-4.46 Describe the management of a chemical burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/communication strategies. (C-1)
4-4.47 Describe the epidemiology of a radiation exposure. (C-1)
4-4.48 Describe the specific anatomy and physiology pertinent to a radiation exposure. (C-1)
4-4.49 Describe the pathophysiology of a radiation exposure, including the types and characteristics of ionizing radiation. (C-1)
4-4.50 Identify and describe the depth classifications of a radiation exposure. (C-1)
4-4.51 Identify and describe the severity of a radiation exposure. (C-1)
4-4.52 Describe considerations which impact management and prognosis of the patient with a radiation exposure. (C-1)
4-4.53 Discuss mechanisms of burn injury associated with a radiation exposure. (C-1)
4-4.54 Discuss conditions associated with a radiation exposure. (C-1)
4-4.55 Describe the management of a radiation exposure, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/communication strategies. (C-1)
4-4.56 Integrate pathophysiological principles to the assessment of a patient with a thermal burn injury. (C-3)
4-4.57 Integrate pathophysiological principles to the assessment of a patient with an inhalation burn injury. (C-3)
4-4.58 Integrate pathophysiological principles to the assessment of a patient with a chemical burn injury. (C-3)
4-4.59 Integrate pathophysiological principles to the assessment of a patient with an electrical burn injury. (C-3)
4-4.60 Integrate pathophysiological principles to the assessment of a patient with a radiation exposure. (C-3)
4-4.61 Synthesize patient history information and assessment findings to form a field impression for the patient with a thermal burn injury. (C-3)
4-4.62 Synthesize patient history information and assessment findings to form a field impression for the patient with an inhalation burn injury. (C-3)
4-4.63 Synthesize patient history information and assessment findings to form a field impression for the patient with a chemical burn injury. (C-3)
4-4.64 Synthesize patient history information and assessment findings to form a field impression for the patient with an electrical burn injury. (C-3)
4-4.65 Synthesize patient history information and assessment findings to form a field impression for the patient with a radiation exposure. (C-3)
4-4.66 Develop, execute and evaluate a management plan based on the field impression for the patient with a thermal burn injury. (C-3)
4-4.67 Develop, execute and evaluate a management plan based on the field impression for the patient with an inhalation burn injury. (C-3)
4-4.68 Develop, execute and evaluate a management plan based on the field impression for the patient with a chemical burn injury. (C-3)
4-4.69 Develop, execute and evaluate a management plan based on the field impression for the patient with an electrical burn injury. (C-3)
4-4.70 Develop, execute and evaluate a management plan based on the field impression for the patient with a radiation exposure. (C-3)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-4.71 Value the changes of a patient's self-image associated with a burn injury. (A-2)
4-4.72 Value the impact of managing a burn injured patient. (A-2)
4-4.73 Advocate empathy for a burn injured patient. (A-2)
4-4.74 Assess safety at a burn injury incident. (A-3)
4-4.75 Characterize mortality and morbidity based on the pathophysiology and assessment findings of a patient with a burn injury. (A-3)
4-4.76 Value and defend the sense of urgency in burn injuries. (A-3)
4-4.77 Serve as a model for universal precautions and body substance isolation (BSI). (A-3)

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-4.78 Take body substance isolation procedures during assessment and management of patients with a burn injury. (P-2)
4-4.79 Perform assessment of a patient with a burn injury. (P-2)
4-4.80 Perform management of a thermal burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/communication strategies, and other management described by local protocol. (P-2)
4-4.81 Perform management of an inhalation burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/communication strategies, and other management described by local protocol. (P-2)
4-4.82 Perform management of a chemical burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/communication strategies, and other management described by local protocol. (P-2)
4-4.83 Perform management of an electrical burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/communication strategies, and other management described by local protocol. (P-2)
4-4.84 Perform management of a radiation exposure, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/communication strategies, and other management described by local protocol. (P-2)
DECLARATIVE

I. Introduction
   A. Epidemiology
      1. Incidence
         a. Supportive statistics
      2. Mortality/morbidity
         a. Supportive statistics
      3. Risk factors
      4. Prevention strategies
   B. Review the anatomy and physiology of the integumentary system

II. General system pathophysiology, assessment and management
   A. Pathophysiology
      1. Pathophysiologic and systemic complications of a burn injury
         a. Fluid loss
         b. Electrolyte loss
         c. Increased catecholamine release
         d. Acidosis
         e. Vasconstriction
         f. Renal failure
         g. Liver failure
         h. Heart failure
         i. Hypoxia
         j. Anoxia
         k. Arrhythmias
         l. Formation of eschar
         m. Hypothermia
         n. Hypovolemia
         o. Infection
         p. Complications of a circumferential burn
   B. Assessment findings
      1. Types of burn injuries
         a. Thermal burn
         b. Inhalation burn
         c. Chemical burn
         d. Electrical burn
            (1) Lightning
            e. Radiation exposure
      2. Depth classification of a burn injury
         a. Superficial burn
         b. Partial-thickness burn
         c. Full-thickness burn
         d. Other depth classifications according to local protocol
      3. Methods for determining body surface area percentage of a burn injury
         a. The "rule of nines"
            (1) Adult
            (2) Pediatric
         b. The "rule of palms"
4. Severity of a burn
   a. Minor burn
   b. Moderate burn
   c. Severe burn
   d. Other severity classifications according to local protocol

5. Criteria for determining severity of a burn injury
   a. The adult patient
   b. The pediatric patient
      (1) Special considerations

6. Considerations which impact management and prognosis of the burn injured patient
   a. Age
   b. Preexisting medical conditions
   c. Trauma

7. Mechanisms of burn injuries
   a. Burn trauma
   b. Blast/ explosion trauma
   c. Fall injury
   d. Other injuries

8. Conditions associated with burn injuries
   a. Trauma
      (1) Soft tissue injuries
      (2) Musculoskeletal injuries
   b. Blast injuries
   c. Airway compromise
   d. Respiratory compromise
   e. Child abuse

9. Signs and symptoms of burn injuries
   a. Pain
   b. Changes in skin condition relative to the affected burn site
   c. Adventitious sounds
   d. Sloughing of the affected skin
   e. Hoarseness
   f. Dysphagia
   g. Dysphasia
   h. Burnt hair
   i. Nausea/ vomiting
   j. Unconsciousness
   k. Altered level of consciousness
   l. Edema
   m. Paresthesia
   n. Hemorrhage
   o. Other soft tissue injuries
   p. Musculoskeletal injuries
   q. Dyspnea
   r. Chest pain

C. Management
   1. Airway, oxygenation, and ventilation
   2. Circulatory management
3. Pharmacological support
   a. Analgesia
4. Non-pharmacological management
5. Transport considerations
   a. Appropriate mode
   b. Appropriate facility
6. Psychological support/communication strategies
   a. Patient and family advocacy

III. Specific burn injuries
   A. Thermal burn injury
      1. Epidemiology of a thermal burn injury
         a. Incidence
            (1) Supportive statistics
         b. Mortality/morbidity
            (1) Supportive statistics
         c. Risk factors
         d. Prevention strategies
      2. Review the specific anatomy and physiology pertinent to the integumentary system
      3. Review of heat energy and the components of the burning agent
      4. Pathophysiology of a thermal burn injury
         a. The process of burn shock
            (1) Emergent phase
            (2) Fluid shift phase
            (3) Hypermetabolic phase
            (4) Resolution phase
         b. Jackson’s thermal wound theory
            (1) Zone of coagulation
            (2) Zone of stasis
            (3) Zone of hyperemia
         c. Inhalation injury (present in 60-70% of all burn patients who die)
            (1) Carbon monoxide poisoning
            (2) Cyanide intoxication
         d. Infectious insult
         e. Eschar formation
            (1) Respiratory compromise secondary to circumferential eschar around the thorax
            (2) Circulatory compromise secondary to circumferential eschar around an extremity
            (3) Escharotomies
      5. Assessment findings in a thermal burn injury
         a. Depth classifications of a thermal burn
         b. Severity of a thermal burn
         c. Criteria for determining severity of a burn injury
            (1) The adult patient
            (2) The pediatric patient
         d. Considerations which impact care and prognosis of the thermal burn injured patient
         e. Mechanisms of burn injury
(1) Scalding  
(2) Steam  
(3) Flame  
(4) Flash  
(5) Retained heat  
(6) Other trauma  

6 Conditions associated with thermal burn injuries  
6.0 Management of a thermal burn injury  
6.0.0 Remove patient to safe area  
6.0.1 Stop the burning process  
6.0.2 Airway, oxygenation, and ventilation  
6.0.3 Circulatory management  
6.0.4 Pharmacological management  
6.0.4.0 Topical applications  
6.0.4.1 Tetanus and antibiotic therapy  
6.0.4.2 Fluid therapy  
6.0.5 Non-pharmacological management  
6.0.5.0 Thermal burn injury management according to local protocol  
6.0.6 Transport considerations  
6.0.6.0 Appropriate mode  
6.0.6.1 Appropriate facility  
6.0.6.2 Transport considerations in conjunction with burn injury management according to local protocol  

6.1 Psychological support/ communication strategies  

6 Inhalation burn injury  
6.0 Epidemiology of an inhalation burn injury  
6.0.0 Incidence  
6.0.0.0 Supportive statistics (e.g., 20-35% of the patients admitted to burn centers have an inhalation injury)  
6.0.0.1 Chemical inhalation injuries are more frequent than thermal inhalation injuries  
6.0.1 Mortality/ morbidity  
6.0.1.0 Supportive statistics  
6.0.2 Risk factors  
6.0.2.0 Often associated with a burn environment  
6.0.2.1 Factors that increase the risk for inhalation injury  
6.0.2.1.0 Standing  
6.0.2.1.1 Screaming  
6.0.2.1.2 Enclosed area  
6.0.3 Prevention strategies  

2 Review the specific anatomy and physiology pertinent to the respiratory system  

3 Pathophysiology of an inhalation injury  
3.0 Compromises the upper airway (supraglottic)  
3.0.1 Compromises the lower airway (infra glottic)  
3.0.2 Complications may occur later  

4 Assessment findings in an inhalation injury  
4.0 Mechanism of injury/ conditions associated with an inhalation burn injury  
4.0.0 Toxic inhalations  
4.0.1 Smoke inhalation
(3) Carbon monoxide poisoning
(4) Thiocyanate intoxication
(5) Thermal burn
(6) Chemical burn

b0 Criteria for determining severity of a burn injury
  (1) The adult patient
  (2) The pediatric patient

c0 Considerations which impact care and prognosis of an inhalation burn injured patient

d0 Conditions associated with inhalation burn trauma

e0 Focused history

5 Management of an inhalation burn injury
a0 Airway, oxygenation, and ventilation
b0 Circulatory management
c0 Pharmacological management
  (1) Sodium thiosulfate therapy
d0 Non-pharmacological management
  (1) Thermal burn injury management according to local protocol
  (2) Hyperbaric therapy - for carbon monoxide
e0 Transport considerations
  (1) Appropriate mode
  (2) Appropriate facility

f0 Psychological support/ communication strategies

C0 Chemical burn injury

1 Epidemiology of a chemical burn injury
a0 Incidence
  (1) Supportive statistics
b0 Mortality/ morbidity
  (1) Supportive statistics
c0 Risk factors
d0 Prevention strategies

2 Anatomy and physiology review

3 Pathophysiology

a0 Types of chemicals which cause chemical burn injuries
  (1) Acids
  (2) Bases (alkali)
    (a) Cement
  (3) Dry chemicals
  (4) Phenols

b0 Characteristics of the burning process of chemicals
  (1) The burning process of an acid
  (2) The burning process of an alkali
  (3) The burning process of dry chemicals

4 Assessment of a chemical burn injury
a0 Mechanism of injury/ conditions for a chemical burn injury
  (1) Industrial accidents most frequent
b0 Depth classification
c0 Severity
d0 Criteria for determining severity of a burn injury
(1) The adult patient
(2) The pediatric patient

e0 Considerations which impact care and prognosis of a chemical burn injured patient

5 Management of a chemical burn injury
a0 Airway, oxygen, and ventilation
b0 Circulatory management
c0 Pharmacological management
d0 Non-pharmacological management
   (1) Acid burn injury management according to local protocol
   (2) Alkali burn injury management according to local protocol
   (3) Chemical burn injury to the eye according to local protocol
   (4) Dry chemical burn injury according to local protocol

e0 Transport considerations
   (1) Appropriate mode
   (2) Appropriate facility

f0 Psychological support/ communication strategies

D0 Chemical burn injury of the eye
1 Epidemiology of a chemical burn injury
   a0 Incidence
      (1) Supportive statistics
   b0 Mortality/ morbidity
      (1) Supportive statistics
   c0 Risk factors
d0 Prevention strategies

2 Anatomy and physiology review of the eye

3 Pathophysiology
   a0 Types of chemicals which cause chemical burn injuries to the eye
      (1) Acids
      (2) Bases (alkali)
         (a) Cement
      (3) Dry chemicals
      (4) Phenols
      (5) Mace/ pepper spray

4 Assessment of a chemical burn injury
   a0 Mechanism of injury/ conditions for a chemical burn injury
      (1) Industrial accidents most frequent
   b0 Severity
c0 Criteria for determining severity of a eye injury
d0 Considerations which impact care and prognosis of a chemical injury to the eye

5 Management of a chemical burn injury of the eye
   a0 Airway, oxygenation, and ventilation
   b0 Circulation management
c0 Pharmacological management
d0 Non-pharmacological management
e0 Transport considerations
   (1) Appropriate mode
   (2) Appropriate facility

f0 Psychological support/ communication strategies
E0 Electrical burn injuries
1 Epidemiology of an electrical burn injury
   a0 Incidence
      (1) Supportive statistics
   b0 Mortality/ morbidity
      (1) Supportive statistics
   c0 Risk factors
   d0 Prevention strategies
2 Anatomy and physiology review
3 Review of the characteristics of electrical current
4 Pathophysiology
   a0 External burn injuries
   b0 Internal burn injuries
   c0 Musculoskeletal injuries
   d0 Cardiovascular injuries
   e0 Respiratory injuries
   f0 Neurological injuries
   g0 Myoglobin release and renal involvement
5 Assessment of an electrical burn injury
   a0 Mechanism of injury/ conditions for an electrical burn injury
      (1) Contact burn injuries
      (2) Arc injuries
      (3) Flame or flash burn injuries
         (a) Welder’s flash
      (4) Lightning injuries
         (a) Direct stroke
         (b) Side flash (splash)
         (c) Step voltage
   b0 Depth classification
   c0 Severity
   d0 Criteria for determining severity of an electrical burn injury
      (1) The adult patient
      (2) The pediatric patient
   e0 Considerations which impact care and prognosis of an electrical burn injured patient
6 Management of an electrical burn injury
   a0 Airway, oxygenation, and ventilation
   b0 Circulation management
   c0 Pharmacological management
   d0 Non-pharmacological management
      (1) Thermal burn injury management according to local protocol
   e0 Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   f0 Psychological support/ communication strategies
F0 Radiation exposure
1 Epidemiology of a radiation exposure
   a0 Incidence
      (1) Supportive statistics
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IV Integration
UNIT TERMINAL OBJECTIVE
4-5 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for the trauma patient with a suspected head injury.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-5.1 Describe the incidence, morbidity, and mortality of facial injuries. (C-1)
4-5.2 Explain facial anatomy and relate physiology to facial injuries. (C-1)
4-5.3 Predict facial injuries based on mechanism of injury. (C-1)
4-5.4 Predict other injuries commonly associated with facial injuries based on mechanism of injury. (C-2)
4-5.5 Differentiate between the following types of facial injuries, highlighting the defining characteristics of each: (C-3)
   a. Eye
   Ear
   Nose
   Throat
   Mouth
4-5.6 Integrate pathophysiological principles to the assessment of a patient with a facial injury. (C-3)
4-5.7 Differentiate between facial injuries based on the assessment and history. (C-3)
4-5.8 Formulate a field impression for a patient with a facial injury based on the assessment findings. (C-3)
4-5.9 Develop a patient management plan for a patient with a facial injury based on the field impression. (C-3)
4-5.10 Explain the pathophysiology of eye injuries. (C-1)
4-5.11 Relate assessment findings associated with eye injuries to pathophysiology. (C-3)
4-5.12 Integrate pathophysiological principles to the assessment of a patient with an eye injury. (C-3)
4-5.13 Formulate a field impression for a patient with an eye injury based on the assessment findings. (C-3)
4-5.14 Develop a patient management plan for a patient with an eye injury based on the field impression. (C-3)
4-5.15 Explain the pathophysiology of ear injuries. (C-1)
4-5.16 Relate assessment findings associated with ear injuries to pathophysiology. (C-3)
4-5.17 Integrate pathophysiological principles to the assessment of a patient with an ear injury. (C-3)
4-5.18 Formulate a field impression for a patient with an ear injury based on the assessment findings. (C-3)
4-5.19 Develop a patient management plan for a patient with an ear injury based on the field impression. (C-3)
4-5.20 Explain the pathophysiology of nose injuries. (C-1)
4-5.21 Relate assessment findings associated with nose injuries to pathophysiology. (C-3)
4-5.22 Integrate pathophysiological principles to the assessment of a patient with a nose injury. (C-3)
4-5.23 Formulate a field impression for a patient with a nose injury based on the assessment findings. (C-3)
4-5.24 Develop a patient management plan for a patient with a nose injury based on the field impression. (C-3)
4-5.25 Explain the pathophysiology of throat injuries. (C-1)
4-5.26 Relate assessment findings associated with throat injuries to pathophysiology. (C-3)
4-5.27 Integrate pathophysiological principles to the assessment of a patient with a throat injury. (C-3)
4-5.28 Formulate a field impression for a patient with a throat injury based on the assessment findings. (C-3)
4-5.29 Develop a patient management plan for a patient with a throat injury based on the field impression. (C-3)
4-5.30 Explain the pathophysiology of mouth injuries. (C-1)
4-5.31 Relate assessment findings associated with mouth injuries to pathophysiology. (C-3)
4-5.32 Integrate pathophysiological principles to the assessment of a patient with a mouth injury. (C-3)
4-5.33 Formulate a field impression for a patient with a mouth injury based on the assessment findings. (C-3)
4-5.34 Develop a patient management plan for a patient with a mouth injury based on the field impression. (C-3)
4-5.35 Describe the incidence, morbidity, and mortality of head injuries. (C-1)
4-5.36 Explain anatomy and relate physiology of the CNS to head injuries. (C-1)
4-5.37 Predict head injuries based on mechanism of injury. (C-2)
4-5.38 Distinguish between head injury and brain injury. (C-3)
4-5.39 Explain the pathophysiology of head/brain injuries. (C-1)
4-5.40 Explain the concept of increasing intracranial pressure (ICP). (C-1)
4-5.41 Explain the effect of increased and decreased carbon dioxide on ICP. (C-1)
4-5.42 Define and explain the process involved with each of the levels of increasing ICP. (C-1)
4-5.43 Relate assessment findings associated with head/brain injuries to the pathophysiological process. (C-3)
4-5.44 Classify head injuries (mild, moderate, severe) according to assessment findings. (C-2)
4-5.45 Identify the need for rapid intervention and transport of the patient with a head/brain injury. (C-1)
4-5.46 Describe and explain the general management of the head/brain injury patient, including pharmacological and non-pharmacological treatment. (C-1)
4-5.47 Analyze the relationship between carbon dioxide concentration in the blood and management of the airway in the head/brain injured patient. (C-3)
4-5.48 Explain the pathophysiology of diffuse axonal injury. (C-1)
4-5.49 Relate assessment findings associated with concussion, moderate and severe diffuse axonal injury to pathophysiology. (C-3)
4-5.50 Develop a management plan for a patient with a moderate and severe diffuse axonal injury. (C-3)
4-5.51 Explain the pathophysiology of skull fracture. (C-1)
4-5.52 Relate assessment findings associated with skull fracture to pathophysiology. (C-3)
4-5.53 Develop a management plan for a patient with a skull fracture. (C-3)
4-5.54 Explain the pathophysiology of cerebral contusion. (C-1)
4-5.55 Relate assessment findings associated with cerebral contusion to pathophysiology. (C-3)
4-5.56 Develop a management plan for a patient with a cerebral contusion. (C-3)
4-5.57 Explain the pathophysiology of intracranial hemorrhage, including: (C-1)
   a. Epidural
   b. Subdural
   c. Intracerebral
   d. Subarachnoid
4-5.58 Relate assessment findings associated with intracranial hemorrhage to pathophysiology, including: (C-3)
   a. Epidural
   b. Subdural
   c. Intracerebral
   d. Subarachnoid
4-5.59 Develop a management plan for a patient with an intracranial hemorrhage, including: (C-1)
   a. Epidural
   11. Subdural
   12. Intracerebral
   13. Subarachnoid
4-5.60 Describe the various types of helmets and their purposes. (C-1)
4-5.61 Relate priorities of care to factors determining the need for helmet removal in various field situations including sports related incidents. (C-3)
4-5.62 Develop a management plan for the removal of a helmet for a head injured patient. (C-3)
4-5.63 Integrate the pathophysiological principles to the assessment of a patient with head/brain injury. (C-3)
4-5.64 Differentiate between the types of head/brain injuries based on the assessment and history. (C-3)
4-5.65 Formulate a field impression for a patient with a head/brain injury based on the assessment findings. (C-3)
4-5.66 Develop a patient management plan for a patient with a head/brain injury based on the field impression. (C-3)
AFFECTIVE OBJECTIVES
None identified for this unit.

PSYCHOMOTOR OBJECTIVES
None identified for this unit.
DEclarative

I. Facial Injury
   A. Introduction
      1. Incidence
      2. Morbidity and mortality
      3. Risk
   B. Review of anatomy/physiology of the face
      1. Arteries and nerves
      2. External carotid
         a. Temporal artery
         b. Mandibular artery
         c. Maxillary artery
      3. Nerves
         a. 5th cranial nerve - trigeminal
         b. 7th cranial nerve - facial
      4. Bones
         a. Nasal
         b. Zygoma/zygomatic arch
         c. Maxilla
         d. Mandible
   C. Common mechanisms of injury
      1. Blunt
         a. Motor vehicular crashes
         b. Falls
         c. Body-to-body contact
         d. Augmented force (i.e. sticks, clubs, etc.)
      2. Penetrating
         a. Gun shot wound, stabbing
         b. Bites - dog, human, biting tongue
   D. Other common associated injuries
      1. Airway compromise
      2. Cervical spine injury
      3. Brain injury
      4. Dental trauma or avulsion
   E. Types of facial injuries
      1. Bony injury
         a. Mandible
            (1) Fracture
            (2) Dislocation
         b. Maxillary fracture
            (1) LeFort I, II and III

United States Department of Transportation
National Highway Traffic Safety Administration
Paramedic: National Standard Curriculum
c. Zygomatic fracture
d. Orbital fracture
   (1) Eye
   (2) Ear
   (3) Nose
   (4) Throat
   (5) Mouth
e. Nasal fracture

2. Soft tissue
   a. Face
   b. Mouth and oropharynx and tongue
   c. Ear
   d. Eye

F. Assessment
   1. Airway patency and adequate ventilation
   2. Cervical spine integrity
   3. Adequate perfusion
   4. Associated injury
      a. Head injury
        (1) Increased ICP
        (2) Presence of CSF
      b. Bony injury
        (1) Malocclusion
        (2) Depressed zygoma
        (3) Facial asymmetry
        (4) Diplopia/ blurred vision
      c. Soft tissue injury
        (1) Open wounds
        (2) Hematomas
      d. Broken or missing teeth

G. History
   1. Mechanism of injury
   2. Events leading up to the injury
   3. Time it occurred
   4. Associated medical problems
   5. Allergies
   6. Medications
   7. Last intake

H. Management
   1. Airway patency and adequate ventilations a priority
      a. Suctioning
      b. Intubating
c. Positioning
d. Ventilating

2. Assuring adequate circulation
3. Assuring cervical spine integrity

II. Throat injuries
A. Introduction
1. Incidence
2. Morbidity and mortality
3. Risk
B. Review of anatomy/physiology of the throat
   1. Critical structures
      a. Airway
         (1) Oropharynx
         (2) Larynx
         (3) Trachea
      b. Cervical spine
         (1) Cord
         (2) Vertebra
      c. Major vessels
         (1) Internal and external jugular veins
         (2) Carotid arteries
         (3) Vertebral arteries
   2. Associated structures
      a. Vagus nerves
      b. Thoracic duct
      c. Pharynx and esophagus
      d. Thyroid gland and parathyroid glands
      e. Lower cranial nerves
      f. Brachial plexus - responsible for lower arm and hand function
      g. Muscles - platysma is major muscle
      h. Soft tissue and fascia
C. Mechanism of injury
   1. Blunt - motor vehicle crashes, blow to the neck, hanging
   2. Penetrating - gun shot wound, stabbing, arrow
      a. Lacerations or puncture
D. Pathophysiology
   1. Transected trachea
      a. Larynx separated from trachea or fractured
         (1) Vocal cord swelling or contusion
         (2) Disruption of normal airway landmarks
         (3) Associated soft tissue swelling
b. Open wound to trachea

2. Vessel lacerated or torn
   a. Arterial interruption
      (1) Hypoxia to brain tissue and infarct
      (2) Open wound may cause an air embolism
   b. Rapid exsanguination

3. Cervical spine trauma
   a. Vertebal instability
   b. Cord interruption
      (1) Paralysis or paresthesia
      (2) Neurogenic shock

4. Impaled object
   a. Do not remove unless obstructing airway
   b. Consider emergency cricothyrotomy

E. Assessment
   1. Signs - pale or cyanotic face, bruising of neck, redness of area, hematoma in neck, with open wound will see frothy blood or sputum in wound; subcutaneous air may be present
   2. Symptoms - voice changes, tickle or feeling of fullness in throat, pain on palpation
   3. Signs of stroke with air emboli or infarct
   4. Signs of paralysis, paresthesia or neurogenic shock if spinal cord involved
   5. Assess for other injury

F. Management
   1. Airway patency and adequate ventilation a priority
      a. If open wound to trachea
         (1) ET tube can be inserted to maintain patency
      b. If closed wound
         (1) BVM with oxygen supplement
         (2) Consider intubation - soft tissue swelling may be extreme, aim for bubbles
         (3) Consider emergency cricothyrotomy
   2. Maintenance of adequate tissue perfusion
      a. If open wound to neck, lay patient on left side in Trendelenburg with occlusive dressing over neck wound
      b. Direct pressure to bleeding site, avoid circumferential dressings, monitor pulse for reflex barding
   3. Maintain cervical immobilization, avoid cervical collars or other devices that obstruct your view of the neck
   4. Stabilize impaled object if not obstructing airway

III. Nasal injuries
A. Review of anatomy and physiology
   1. Nasal bone - between the eyes
   2. Nasal cartilage - defines shape of nose
   3. Internal structures - septum, turbinates and sinuses

B. Mechanism of injury
   1. Blunt - motor vehicle crashes, body-to-body contact, falls
   2. Penetrating - gun shot wounds, stabbing
   3. Foreign bodies - beans, crayons, anything a child can pick up

C. Pathophysiology
   1. Epistaxis - nose bleeds (may compromise airway)
      a. Anterior bleeds - from septum, venous bleeding
      b. Posterior bleeds - often drains down back of throat
      c. Associated injury
         (1) Sphenoid and/ or ethmoid bone fractures
         (2) Basilar skull fracture
   2. Foreign bodies
      a. Common in young children
      b. Leave alone and transport
      c. Attempt to remove only if airway is compromised

D. Assessment
   1. Airway patency
   2. Cervical spine precautions
   3. CSF drainage
   4. Associated injuries

E. Management
   1. Direct pressure
   2. If bleeding severe, treatment similar to hemorrhagic shock
      a. Sit upright, leaning forward or lying on side so blood is not swallowed
   3. If CSF detected do not apply direct pressure, let drain freely
   4. Elevate head of bed in reverse Trendelenburg

IV. Ear injuries
A. Review of anatomy and physiology
   1. Outer ear - Pinna
      a. Cartilage
      b. Poor blood supply
   2. External ear canal
      a. Considered a mucous membrane but secretes wax for protection
   3. Middle ear
      a. Separated from external canal by ear drum
      b. Delicate structures necessary for hearing
B. Mechanism of injury
1. Blunt - motor vehicle crashes, body-to-body contact, augmented force
2. Penetrating - gun shot wound, cutting, foreign body, puncture wound
3. Blast injuries-explorations
4. Pressure injuries-diving

C. Pathophysiology
1. Ruptured ear drum
2. Basilar skull fracture
3. Separation of ear cartilage

D. Assessment
1. Adequate assessment of external ear canal and middle ear cannot be done in the field
2. Airway patency and adequate ventilation a priority
3. Maintaining adequate tissue perfusion
4. Additional injuries
   a0 If mechanism warrants, cervical spine precautions

E0 Management
1 Considerations
   a0 Difficult for cartilage to heal
   b0 Infection is prime influence for failure to heal
2 Realign ear into position and gently bandage with sufficient padding
3 Cover draining ear with loose dressing

V Eye injuries
A0 Review of anatomy and physiology
1 External parts
   a0 Bony orbit
   b0 Eyelids
   c0 Lacrimal apparatus
2 Internal parts
   a0 Sclera
   b0 Cornea
   c0 Conjunctiva
   d0 Iris
   e0 Pupil
   f0 Lens
   g0 Retina
   h0 Optic nerve
   i0 Muscle control
      (1) Pairs
      (2) Characteristics
3 Types of vision
a0 Central vision
b0 Peripheral vision

B0 Mechanism of injury
1 Penetrating - bullets, knives, glass, arrows, foreign bodies
2 Blunt - balls, falls, vehicle crashes, motorcycles
3 Burns - welding, sun, chemicals

C0 Pathophysiology
1 Penetrating
   a0 Abrasions
   b0 Foreign bodies
      (1) Superficial
      (2) Deep
   c0 Lacerations
      (1) Superficial
      (2) Deep
2 Blunt
   a0 Swelling
   b0 Conjunctival hemorrhage
   c0 Hyphema
   d0 Ruptured globe
   e0 Blow-out fracture of orbital rim
   f0 Retinal detachment
3 Burns
   a0 Flash burns
   b0 Acid/ alkali
4 Other
   a0 Lacerated eyelid
   b0 Impaled object
   c0 Avulsion

D0 Assessment
1 History
   a0 When did the symptoms begin
   b0 Mechanism of injury
   c0 What did the patient first notice
   d0 Were both eyes effected?
   e0 Past history
      (1) Visual acuity - glasses, contacts
      (2) Diseases or conditions - glaucoma, etc.
   f0 Any medications
2 Physical assessment
   a0 Addressing priorities
      (1) Maintaining open airway and assuring adequate ventilation
(2) Controlling bleeding and supporting cardiovascular system
(3) Potential for central nervous system injury
b0 Orbital rim
c0 Lids
d0 Cornea
e0 Conjunctiva
f0 Eye movement
   (1) Dysconjugate gaze
   (2) Paralysis of gaze
g0 Pupils
h0 Visual acuity

Management
E0
1 Blunt trauma treatment
   a0 Positioning
   b0 Bandaging eye(s)
      (1) One versus both
      (2) No pressure
2 Penetrating trauma treatment
   a0 Positioning
   b0 Removal of foreign bodies versus not
   c0 Moist bandage versus dry
   d0 Stabilize impaled object
3 Avulsion treatment
4 Burn
   a0 Acid/ alkali
   b0 Flash burn
5 Lacerated eyelid treatment

Mouth injuries
VI
A0 Introduction
   1 Incidence
   2 Morbidity and mortality
   3 Risk
B0 Review of anatomy/ physiology of the mouth
   1 Muscles
      a0 Tongue
      b0 Orbicular oris - lips
      c0 Masseter muscles - cheeks
   2 Nerves
      a0 Hypoglossal
      b0 Glossopharyngeal
      c0 Trigeminal (mandibular branch)
d0 Facial

3 Bones
   a0 Hyoid
   b0 Palate
   c0 Mandible
   d0 Maxilla

4 Teeth

5 Salivary glands

6 Lymphoid tissue

C0 Mechanisms of injury
1 Blunt
   a0 Motor vehicle crash
   b0 Blows to the mouth or chin

2 Penetrating
   a0 Gun shot wounds
   b0 Lacerations or punctures

D0 Pathophysiology
1 Lacerated tongue
   a0 Airway compromise
      (1) Blood and tissue
      (2) Inability to communicate
   b0 Broken or avulsed tooth
      (1) Airway compromise
   c0 Impaled object
      (1) Airway compromise
   d0 Lacerated mucous membranes
      (1) Copious bleeding
      (2) Airway compromise

2 Assessment
   a0 Signs
      (1) Copious bleeding
      (2) Blood tinged mucous
   b0 Symptoms
      (1) Inability to talk unless leaning forward to allow for drainage

3 Management
   a0 Airway patency and adequate ventilation is the first priority
   b0 Impaled object
      (1) If patient is able to breathe - stabilize
      (2) Otherwise remove
   c0 Collect tissue
      (1) Tongue - manage as any other piece of tissue
      (2) Tooth - rinse with normal saline and transport with patient
### VII  Head trauma

#### A0  Introduction

1. Incidence - approximately 4 million people sustain head injuries in the U.S. each year.
2. Morbidity and mortality - approximately 450,000 require hospitalization
   - Most are minor injuries (GCS 13-15)
   - Major head injury (GCS <8) is the most common cause of death from trauma in trauma centers
   - Over 50% of all trauma deaths involve head injury

#### B0  Review of anatomy/physiology of head/brain

1. Scalp
   - Hair
   - Subcutaneous tissue - contains major scalp veins which bleed profusely
   - Muscle - attached just above the eyebrows and at the base of the occiput
   - Galea - freely moveable sheet of connective tissue, helps deflect blows
   - Loose connective tissue - contains emissary veins that drain intracranially (becomes important as a route for infection)

2. Skull - divided into two main groups of bones - face and cranium
   - Cranial bones
     - (1) Composed of double layer of solid bone which surrounds a spongy middle layer gives greater strength
     - (2) Frontal, occipital, temporal, parietal, and mastoid
   - Middle meningeal artery
     - (1) Lies under temporal bone, if fractured can tear artery
     - (2) Source of epidural hematoma
   - Skull floor - many ridges
   - Foramen magnum - opening at base of skull for spinal cord

3. Brain - occupies 80% of intracranial space
   - Divisions
     - (1) Cerebrum - each lobe named after skull plates that lie immediately above
       - (a) Cortex controls
i Voluntary skeletal movement - interference with will result in extremity paresthesia, weakness and/or paralysis

ii Level of awareness - part of consciousness

(b) Frontal lobe - personality, trauma here may result in placid reactions or seizures

(c) Parietal lobe - somatic sensory input, memory, emotions

(d) Temporal lobe - speech centers here, 85% of population has center on left, long term memory, taste and smell

(e) Occipital lobe - origin of optic nerve, trauma here may cause complaints of seeing "stars", blurred vision or other visual disturbances

(f) Hypothalamus - centers for vomiting, regulating body temperature and water

(2) Cerebellum - coordination of voluntary movement started by cerebral cortex

(3) Brain stem - connects the hemispheres of the brain, cerebellum and spinal cord responsible for vegetative functions and vital signs

(a) Parts - midbrain, pons and medulla oblongata

(b) Cranial nerves

   i CN III - oculomotor, origin from midbrain - controls pupil size - pressure on nerve paralyzes nerve, pupil unreactive

   ii CN X - vagal, origin from medulla - a bundle of nerves, primarily from parasympathetic system, that supply SA and AV node, stomach and GI tract - pressure on nerve stimulates bradycardia

   iii Reticular activating system - level of arousal and responsible for specific motor movements

b0 Level of consciousness

   (1) Reticular activating centers - level of arousal

   (2) Intact cortical function - level of awareness

(1) Dura mater - outer layer, tough and fibrous; literally two layers, inner layer serves to divide and separate various brain structures, forms the tentorium that surrounds the brain stem and separates the cerebellum below from the
cerebral structures above, used as a landmark to describe intracranial lesions or when swelling is involved

(2) Arachnoid - middle layer, web-like with venous blood vessels that reabsorb cerebrospinal fluid

(3) Pia mater - inner layer, directly attached to brain tissue, provides form

d0 Cerebral spinal fluid (CSF) - clear, colorless fluid, circulates through entire brain and spinal cord

(1) Function - cushion and protect

(2) Ventricles - in center of brain, secretes CSF by filtering blood, forms blood-brain barrier

e0 Metabolism and perfusion

(1) High metabolic rate

(2) Nutrients

(a) Consumes 20% of body's oxygen

(b) Glucose

(c) Thiamine

(d) Other nutrients

(e) Nutrients cannot be stored

(3) Blood supply

(a) Vertebral arteries

(b) Receives 15% cardiac output

(4) Perfusion

(a) Cerebral perfusion pressure (CPP)

(b) Mechanism called autoregulation regulates body's blood pressure to maintain CPP

(c) CPP = mean arterial pressure (MAP) - ICP

(d) MAP of at least 60 mmHg required to perfuse brain

(e) Interference with CPP - edema, bleeding, hypotension

C0 Mechanisms of injury

1 Motor vehicle crashes

(a0 Most common cause of head trauma

(b0 Most common cause of subdural hematoma

2 Sports

3 Falls

(a0 In elderly or in presence of alcohol abuse

(b0 Associated with chronic subdural hematomas

4 Penetrating trauma

(a0 Missiles (rifles, hand guns, shotguns) more common

(b0 Sharp projectiles (knives, ice picks, axes and screwdrivers) not as common
**D0 General categories of injury**

1. **Coup injuries**
   a. Directly below point of impact
   b. More common when front of head struck because of irregularity of inner surface of frontal bones; occipital area is smooth

2. **Contrecoup injuries**
   a. On the pole opposite the site of impact
   b. More common when back of head struck because of irregularity of inner surface of frontal bones

3. **Diffuse axonal injury (DAI)**
   a. Shearing, tearing, stretching force of nerve fibers with axonal damage
   b. More common with vehicular occupants and pedestrians struck by vehicle

4. **Focal injury**
   a. An identifiable site of injury limited to a particular area or region of the brain

**E0 Causes of brain injury**

1. **Direct or primary**
   a. Caused by the impact
   b. Mechanical disruption of cells
   c. Vascular permeability

2. **Indirect - secondary or tertiary**
   a. Secondary - caused by edema, hemorrhage, infection and pressure inadequate perfusion (ischemia) tissue hypoxia
   b. Tertiary - caused by apnea, hypotension, pulmonary resistance and change in ECG

**F0 Head injury - broad and inclusive**

1. **Defined - a traumatic insult to the head that may result in injury to soft tissue, bony structures and/ or brain injury**

2. **Categories - blunt (closed) trauma and open (penetrating trauma)**

3. **Blunt head trauma**
   a. More common
   b. Dura remains intact
   c. Brain tissue not exposed to the environment
   d. May result in fractures, focal brain injuries and/ or diffuse axonal injuries (DAI)

4. **Penetrating head trauma**
   a. Less common, gun shot wound most frequent cause
   b. Dura and cranial contents penetrated
   c. Brain tissue exposed to the environment
   d. Results in fractures and focal brain injury
G0  Brain injury
1  Defined (by National Head Injury Foundation) - "a traumatic insult to the brain capable of producing physical, intellectual, emotional, social and vocational changes"
2  Categories - focal injury, subarachnoid hemorrhage or diffuse axonal injury
   a0  Focal injury - specific, grossly observable brain lesions
       (1) Cerebral contusion - related to severity of amount of energy transmitted
       (2) Intracranial hemorrhage
           (a) Penetrating
           (b) Non-penetrating
       (3) Epidural hemorrhage
   b0  Diffuse axonal injury (DAI) - effect of acceleration/ deceleration
       (1) Concussion - mild and classic
       (2) DAI - moderate and severe

H0  Pathophysiology of head/ brain injury
1  Increased intracranial pressure (ICP)
   a0  Direct or indirect injury
       (1) Edema
       (2) Bleeding
       (3) Hypotension
       (4) Hypercarbia
   b0  This decreases cerebral perfusion pressure (CPP)
   c0  As CPP decreases, cerebral vasodilation occurs which results in increased cerebral blood volume which leads to an increase in ICP which results in a decreased CPP which leads to further cerebral vasodilation and so on
   d0  Hypercarbia causes cerebral vasodilation which results in increased cerebral blood volume, which leads to increased ICP, etc.
   e0  Hypotension results in decreased CPP which leads to cerebral vasodilation, etc.
2  Mechanism
   a0  As ICP approaches MAP the gradient for flow decreases, therefore cerebral blood flow is restricted
   b0  This decreases cerebral perfusion pressure (CPP)
   c0  As CPP decreases, cerebral vasodilation occurs which results in increased cerebral blood volume which leads to an increase in ICP which results in a decreased CPP which leads to further cerebral vasodilation and so on
   d0  Hypercarbia causes cerebral vasodilation which results in increased cerebral blood volume, which leads to increased ICP, etc.
   e0  Hypotension results in decreased CPP which leads to cerebral vasodilation, etc.
3  Assessment
   a0  Pressure exerted downward
       (1) Cerebral cortices and/ or reticular activating system effected
           (a) Altered level of consciousness - amnesia of event, confusion, disorientation, lethargy or combativeness, focal deficit or weakness
(2) Hypothalamus - vomiting

(3) Brain stem
  (a) Blood pressure elevates to maintain MAP and thus CPP
  (b) Vagal nerve pressure - bradycardia
  (c) Respiratory centers - irregular respirations or tachypnea
  (d) Oculomotor nerve paralysis - unequal/ unreactive pupils
  (e) Posturing - flexion/ extension

(4) Seizures - depending on location of injury

b0 Levels of increasing ICP
(1) Cerebral cortex and upper brain stem involved
  (a) BP rising and pulse rate begins slowing
  (b) Pupils still reactive
  (c) Cheyne-Stokes respirations
  (d) Initially try to localize and remove painful stimuli
     i. Eventually withdraws then flexion occurs
  (e) All effects reversible at this stage

(2) Middle brain stem involved
  (a) Wide pulse pressure and bradycardia
  (b) Pupils nonreactive or sluggish
  (c) Central neurogenic hyperventilation (CNH)
  (d) Extension
  (e) Few patients function normally from this level

(3) Lower portion of brain stem involved/ medulla
  (a) Pupil blown - same side as injury
  (b) Respirations ataxic (erratic, no rhythm) or absent
  (c) Flaccid
  (d) Labile pulse rate, irregular often great pulse swings in rate
  (e) QRS, S-T and T wave changes
  (f) Decreased BP, often labile BP
  (g) Not considered survivable

c0 Glasgow coma scale - method to assess level of consciousness
(1) Three independent measurements
  (a) Eye opening
  (b) Verbal response
  (c) Motor response

(2) Numerical score - 3 to 15

(3) Head injury classified according to score
  (a) Mild - 13 to 15
(b) Moderate - 8 to 12
(c) Severe - < 8

d0 Vital signs
e0 Pupil size and reaction
f0 Presence of focal deficit
g0 History of unconsciousness or amnesia of event

4 Management

a0 Suspect cervical spine injury

b0 Airway and ventilation - oxygenate to 95% -100% saturations
   (1) Oxygenation does not always require hyperventilation
   (2) Hyperventilate with signs and symptoms of increased ICP
      (a) Do not exceed rate of 30 - does not allow for adequate exhalation and retains carbon dioxide further contributing to hypercarbia
      (3) Avoid if possible nasal intubation - increases ICP

c0 Circulation - start IV of isotonic fluid (NS or LR) and titrate to BP
   (1) Prevent hypotension to preserve CPP
   (2) If hypotension present, look for internal bleeding
   (3) Stop external bleeding

d. Disability - repeated assessment crucial to monitor presence of increased ICP, GCS and focal deficit

e. Pharmacology
   (1) Osmotic diuretics
      (a) Mannitol and/ or furosemide
   (2) Paralytics/ sedation
   (3) Avoid glucose unless hypoglycemia confirmed

f. Non-pharmacological treatment
   (1) Position - head end of the backboard elevated 30 degrees
   (2) Decrease CNS stimulation

g. Transport considerations
   (1) Trauma center candidate - follow system guidelines
      (a) Moderate to severe head injury (GCS < 12)
   (2) Use of helicopter versus ground transport
   (3) Use of lights/ sirens

h. Psychological support/ communication strategies

l. Specific Injuries - diffuse axonal injury and focal injuries

1. Diffuse axonal injury - shearing, stretching or tearing of nerve fibers with subsequent axonal damage
   a. Concussion (mild DAI) - physiologic neurologic dysfunction without substantial anatomic disruption which results in transient episode of neuronal dysfunction with rapid return to normal neurologic activity
(1) Epidemiology - most common result of blunt trauma to the head
(2) Assessment - confusion, disorientation, amnesia of the event
(3) Management - quiet, calm atmosphere, constant orientation and reassessment, intact airway with adequate tidal volume a priority

2. Moderate DAI - shearing, stretching or tearing results in minute petechial bruising of brain tissue, brain stem and reticular activating system may be involved leading to unconsciousness
   a. Epidemiology - occurs in 20% of all severe head injuries and 45% of all cases of DAI, commonly associated with basilar skull fracture, most survive but with neurologic impairment common
   b. Assessment - may result in immediate unconsciousness or persistent confusion, disorientation and amnesia of the event extending to amnesia of moment-to-moment events; may have focal deficit; residual cognitive (inability to concentrate), psychologic (frequent periods of anxiety, uncharacteristic mood swings) and sensorimotor deficits (sense of smell altered) may persist
   c. Management - quiet, calm atmosphere, avoid bright lights due to photophobia, constant orientation if conscious, frequent reassessment with loss of consciousness, intact airway with adequate tidal volume a priority

3. Severe DAI - formerly called brain stem injury, involves severe mechanical disruption of many axons in both cerebral hemispheres and extending to the brainstem
   a. Epidemiology - represents 16% of all severe head injuries and 36% of all cases of DAI
   b. Assessment - unconsciousness for prolonged period, posturing common, other signs of increased ICP occur depending on various degrees of damage
   c. Management

4. Focal injury
   a. Skull fracture - the significance is in the amount of force involved
      (1) Epidemiology - intact galea protects skull by deflecting force more common with augmented blunt injury, such as vehicular crashes or falls from a height
      (2) Types
         (a) Linear (80% of all skull fractures)
            i) May have fluid leak out forming a bulge
            ii) Fluid leak may not occur for 24 hours
iii) If no associated injuries there is no danger

(b) Depressed
   i) Bone fragments protrude into brain
   ii) Neurologic signs and symptoms evident

(c) Basilar
   i) Extension of linear fracture to floor of skull, may not be seen on X-ray/CT
   ii) Signs and symptoms depend on amount of damage
   iii) Most frequently blood vessels disrupted
      a) CSF/blood from ear(s) or nose - target sign
      b) Bilateral black eyes - raccoon’s sign
      c) Bruising behind ear(s) - battle’s sign
   iv) May have seizures due to irritation of blood on brain tissue

(d) Open skull fractures
   i) Severe force involved, brain tissue may be exposed
   ii) Neurologic signs and symptoms evident

(3) Assessment - linear fractures may be missed, depressed and open skull fractures usually found on palpation of head, use balls of fingers to palpate
(a) Airway patency and breathing adequacy a priority
(b) Vomiting and inadequate respirations are common
(c) Assess for signs and symptoms of increased intracranial pressure
   i) Altered LOC
   ii) Glasgow coma scale
   iii) Vomiting
   iv) Pupil changes
   v) Pulse, respiration and BP changes

(4) Management
(a) Cervical spine precautions
(b) Assuring clear airway and adequate ventilation with good tidal volume
(b) Cerebral contusion - a focal brain injury in which brain tissue is bruised and damaged in a local area; may occur at both the area of
direct impact (coup) and/or on the opposite side (contrecoup) of impact.

(1) Epidemiology
   (a) Relatively common in blunt head injury resulting in prolonged confusion
   (b) Most commonly found in frontal lobes
   (c) Often associated with a serious concussion
   (d) Patients may have multiple sites of contusion

(2) Assessment
   (a) Airway patency and breathing adequacy a priority
   (b) Alteration in level of consciousness
      (i) Confusion or unusual behavior common
   (c) May complain of progressive headache and/or photophobia
   (d) May be unable to lay down memory - repetitive phrases common
   (e) Assess for signs and symptoms of increased intracranial pressure
      (i) Altered LOC
      (ii) Glasgow coma scale
      (iii) Vomiting
      (iv) Pupil changes
      (v) Pulse, respiration and BP changes

(3) Management
   (a) Cervical spine precautions
   (b) Assuring clear airway and adequate ventilation with good tidal volume
   (c) Hypoxia must be prevented to prevent secondary injury to brain tissue
   (d) Keep warm and comfortable
   (e) May need to repeat information

c. Intracranial hemorrhage
   (1) Types
      (a) Epidural
      (b) Subdural
      (c) Intracerebral
      (d) Subarachnoid
   (2) Epidemiology
      (a) Epidural hematomas almost always result from arterial tears, usually from the middle meningeal artery; they amount to about 0.5 to 1% of head injuries
(b) Subdural hematomas are more common, result from rupture of bridging veins between cortex and dura; may be acute or chronic (chronic bleeds more common in the elderly and the alcoholic)

(c) Subarachnoid hematoma results in bloody CSF and meningeal irritation

(d) Intracerebral hematoma is within the brain substance; many small, deep intracerebral hemorrhages are associated with other brain injuries (especially DAI); neurologic deficits depend on the associated injuries and the region involved, the size of the hemorrhage and whether bleeding continues

(3) Assessment

(a) May be impossible to tell which type of hematoma is present
   i) History is important, what were they doing? What happened? What is wrong now? What doesn't seem right?

(b) More important to recognize the presence of brain injury

(c) Signs/ symptoms of increasing intracranial pressure
   i) Headache that gets increasingly severe, vomiting, lethargy, confusion, changes in consciousness, comatose, pupil changes, pulse slows or becomes irregular, respirations become irregular, posturing, seizures

(d) Signs/ symptoms of neurological deficit

(e) Early signs and symptoms of alterations in level of consciousness

(f) Signs of brain irritation - change in personality, irritability, lethargy, confusion, repeating words or phrases, changes in consciousness, paralysis of one side of the body, seizures

(g) GCS

(4) Management

(a) Cervical spine precautions

(b) Maintaining airway and adequate ventilation

(c) Elevating head of stretcher or backboard 30°

(d) Establish IV, manage hypotension with fluid boluses, not to exceed a systolic of 90-100 mmHg in the adult male <40 (avoid shock)
5. Helmet issues
   a. Purpose of helmet
      (1) Protect head
      (2) Protect the brain
      (3) Cervical spine remains vulnerable
   b. Various types
      (1) Full face or open face (motorcycle, bicycle, roller-blade, etc.)
      (2) Sports helmet (football, moto-cross, etc.)
   c. Controversy regarding removal, at scene versus hospital
      (1) Priorities
         (a) Airway management
         (b) Spinal immobilization
      (2) Factors determining need for immediate removal
         (a) Access to airway
         (b) Patient’s condition
      (3) Other considerations include
         (a) Ready access of athletic trainer in case of sports helmet (often have special equipment to remove face piece, allowing access to airway)
         (b) Presence of other garb which could further compromise the cervical spine if only the helmet were removed (e.g. shoulder pads)
         (c) Firm fit of helmet may provide firm support for head
   d. Cervical spine immobilization must be done whether or not a helmet is present
   e. When helmet removal occurs
      (1) Requires sufficient help (stay to help in ED)
      (2) Training in specific technique necessary for efficient removal
      (3) Requires sufficient padding
UNIT TERMINAL OBJECTIVE
4-6 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for the patient with a suspected spinal injury.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-6.1 Describe the incidence, morbidity, and mortality of spinal injuries in the trauma patient. (C-1)
4-6.2 Describe the anatomy and physiology of structures related to spinal injuries. (C-1)
   a. Cervical
   b. Thoracic
   c. Lumbar
   d. Sacrum
   e. Coccyx
   f. Head
   g. Brain
   h. Spinal cord
   i. Nerve tract(s)
   j. Dermatomes
4-6.3 Predict spinal injuries based on mechanism of injury. (C-2)
4-6.4 Describe the pathophysiology of spinal injuries. (C-1)
4-6.5 Explain traumatic and non-traumatic spinal injuries. (C-1)
4-6.6 Describe the assessment findings associated with spinal injuries. (C-1)
4-6.7 Describe the management of spinal injuries. (C-1)
4-6.8 Identify the need for rapid intervention and transport of the patient with spinal injuries. (C-1)
4-6.9 Integrate the pathophysiological principles to the assessment of a patient with a spinal injury. (C-3)
4-6.10 Differentiate between spinal injuries based on the assessment and history. (C-3)
4-6.11 Formulate a field impression based on the assessment findings. (C-3)
4-6.12 Develop a patient management plan based on the field impression. (C-3)
4-6.13 Describe the pathophysiology of traumatic spinal injury related to: (C-1)
   a. Spinal shock
   b. Spinal neurogenic shock
   c. Quadriplegia/ paraplegia
   d. Incomplete cord injury/ cord syndromes:
      1. Central cord syndrome
      5. Anterior cord syndrome
      6. Brown-Sequard syndrome
4-6.14 Describe the assessment findings associated with traumatic spinal injuries. (C-1)
4-6.15 Describe the management of traumatic spinal injuries. (C-1)
4-6.16 Integrate pathophysiological principles to the assessment of a patient with a traumatic spinal injury. (C-3)
4-6.17 Differentiate between traumatic and non-traumatic spinal injuries based on the assessment and history. (C-3)
4-6.18 Formulate a field impression for traumatic spinal injury based on the assessment findings. (C-3)
4-6.19 Develop a patient management plan for traumatic spinal injury based on the field impression. (C-3)

4-6.20 Describe the pathophysiology of non-traumatic spinal injury, including: (C-1)
   a. Low back pain
   b. Herniated intervertebral disk
   c. Spinal cord tumors

4-6.21 Describe the assessment findings associated with non-traumatic spinal injuries. (C-1)

4-6.22 Describe the management of non-traumatic spinal injuries. (C-1)

4-6.23 Integrate pathophysiological principles to the assessment of a patient with non-traumatic spinal injury. (C-3)

4-6.24 Differentiate between traumatic and non-traumatic spinal injuries based on the assessment and history. (C-3)

4-6.25 Formulate a field impression for non-traumatic spinal injury based on the assessment findings. (C-3)

4-6.26 Develop a patient management plan for non-traumatic spinal injury based on the field impression. (C-3)

**AFFECTIVE OBJECTIVES**

At the completion of this unit, the paramedic student will be able to:

4-6.27 Advocate the use of a thorough assessment when determining the proper management modality for spine injuries. (A-3)

4-6.28 Value the implications of failing to properly immobilize a spine injured patient. (A-2)

**PSYCHOMOTOR OBJECTIVES**

At the completion of this unit, the paramedic student will be able to:

4-6.29 Demonstrate a clinical assessment to determine the proper management modality for a patient with a suspected traumatic spinal injury. (P-1)

4-6.30 Demonstrate a clinical assessment to determine the proper management modality for a patient with a suspected non-traumatic spinal injury. (P-1)

4-6.31 Demonstrate immobilization of the urgent and non-urgent patient with assessment findings of spinal injury from the following presentations: (P-1)
   - Supine
   - Prone
   - Semi-prone
   - Sitting
   - Standing

4-6.32 Demonstrate documentation of suspected spinal cord injury to include: (P-1)
   a. General area of spinal cord involved
   b. Sensation
14. Dermatomes
15. Motor function
16. Area(s) of weakness

4-6.33 Demonstrate preferred methods for stabilization of a helmet from a potentially spine injured patient. (P-1)
4-6.34 Demonstrate helmet removal techniques. (P-1)
4-6.35 Demonstrate alternative methods for stabilization of a helmet from a potentially spine injured patient. (P-1)
4-6.36 Demonstrate documentation of assessment before spinal immobilization. (P-1)
4-6.37 Demonstrate documentation of assessment during spinal immobilization. (P-1)
4-6.38 Demonstrate documentation of assessment after spinal immobilization. (P-1)
DEclarative

I Introduction
   A0 Spinal cord injury (SCI) impacts
      1 Human physiology
      2 Lifestyle
      3 Financial
      4 1.25 million to care for a single victim with permanent SCI (overall life span)

II Incidences
   A0 15,000 - 20,000 SCI per year
   B0 Higher in men between ages 16 - 30 years
   C0 Common causes
      1 Motor vehicle crashes - 2.1 million per year (48%)
      2 Falls (21%)
      3 Penetrating injuries (15%)
      4 Sports injuries (14%)

III Morbidity and mortality
   A0 40% of trauma patients with neurological deficit will have temporary or permanent SCI
   B0 25% of SCI may be caused by improper handling
   C0 Education in proper handling and transportation can decrease SCI

IV Traditional spinal assessments/ criteria
   A0 Based upon mechanism of injury (MOI)
   B0 Past emphasis for spinal immobilization considerations
      1 Unconscious accident victims
      2 Conscious accident victims checked for SCI prior to movement
      3 Any patient with a “motion” injury
   C0 Lack of clear clinical guidelines or specific criteria to evaluate for SCI
   D0 Signs which may indicate SCI
      1 Pain
      2 Tenderness
      3 Painful movement
      4 Deformity
      5 Cuts/ bruises (over spinal area)
      6 Paralysis
      7 Paresthesias
      8 Paresis (weakness)
9  Shock
10  Priapism

E0  Not always practical to immobilize every “motion” injury
F0  Most suspected injuries were moved to a normal anatomical position
   1  Lying flat on a spine board
   2  No exclusion criteria used for moving patients to an anatomical position
G0  Need to have clear criteria to assess for the presence of SCI

V  General spinal anatomy and physiology review
A0  Spinal column
   1  Long bone
   2  33 vertebrae
   3  Head balances at top of spine
   4  Spine supported by pelvis
   5  Ligaments and muscles connect head to pelvis
      a0  Anterior longitudinal ligament
           (1) Runs on anterior portion of the body
           (2) Major source of stability
           (3) Protects against hyperextension
      b0  Posterior longitudinal ligament
           (1) Runs along posterior body within the vertebral canal
           (2) Prevents hyperflexion
           (3) Can be a major source of injury
      c0  Other ligaments
           (1) Cruciform ligament
           (2) Accessory atlantoaxial ligament
           (3) Add to strength, stability, and articulation
   6  Injury to ligaments may cause excess movement of vertebrae
B0  Cervical spine
   1  7 vertebrae
   2  Supports head (16 - 25 lbs)
   3  Considered “joint above” in splinting
   4  Very flexible
   5  C1 (atlas)
   6  C2 (axis)
C0  Thoracic spine
   1  12 vertebrae
   2  Ribs connected
   3  Provides rigid framework of thorax
D0  Lumbar spine
   1  5 vertebrae
2  Largest vertebral body
3  Flexible
4  Carries most of body weight
5  Torso balances on sacrum

**E0** Sacrum
1  5 fused vertebrae
2  Common to spine and pelvis
3  Forms “joint below” with pelvis for splinting

**F0** Coccyx
1  4 fused vertebrae
2  Tailbone

**G0** Vertebral structure
1  Body
   a0  Constructed of cancellous bone
   b0  Posterior portion forms part of the vertebral foramen
   c0  Increase in size when moving from cervical to sacral region for support of the trunk

**H0** Vertebral foramen
1  When all vertebrae are in place forms opening for spinal cord (vertebral canal)
2  Formed by
   a0  Posterior portion of vertebral body
   b0  Pedicles
      (1)  Projecting posteriorly from vertebral body
   c0  Laminae
      (1)  Arise from pedicles and fuse into spinous process
      (2)  Failure of the laminae to unite during fetal development causes spina bifida
         (a)  Most commonly in the lumbosacral region

**I0** Transverse process
1  Runs from between the pedicles and laminae in most vertebrae
2  Projects laterally and posteriorly
3  Attachment site for various muscles and ligaments

**J0** Spinous process
1  Posterior aspect
2  Formed by the laminae
3  Attachment site for muscles and ligaments

**K0** Intervertebral foramen
1  Formed by the lower surfaces of the vertebrae
2  Creates a “notch” for spinal nerves
   a0  Allows nerves to connect to the spinal cord
L0  Intervertebral disk
  1  Mass of fibrocartilage separating each vertebrae
  2  Connecting together by ligaments
  3  Acts as a shock absorber
      a0  Reducing bone wear
      b0  Compression protection

M0  Brain and spinal cord (central nervous system)
  1  Brain
      a0  Largest and most complex portion of the nervous system
      b0  Continuous with spinal cord
      c0  Responsible for all sensory and motor functions
  2  Spinal cord
      a0  Located within the vertebral canal
          (1)  Begins at foramen magnum
          (2)  Ending near L-2
      b0  Dural sheath
          (1)  Sheathed, tube-like sac
          (2)  Filled with cerebrospinal fluid (CSF)
  3  Blood supplied by
      a0  Vertebral arteries
      b0  Spinal arteries
  4  Gray matter
      a0  Core pattern in cord resembling butterfly with outspread wings
      b0  Most neurons in gray matter are interneurons
  5  White matter
      a0  Anatomical spinal tracts
          (1)  Longitudinal bundles of myelinated nerve fibers
  6  Ascending nerve tracts
      a0  Carries impulses from body parts and sensory information to the brain
      b0  Fasciculus gracilis and cuneatus
          (1)  Part of the posterior funiculi of cord
          (2)  Conduct sensory impulse from skin, muscle tendons, and joints to the brain for interpretation as sensations of touch, pressure, and body movement
          (3)  Cross over at the medulla oblongata from one side to the other, therefore impulses originating from the left side ascend to the right side of the brain and vice versa
      c0  Spinothalamic tracts
          (1)  Lateral and anterior tracts located in the lateral and anterior funiculi
(2) Lateral tracts conduct impulses of pain and temperature to the brain
(3) Impulses cross over in the spinal cord
(4) Anterior tracts carry impulses of touch and pressure to the brain
(5) Spinocerebellar tracts (anterior and posterior) are found near the lateral funiculi and function to coordinate impulses necessary for muscular movements by carrying impulses from muscles in legs and trunk to cerebellum

7 Descending nerve tracts
   a0 Carries motor impulses from the brain to the body
   b0 Corticospinal tracts (pyramidal tracts)
      (1) Lateral tract crosses over at medulla oblongata
          (a) Anterior tract descend uncrossed
          (b) Functions to conduct motor impulses from the brain to spinal nerves and out to the body for voluntary movements
      (2) Reticulospinal tracts
          (a) Lateral, anterior, and medial tracts
          (b) Mix of crossed and uncrossed fibers
              i Some lateral fibers cross over while others do not
              ii Anterior and medial tracts remain uncrossed
          (c) Motor impulses originate in the brain to control muscle tone and sweat gland activity
      (3) Rubrospinal tracts
          (a) Fibers cross over in brain at pass through the lateral funiculi
          (b) Motor impulses from the brain controlling muscle coordination and control of posture

8 Spinal nerves
   a0 31 pairs
      (1) Originates from the spinal cord
   b0 Mixed nerves
      (1) Carries both sensation and motor function
      (2) Provides two-way communication between spinal cord and body parts
   c0 Named according to level of spine from which they arise
      (1) Cervical 1-8
      (2) Thoracic 1-12
      (3) Lumbar 1-5
(4) Sacral 1-5
(5) Coccygeal 1 set of nerves

d0 Spinal nerve
(1) Emerges from the cord
(2) Two short branches or roots
(3) Dorsal root
   (a) Carries sensory impulses to the cord
(4) Ventral root
   (a) Carries motor impulses from the cord to the body

Motor and sensory dermatomes

a0 Dermatome is the particular area in which the spinal nerves travels or controls

b0 Mapped out by level of the spinal nerve

c0 Useful for assessment for a specific level of SCI

d0 Table for common nerve root and motor/ sensory correlation

<table>
<thead>
<tr>
<th>Nerve Root</th>
<th>Motor</th>
<th>Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-3,4</td>
<td>Trapezius (shoulder shrug)</td>
<td>Top of shoulder</td>
</tr>
<tr>
<td>C-3,4,5</td>
<td>Diaphragm</td>
<td>Top of shoulder</td>
</tr>
<tr>
<td>C-5,6</td>
<td>Biceps (elbow flexion)</td>
<td>Thumb</td>
</tr>
<tr>
<td>C-7</td>
<td>Triceps (elbow extension)</td>
<td>Middle finger wrist/ finger extension</td>
</tr>
<tr>
<td>C-8/ T-1</td>
<td>Finger abduction/ adduction</td>
<td>Little finger</td>
</tr>
<tr>
<td>T-4</td>
<td>Nipple</td>
<td></td>
</tr>
<tr>
<td>T-10</td>
<td>Umbilicus</td>
<td></td>
</tr>
<tr>
<td>L-1,2</td>
<td>Hip flexion</td>
<td>Inguinal crease</td>
</tr>
<tr>
<td>L-3,4</td>
<td>Quadriceps</td>
<td>Medial thigh/ calf</td>
</tr>
<tr>
<td>L-5</td>
<td>Great toe/ foot dorsiflexion</td>
<td>Lateral calf</td>
</tr>
<tr>
<td>S-1</td>
<td>Knee flexion</td>
<td>Lateral foot</td>
</tr>
<tr>
<td>S-1,2</td>
<td>Foot plantar flexion</td>
<td></td>
</tr>
<tr>
<td>S-2,3,4</td>
<td></td>
<td>Anal sphincter tone</td>
</tr>
</tbody>
</table>

VI General assessment of spinal injuries

A0 Determine mechanism of injury/ nature or injury

1 Positive MOI

a0 Always requires full spinal immobilization

1 High speed motor vehicle crash(es)
(2) Falls greater than three times patient’s height
(3) Violent situations occurring near the spine
   (a) Stabbings
Trauma: 4
Spinal Trauma: 6

(b) Gun shots
(c) Others
(4) Sports injuries
(5) Other high impact situations

Some medical directors may allow field personnel to not immobilize patients with MOI but without signs and/or symptoms of a SCI

(1) Based on assessment
(a) Patient reliability
(b) No distracting injuries
(c) Lack of signs or symptoms

2 Negative MOI

Forces or impact involved does not suggest a potential spinal injury

(1) Examples
(a) Dropping a rock on foot
(b) Twisted ankle while running
(c) Isolated soft tissue injury

3 Uncertain MOI

Unclear or uncertainty regarding the impact or forces

Clinical criteria used for a basis of whether to employ spinal immobilization

(1) Examples
(a) Person trips over garden hose, falling to the ground and hitting their head
(b) Fall from 2-4 feet
(c) Low speed motor vehicle crash (fender bender)

4 Clinical criteria versus mechanism of injury

Initial management

(1) Based solely upon MOI

Positive MOI

(1) Spine immobilization

Negative MOI

(1) Without signs or symptoms
(a) No spine immobilization

Uncertain MOI

(1) Need for further clinical assessment and evaluation

In some non-traumatic spinal conditions immobilization may be necessary/indicated

Altered LOC or unconsciousness requires spine stabilization

VII Assessment of uncertain MOIs
A0 Specific clinical criteria
1 Necessary to assess when electing not to immobilize a trauma patient
2 Begins with patient reliability
   a0 Continually reassessed during specific exam
3 If specific criteria cannot be clearly satisfied; complete spine immobilization undertaken
4 Positive MOI always equals spine immobilization
   a0 This specific assessment may still be used to determine level of injury

B0 Specific criteria
1 Prevent motion of the spine by assistant maintaining stabilization throughout the exam
2 Reliable patients/ exam
   a0 In order for assessments of pain, tenderness, motor, and sensory function to be accurate the patient must be reliable
   b0 Patient must be
      (1) Calm
      (2) Cooperative
      (3) Sober
         (a) Alcohol
         (b) Drugs
      (4) Alert and oriented
   c0 Unreliable patient defined
      (1) Acute stress reaction
         (a) Sudden stress of any type
      (2) Brain injury
         (a) Any temporary change in consciousness or altered level of consciousness
         (b) Uncooperative or belligerent behavior
      (3) Intoxication
      (4) Abnormal mental status
      (5) Distracting injuries
      (6) Communication problems
   d0 Unreliable indicators present
      (1) Full spinal immobilization indicated
3 Assess for spinal pain
   a0 Patient is asked about
      (1) Any related spinal pain
      (2) Signs
      (3) Symptoms
   b0 May be poorly localized
c0 Might not feel directly over the spinous process

d0 Pain with active movement of head and neck
  (1) Patient is asked to slowly move their head and neck
  (2) If any pain occurs
      i Full immobilization is indicated
      ii May not be able to splint in normal anatomical position

4 Assess for spine tenderness

a0 Palpate over each of the spinous processes of the vertebra
b0 Begin at the neck and work towards the pelvis
c0 May be beneficial to palpate back up from the pelvis to the neck

5 Upper extremity neurological function assessment

a0 Motor function
  (1) Finger abduction/ adduction
      (a) Test interosseous muscle function controlled by T-1 nerve roots
      (b) Have patient spread fingers of both hands and keep them apart while you squeeze the 2nd and 4th fingers
      (c) Normal resistance should be spring-like and equal on both sides
  (2) Finger/ hand extension
      (a) Test the extensors of the hand and fingers controlled by C-7 nerve roots
      (b) Have patient hold wrist or fingers straight out and keep them out while you press down on their fingers
      (c) Support the arm at the wrist to avoid testing arm function and other nerve roots
      (d) Normal resistance should be felt to moderate pressure
      (e) Both right and left sides should be checked
      (f) Can still check if isolated, e.g., finger fracture, push on hand only not fingers; if wrist injury support MP joints and push on fingers only

b0 Sensory function
  (1) Pain sensation
      (a) Abnormal sensation - ask patient about weakness, numbness, paresthesia, or radicular pain
      (b) Pain or pinprick controlled by spinothalamic tracts
      (c) Need to separate from light touch (remember light touch carried by more than one tract)
(d) Use end of pen or broken Q-tip (avoid sharp objects which may damage or cause bleeding)
(e) Have patient close eyes and hold out hands; ask the patient to compare between sharp and dull pain
(f) Compare on both sides of the body; equal on both sides

6  Lower extremity neurological function assessment
   a0  Motor function
       (1) Foot plantar flexion
           (a) Tests plantar flexors of the foot controlled by S-1,2 nerve root
           (b) Place your hands at the sole of each foot and have the patient push against your hands
           (c) Both sides should feel equal and strong
       (2) Foot/ great toe dorsiflexion
           (a) Tests the dorsal flexors of the foot and great toe controlled by the L-5 nerve roots
           (b) Hold foot with fingers on toes and instruct patient to pull foot back or towards their nose

   b0  Sensory function
       (1) Pain sensation
           (a) Abnormal sensation - ask patient about weakness, numbness, paresthesia, or radicular pain
           (b) Pain or pinprick controlled by spinothalamic tracts
           (c) Need to separate from light touch (remember light touch carried by more than one tract)
           (d) Use end of pen or broken Q-tip (avoid sharp objects which may damage or cause bleeding)
           (e) Have patient close eyes and hold out hands; ask the patient to compare between sharp and dull pain
           (f) Compare on both sides of the body; equal on both sides

7.  General motor function assessment
   a. Tests nerve roots at both cervical and lumbar/ sacral spine levels
   b. Check two sets of nerve roots at each level as well as left and right sides
   c. Able to determine most clinical patterns of SCI
   d. Motor exams can be completed even if local injury exists
       (1) If exam cannot be completed due to local injury entire exam is unreliable
           (a) Spinal immobilization indicated
8. Sensory function assessment
   a. Test (exam) sensory
      (1) At cervical and lumbar/sacral spine levels
         (a) On both right and left sides
      b. Sensory exam will detect clinical patterns of SCI
      c. Any signs or symptoms of abnormal sensation
         (1) Spinal immobilization indicated

VIII. General management of spinal injuries
A. Principles of spinal immobilization
   1. Primary goal is to prevent further injury
   2. Treat spine as a long bone with a joint at either end (head and pelvis)
   3. 15% of secondary spinal injuries are preventable with proper immobilization
   4. Always use “complete” spine immobilization
      a. Impossible to isolate and splint specific injury site
   5. Spine stabilization begins in the initial assessment
      a. Continues until the spine is completely immobilized on a long backboard
   6. Head and neck should be placed in a neutral, in-line position unless contraindicated
      a. Neutral positioning allows for the most space for the cord
         (1) Reducing cord hypoxia
         (2) Reducing excess pressure
      b. Most stable position for the spinal column
         (1) Reduces instability

B. Spinal stabilization/immobilization
   1. Systematic approach
      a. Cervical immobilization
         (1) Manual
         (2) Rigid collar
      b. Interim immobilization device
         (1) When indicated (vest type mobilization device, short backboard)
         (2) Movement of a stable patient from a seated position to a long backboard
      c. Long backboard
      d. Full body vacuum splints
      e. Padding (body shims)
         (1) Use to maintain anatomical position
         (2) Limits movement of patient
(3) Fill all voids
(4) Pillows
(5) Towels
(6) Blankets

f. Straps
   (1) Sufficient to immobilize to the long backboard
      (a) Upper torso
      (b) Pelvis
      (c) Legs
      (d) Feet

g. Cervical immobilization device
   (1) Commercial
   (2) Tape
   (3) Blanket roll
   (4) Pillows

h. Helmeted patients
   (1) Special assessment needs for patients wearing helmets
      (a) Airway and breathing
      (b) Fit of helmet and movement within the helmet
      (c) Ability to gain access to airway and breathing
   (2) Indications for leaving the helmet in place
      (a) Good fit with little or no head movement within helmet
      (b) No impending airway or breathing problems
      (c) Removal may cause further injury
      (d) Proper spinal immobilization could be performed with helmet in place
      (e) No interference with ability to assess and reassess airway
   (3) Indications for helmet removal
      (a) Inability to assess or reassess airway and breathing
      (b) Restriction of adequate management of the airway or breathing
      (c) Improperly fitted helmet with excessive head movement within helmet
      (d) Proper spinal immobilization cannot be performed with helmet in place
      (e) Cardiac arrest
   (4) Types of helmets
      (a) Sports
         i) Typically worn anteriorly
         ii) Easier access to airway
(b) Motorcycle
   i) Full face
   ii) Shield
(c) Other

(5) General guidelines for helmet removal
(a) Type of helmet worn by the patient will influence the technique used for removal
(b) First person stabilizes the head and neck by placing hands on the side of the helmet with fingers extended under lower face piece (or chin)
(c) Second person removes face shield (if present) and/or eye wear before helmet removal
(d) Second person removes chin strap
(e) Second person places one hand on mandible and the other posteriorly on the occipital region (posterior caudal edge of helmet)
(f) First person then begins to remove the helmet by pulling the sides apart, sliding the helmet a short distance (approximately 4-6 cm) and then stops
(g) First person again stabilizes the head and neck with hands holding the sides of the helmet
(h) Second person slides hands cephalad (towards the top of the head) until the head is stabilized between the posterior or hand (now cupped under the inferior occiput) and the anterior hand now inserted under the lower part of the face piece - if the helmet has one (thumb and first finger now holding the unmovable maxilla)
(i) First person again pulls the sides of the helmet apart and continues to withdraw the helmet - rotating the helmet as necessary so any lower face piece clears the nose and then an opposite movement so the posterior caudal end of the helmet is removed following the posterior curvature of the patient’s head
(j) Once the helmet has been completely removed, the first person regains stabilization of the patient’s head and neck by placing their hands along the sides of the patient’s head with their fingers spread apart for maximum support - second person can now let go of the anterior/posterior support
(k) Second person can now continue with the assessment, measurement and application of a cervical collar, further immobilization and care of the patient.

C. Use of steroids for traumatic spine injuries

IX. Traumatic injuries
A. Causes
1. Direct trauma
2. Excessive movement
   a. Acceleration
   b. Deceleration
   c. Deformation
3. Directions of force
   a. Flexion or hyperflexion
      (1) Excessive forward motion of the head
      (2) May cause
         (a) Wedge fracture of anterior vertebrae
         (b) Stretching or rupturing of interspinous ligaments
         (c) Compressed injury to spinal cord
         (d) Disruption of disk with forward dislocation of vertebrae
         (e) Fracture of pedicle and disruption of interspinous ligament
      (3) Cervical area common injury site
   b. Extension or hyperextension
      (1) Excessive backward movement of the head
      (2) May cause
         (a) Disruption of the intervertebral disks
         (b) Osteophytes and compression of the spinal cord
         (c) Compression of the interspinous ligament
         (d) Fracture
      (3) Cervical area common injury site
   c. Rotational
      (1) Usually from acceleration forces
      (2) May cause
         (a) Flexion-rotation dislocation
(b) Fracture or dislocation of vertebrae
(c) Rupture of supporting ligaments
(3) Cervical area common injury site
d. Lateral bending
   (1) Often caused by direct blow to the side of the body
   (2) May cause
      (a) May cause lateral compression of the vertebral body
      (b) may cause lateral displacement of the vertebra
      (c) May stretch the ligaments
e. Vertical compression
   (1) Force applied along spinal axis
      (a) Usually from top of cranium to vertebral body from
      sudden deceleration, e.g., diving accident
   (2) May cause
      (a) Compression fracture without SCI
      (b) Crushed vertebral body with SCI
   (3) Most common injury site(s)
      (a) T-12 to L-2
f. Distraction
   (1) Force applied to spinal axis to distract or pull apart, e.g.,
   hanging injury
   (2) May cause
      (a) Stretching of spinal cord
      (b) Stretching of supporting ligaments
   (3) Cervical area most common injury site

4. Can have “spinal column injury” (bony injury) with or without “SCI”
5. Can have “SCI” with or without “spinal injury”

B. Types of spinal cord injuries (SCI)
1. Primary injury
   a. Occurs at time of impact/ injury
   b. Causes
      (1) Cord compression
      (2) Direct cord injury
         (a) Sharp or unstable bony structures
      (3) Interruption in the cord’s blood supply

2. Secondary injury
   a. Occurs after initial injury
   b. Causes
      (1) Swelling
      (2) Ischemia
      (3) Movement of bony fragments
3. Cord concussion
   a. Results from temporary disruption of cord-mediated functions

4. Cord contusion
   a. Bruising of the cord’s tissues
   b. Causes
      (1) Swelling
   c. Temporary loss of cord-mediated function

5. Cord compression
   a. Pressure on the cord
   b. Causes tissue ischemia
   c. Must be decompressed to avoid permanent loss/damage to cord

6. Laceration
   a. Tearing of the cord tissue
   b. May be reversed if only slight damage
   c. May result in permanent loss if spinal tracts are disrupted

7. Hemorrhage
   a. Bleeding into the cord’s tissue
   b. Caused by damage to blood vessels
      (1) Injury related to amount of hemorrhage
   c. Damage or obstruction to spinal blood supply results in local ischemia

8. Cord transection
   a. Complete
      (1) All tracts of the spinal cord completely disrupted
      (2) Cord-mediated functions below transection are permanently lost
      (3) Accurately determined after at least 24 hours post-injury
      (4) Results in
         (a) Quadriplegia
            i) Injury at the cervical level
            ii) Loss of all function below injury site
         (b) Paraplegia
            i) Injury at the thoracic or lumbar level
            ii) Loss of lower trunk only
   b. Incomplete
      (1) Some tracts of the spinal cord remain intact
      (2) Some cord-mediated functions intact
      (3) Has potential for recovery
         (a) Function may only be temporarily lost
      (4) Types
         (a) Anterior cord syndrome
i) Caused by bony fragments or pressure on spinal arteries
ii) Involves loss of motor function and sensation to pain, temperature and light touch
iii) Sensation to light touch, motion, position, and vibration are spared

(b) Central cord syndrome
i) Usually occurs with a hyperextension of the cervical region
ii) Weakness or paresthesias in upper extremities but normal strength in lower extremities
iii) May have varying degrees of bladder dysfunction

(c) Brown-Sequard syndrome
i) Caused by penetrating injury
ii) Hemisection of the cord
iii) Involves only one side of the cord
iv) Complete damage to all spinal tract on involved side
v) Isolated loss of all types of functions, e.g., motor pain, temperature, motion, position, etc.
vi) Pain and temperature lost on opposite side of the body
vii) Motor function, motion, position, vibration, and light touch on the same side as injury

9. Chemical and metabolic changes due to SCI
10. Spinal shock
a. Refers to temporary loss of all types of spinal cord function distal to injury
b. Flaccid paralysis distal to injury site
c. Loss of autonomic function
   (1) Hypotension
   (2) Vasodilatation
   (3) Loss of bladder and bowel control
   (4) Priapism
   (5) Loss of thermoregulation
d. Does not always involve permanent primary injury
   (1) Usually will resolve in a period of hours to weeks
   (2) Manage carefully to avoid secondary injury

11. Spinal neurogenic shock
a. Also called spinal vascular shock
b. Temporary loss of the autonomic function of the cord at the level of injury which controls cardiovascular function.

c. Presentation includes:
   1. Loss of sympathetic tone
   2. Relative hypotension
      a. Systolic pressure 80 - 100 mmHg
   3. Skin pink, warm and dry
      a. Due to cutaneous vasodilation
   4. Relative bradycardia

d. Rare in occurrence

e. Shock presentation is usually the result of hidden volume loss:
   1. Chest injuries
   2. Abdominal injuries
   3. Other violent injuries

f. Treatment:
   1. Focus primarily on volume replacement

12. Autonomic hyperreflexia syndrome

a. Associated after resolution of spinal shock:
   1. Chronic SCI patients

b. Massive, uncompensated cardiovascular response:
   1. Stimulation of the sympathetic nervous system

c. Life-threatening condition usually seen with injuries at T-6 or above

d. Characteristics are:
   1. Paroxysmal hypertension (up to 300 mmHg systolic)
   2. Headache (pounding)
   3. Blurred vision
   4. Sweating
      a. Above level of injury with flushing of the skin
   5. Increased nasal congestion
   6. Nausea
   7. Bradycardia
   8. Associate distended bladder or rectum

e. Stimulation of the sensory receptors below the level of the cord injury:
   1. Autonomic nervous system reflexively responds with arteriolar spasm
      a. Increases blood pressure
   2. Cerebral, carotid, and aorta baroreceptors sense hypertension
      a. Stimulates the parasympathetic nervous system
(b) Heart rate decreases
(c) Peripheral and visceral vessels unable to dilate due to cord damage
(3) May be treated with an antihypertensive medication

X. Non-traumatic spinal conditions
A. Low back pain (LBP)
   1. Affected area
      a. Between lower rib cage and gluteal muscles
      b. May radiate to thighs
   2. 1% of acute low back pain is sciatica
      a. Usual cause is in the lumbar nerve root
      b. Pain accompanied by motor and sensory deficits, e.g., weakness
   3. 60% - 90% of population experience some form of low back pain
      a. Affects men and women equally
      b. Women over 60 years old report low back pain symptoms more often
   4. Most cases of LBP are idiopathic
      a. Precise diagnosis difficult
   5. Causes
      a. Tension from tumors
      b. Disk prolapsed
      c. Bursitis
      d. Synovitis
      e. Rising venous pressure
      f. Tissue pressure due to degenerative joint disease
      g. Abnormal bone pressure
      h. Problems with spinal mobility
      i. Inflammation caused by infection
         (1) Osteomyelitis
      j. Fractures
      k. Ligament strains
   6. Risk factors
      a. Occupations requiring repetitious lifting
      b. Exposure to vibrations from vehicles or industrial machinery
      c. Osteoporosis
   7. Anatomical considerations
      a. Pain from innervated structures
         (1) Varies from person-to-person
      b. Disk has no specific innervation
         (1) Compresses cord if herniated
c. Source of pain in L-3,4,5, and S-1 may be interspinous bursae
d. Anterior and posterior longitudinal ligaments, and other ligaments are richly
   supplied with pain receptors
e. Muscles of spine vulnerable to sprains/strains

8. Degenerative disk disease
   a. Common for patients over 50 years of age
   b. Causes
      (1) Degeneration of disk
      (a) Biomechanical alterations of intervertebral disk
c. Narrowing of the disk
      (1) Results in variable segment stability

9. Spondylolysis
   a. Structural defect of spine
      (1) Involves the lamina or vertebral arch
   b. Usually occurs between superior and inferior articulating facets
   c. Heredity a significant factor
   d. Rotational fractures common at affected site

10. Herniated intervertebral disk
    a. Also called herniated nucleus pulposus
    b. Tear in the posterior rim of capsule enclosing the gelatinous center of the disk
    c. Causes
       (1) Trauma
       (2) Degenerative disk disease
       (3) Improper lifting
           (a) Most common cause
d. Men ages 30 - 50 years are more prone than women
e. Commonly affects L-5, S-1 and L-4, L-5 disks
f. May also occur in C-5, C-6, and C-7

11. Spinal cord tumors
    a. Causes
       (1) Compression of the cord
       (2) Degenerative changes in the bone/joints
       (3) Interrupted the blood supply
    b. Manifestations are dependent upon
       (1) Tumor type and location

XI. Assessment and management of non-traumatic spinal conditions
    A. Assessment - based mainly upon the patient’s chief complaint and physical exam
1. Low back pain
   a. Based mainly upon history and chief complaint
      (1) Risk factors include
          (a) Occupations requiring repetitive lifting
          (b) Exposure to vibrations from vehicles or industrial machinery
          (c) Osteoporosis
   b. Precise diagnosis difficult
      (1) Based primarily on physical exam and other in-hospital testing
          (a) CT scan
          (b) Electromyelography
          (c) MRI
          (d) Others

2. Herniated intervertebral disk
   a. Tear in the posterior rim of capsule enclosing the gelatinous center of the disk
      (1) Causes
          (a) Trauma
          (b) Degenerative disk disease
          (c) Improper lifting
              i) Most common cause
      (2) Pain usually occurs with straining
          (a) Coughing or sneezing
      (3) May have limited range of motion in lumbar spine
      (4) Tenderness upon palpation
      (5) Alternations in sensation, pain, and temperature
      (6) Due to nerve root pressure
      (7) Cervical herniations may include
          (a) Upper extremity pain or paresthesia
              i) Increasing with neck motion
          (b) Slight motor weakness may also occur in biceps and triceps

3. Spinal cord tumors
   a. Tumors of the spine which cause
      (1) Compression of the cord
      (2) Degenerative changes in the bone/joints
      (3) Interruption in the blood supply
   b. Manifestations are dependent upon
      (1) Tumor type
      (2) Location
B. Management
   1. Primarily palliative to decrease any pain or discomfort from movement
   2. May elect to immobilize to aid in comfort
      a. Long back board
      b. Vacuum type stretcher
   3. Full spinal immobilization is not required unless condition is a result of trauma

REFERENCES


UNIT TERMINAL OBJECTIVE
4-7 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for a patient with a thoracic injury.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-7.1 Describe the incidence, morbidity, and mortality of thoracic injuries in the trauma patient. (C-1)
4-7.2 Discuss the anatomy and physiology of the organs and structures related to thoracic injuries. (C-1)
4-7.3 Predict thoracic injuries based on mechanism of injury. (C-2)
4-7.4 Discuss the types of thoracic injuries. (C-1)
4-7.5 Discuss the pathophysiology of thoracic injuries. (C-1)
4-7.6 Discuss the assessment findings associated with thoracic injuries. (C-1)
4-7.7 Discuss the management of thoracic injuries. (C-1)
4-7.8 Identify the need for rapid intervention and transport of the patient with thoracic injuries. (C-1)
4-7.9 Discuss the pathophysiology of specific chest wall injuries, including: (C-1)
   a. Rib fracture
   Flail segment
   Sternal fracture
4-7.10 Discuss the assessment findings associated with chest wall injuries. (C-1)
4-7.11 Identify the need for rapid intervention and transport of the patient with chest wall injuries. (C-1)
4-7.12 Discuss the management of chest wall injuries. (C-1)
4-7.13 Discuss the pathophysiology of injury to the lung, including: (C-1)
   Simple pneumothorax
   Open pneumothorax
   Tension pneumothorax
   Hemothorax
   Hemopneumothorax
   Pulmonary contusion
4-7.14 Discuss the assessment findings associated with lung injuries. (C-1)
4-7.15 Discuss the management of lung injuries. (C-1)
4-7.16 Identify the need for rapid intervention and transport of the patient with lung injuries. (C-1)
4-7.17 Discuss the pathophysiology of myocardial injuries, including: (C-1)
   a. Pericardial tamponade
   Myocardial contusion
   Myocardial rupture
4-7.18 Discuss the assessment findings associated with myocardial injuries. (C-1)
4-7.19 Discuss the management of myocardial injuries. (C-1)
4-7.20 Identify the need for rapid intervention and transport of the patient with myocardial injuries. (C-1)
4-7.21 Discuss the pathophysiology of vascular injuries, including injuries to: (C-1)
   a. Aorta
Vena cava
Pulmonary arteries/ veins
4-7.22 Discuss the assessment findings associated with vascular injuries. (C-1)
4-7.23 Discuss the management of vascular injuries. (C-1)
4-7.24 Identify the need for rapid intervention and transport of the patient with vascular injuries. (C-1)
4-7.25 Discuss the pathophysiology of diaphragmatic injuries. (C-1)
4-7.26 Discuss the assessment findings associated with diaphragmatic injuries. (C-1)
4-7.27 Discuss the management of diaphragmatic injuries. (C-1)
4-7.28 Identify the need for rapid intervention and transport of the patient with diaphragmatic injuries. (C-1)
4-7.29 Discuss the pathophysiology of esophageal injuries. (C-1)
4-7.30 Discuss the assessment findings associated with esophageal injuries. (C-1)
4-7.31 Discuss the management of esophageal injuries. (C-1)
4-7.32 Identify the need for rapid intervention and transport of the patient with esophageal injuries. (C-1)
4-7.33 Discuss the pathophysiology of tracheo-bronchial injuries. (C-1)
4-7.34 Discuss the assessment findings associated with tracheo-bronchial injuries. (C-1)
4-7.35 Discuss the management of tracheo-bronchial injuries. (C-1)
4-7.36 Identify the need for rapid intervention and transport of the patient with tracheo-bronchial injuries. (C-1)
4-7.37 Discuss the pathophysiology of traumatic asphyxia. (C-1)
4-7.38 Discuss the assessment findings associated with traumatic asphyxia. (C-1)
4-7.39 Discuss the management of traumatic asphyxia. (C-1)
4-7.40 Identify the need for rapid intervention and transport of the patient with traumatic asphyxia. (C-1)
4-7.41 Integrate the pathophysiological principles to the assessment of a patient with thoracic injury. (C-1)
4-7.42 Differentiate between thoracic injuries based on the assessment and history. (C-3)
4-7.43 Formulate a field impression based on the assessment findings. (C-3)
4-7.44 Develop a patient management plan based on the field impression. (C-3)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-7.45 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for thoracic trauma. (A-3)
4-7.46 Advocate the use of a thorough scene survey to determine the forces involved in thoracic trauma. (A-3)
4-7.47 Value the implications of failing to properly diagnose thoracic trauma. (A-2)
4-7.48 Value the implications of failing to initiate timely interventions to patients with thoracic trauma. (A-2)
PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-7.49 Demonstrate a clinical assessment for a patient with suspected thoracic trauma. (P-1)
4-7.50 Demonstrate the following techniques of management for thoracic injuries: (P-1)
   a. Needle decompression
   17. Fracture stabilization
   18. Elective intubation
   19. ECG monitoring
   20. Oxygenation and ventilation
DECLARATIVE

I. Introduction
   A. Epidemiology
      1. Incidence
      2. Morbidity and mortality of thoracic injuries
      3. Risk factors
      4. Prevention strategies
         a. Gun safety education
         b. Sports training
         c. Seat belts
         d. Other
   B. Mechanism of injury
      1. Classification
         a. Blunt thoracic injuries
            (1) Deceleration
            (2) Compression
         b. Penetrating thoracic injuries
      2. Injury patterns
         a. General Types
            (1) Open injuries
            (2) Closed Injuries
         b. Thoracic cage
         c. Cardiovascular
         d. Pleural and pulmonary
         e. Mediastinal
         f. Diaphragmatic
         g. Esophageal
         h. Penetrating cardiac trauma
      3. Blast injury
         a. Confined spaces
         b. Shock wave
   C. Anatomy and physiology review of the thorax
      1. Anatomy
         a. Skin
         b. Bones
            (1) Thoracic cage
            (2) Sternum
            (3) Thoracic spine
         c. Muscles
            (1) Intercostal
            (2) Trapezius
            (3) Latisissimus dorsi
            (4) Rhomboids
            (5) Pectoralis major
            (6) Diaphragm
d. Trachea

e. Bronchi

f. Lungs
(1) Parenchyma
(2) Alveoli
(3) Alveolar - capillary interface
(4) Pleura
   (a) Visceral
   (b) Parietal
   (c) Serous fluid

(5) Lobes

g. Vessels
(1) Arteries
   (a) Aorta
   (b) Carotid
   (c) Subclavian
   (d) Intercostal arteries
   (e) Innominate
   (f) Internal mammary

(2) Veins
   (a) Superior vena cava
   (b) Inferior vena cava
   (c) Subclavian
   (d) Internal jugular

(3) Pulmonary
   (a) Arteries
   (b) Veins

h. Heart
(1) Ventricles
(2) Atria
(3) Valves
(4) Pericardium

i. Esophagus
(1) Thoracic inlet
(2) Course through chest
(3) Esophageal foramen through diaphragm

j. Mediastinum
(1) Structures located in mediastinum
   (a) Heart
   (b) Trachea
   (c) Vena cava
   (d) Aorta
   (e) Esophagus

2. Physiology
a. Ventilation
(1) Expansion and contraction of thoracic cage
   (a) Bellows system
   (b) Musculoskeletal structure
   (c) Intercostal muscles
   (d) Diaphragm
II. General system pathophysiology, assessment and management of thoracic trauma

A. Pathophysiology

1. Impairments in cardiac output
   a. Blood loss
   b. Increased intrapleural pressures
   c. Blood in pericardial sac
   d. Myocardial valve damage
   e. Vascular disruption

2. Impairments in ventilatory efficiency
   a. Chest bellow action compromise
      (1) Pain restricting chest excursion
      (2) Air entering pleural space
      (3) Chest wall fails to move in unison
   b. Bleeding in pleural space
   c. Ineffective diaphragmatic contraction

3. Impairments in gas exchange
   a. Atelectasis
   b. Contused lung tissue
   c. Disruption of respiratory tract

B. Assessment findings

1. Pulse
   a. Deficit
   b. Tachycardia
   c. Bradycardia

2. Blood pressure
   a. Narrow pulse pressure
   b. Hypertension
   c. Hypotension
   d. Pulsus paradoxus

3. Respiratory rate and effort
   a. Tachypnea
   b. Bradypnea
   c. Labored
   d. Retractions
   e. Other evidence of respiratory distress

4. Possible hypothermia

(e) Accessory muscles
(f) Changes in intrathoracic pressure

b. Respiration
   (1) Neurochemical control
   (2) Gas exchange
      (a) Alveolar-capillary interface
      (b) Capillary-cellular interface
      (c) Pulmonary circulation
      (d) Cardiac circulation
      (e) Acid-base balance
         i) Henderson-Hasselbach equation
         ii) Respiratory alkalosis
         iii) Respiratory acidosis
         iv) Compensation for metabolic acidosis and alkalosis
5. Skin
   a. Diaphoresis
   b. Pallor
   c. Cyanosis
   d. Open wounds
   e. Ecchymosis
   f. Other evidence of trauma

6. Hemoptysis

7. Neck
   a. Position of trachea
   b. Subcutaneous emphysema
   c. Jugular venous distention
   d. Penetrating wounds

8. Chest
   a. Contusions
   b. Tenderness
   c. Asymmetry
   d. Lung sounds
      (1) Absent or decreased
         (a) Unilateral
         (b) Bilateral
      (2) Location
      (3) Bowel sounds in hemithorax
   e. Abnormal percussion finding
      (1) Hyperresonance
      (2) Hypoventilation
   f. Heart sounds
      (1) Muffled
      (2) Distant
      (3) Regurgitant murmur
   g. Shift of apical impulse
   h. Open wounds
   i. Impaled object or penetration
   j. Crepitation
   k. Paradoxical movement of chest wall segment

9. Scaphoid abdomen

10. Decreased level of consciousness

11. ECG
   a. ST - T wave elevation or depression
   b. Conduction disturbances
   c. Rhythm disturbances

12. History
   a. Dyspnea
   b. Chest pain
   c. Associated symptoms
      (1) Other areas of pain or discomfort
      (2) Symptoms prior to incident
   d. Past history of cardiorespiratory disease
   e. Use of restraint in motor vehicle crash
C0 Management
1 Airway and ventilation
   a0 Oxygen therapy
   b0 Endotracheal intubation
   c0 Needle cricothyrotomy
   d0 Surgical cricothyrotomy
   e0 Positive pressure ventilation
   f0 Occlude open wounds
   g0 Stabilize chest wall
2 Circulation
   a0 Manage cardiac dysrhythmias
   b0 Intravenous access
3 Pharmacologic
   a0 Analgesics
   b0 Antiarrhythmics
4 Non-pharmacologic
   a0 Needle thoracostomy
   b0 Tube thoracostomy - in hospital management
   c0 Pericardiocentesis - in hospital management
5 Transport considerations
   a0 Appropriate mode
   b0 Appropriate facility

III Chest wall injuries
A0 Rib fractures
1 Epidemiology
   a0 Incidence
     (1) Infrequent until adult life
     (2) Most often elderly patients
     (3) Significant force required
   b0 Morbidity/ mortality
     (1) Can lead to serious consequences
     (2) Older ribs more brittle and rigid
     (3) Associated underlying pulmonary or cardiovascular injury
     (4) Increases with
         (a) Age
         (b) Number of fractures
         (c) Location of fractures
2 Anatomy and physiology review
3 Pathophysiology
   a0 Most often caused by blunt trauma, bowing effect with midshaft fracture
   b0 Ribs 4 to 9 are most often fractured (thin and poorly protected)
   c0 Respiratory restriction due to pain and splinting
     (1) Atelectasis
     (2) Ventilation/ perfusion mismatch
   d0 May be associated with underlying lung or cardiac contusion
   e0 Intercostal vessel injury
   f0 Associated complications
     (1) First and second ribs are injured by severe trauma
         (a) Rupture of aorta
         (b) Tracheobronchial tree injury
Vascular injury
(2) Left lower rib injury associated with splenic rupture
(3) Right lower rib injury associated with hepatic injury
(4) Multiple rib fractures
  (a) Atelectasis
  (b) Hypoventilation
  (c) Inadequate cough
  (d) Pneumonia
(5) Open rib fracture associated with visceral injury
(6) Posterior rib fracture
  (a) Fifth through ninth ribs most frequently injured
  (b) Lower ribs associated with spleen and kidney injury

4 Assessment findings
a0 Localized pain
b0 Pain that worsens
  (1) Movement
  (2) Deep breathing
  (3) Coughing
c0 Point tenderness
d0 Crepitus or audible crunch
e0 Splinting on respiration
f0 Anteroposterior pressure elicits pain

5 Management
a0 Airway and ventilation
  (1) Oxygen therapy
  (2) Positive pressure ventilation
  (3) Encourage coughing and deep breathing
b0 Pharmacological
  (1) Analgesics
c0 Non-pharmacological
  (1) Splint - but avoid circumferential splinting
d0 Transport consideration
  (1) Appropriate mode
  (2) Appropriate facility
e0 Psychological support/ communication strategies

B0 Flail segment
1 Epidemiology
a0 Incidence
  (1) Most common cause is vehicular crash
  (2) Falls from heights
  (3) Industrial accidents
  (4) Assault
  (5) Birth trauma
b0 Morbidity/ mortality
  (1) Significant chest trauma
  (2) Mortality rates 20-40% due to associated injuries
  (3) Mortality increased with
    (a) Advanced age
    (b) Seven or more rib fractures
    (c) Three or more associated injuries
    (d) Shock
(e) Head injuries

2 Pathophysiology
a0 Three or more ribs fractured in two or more places producing a free floating segment of chest wall
b0 Respiratory failure due to
   (1) Underlying pulmonary contusion
   (2) Associated intrathoracic injury
   (3) Inadequate bellow action of chest
c0 Paradoxical movement of the chest
   (1) Minimal because of muscle spasm
   (2) Must be large to compromise ventilation
d0 Pain
   (1) Reduces thoracic expansion
   (2) Decreases ventilation
e0 Pulmonary contusion
   (1) Decreased lung compliance
   (2) Intra alveolar-capillary hemorrhage
   (3) Alveolar hemorrhage
f0 Decreased ventilation
g0 Impaired venous return with resultant ventilation-perfusion mismatch
h0 Hypercapnia
i0 Hypoxia

3 Assessment findings
a0 Chest wall contusion
b0 Respiratory distress
c0 Paradoxical chest wall movement
d0 Pleuritic chest pain
e0 Crepitus
f0 Pain and splinting of affected side
g0 Tachypnea
h0 Tachycardia
i0 Possible bundle branch block on ECG

4 Management
a0 Airway and ventilation
   (1) Positive pressure ventilation may be needed
   (2) Oxygen (high concentration)
   (3) Evaluate the need for endotracheal intubation
   (4) Stabilize flail segment (may be controversial locally)
   (5) Positive end expiratory pressure (PEEP)
b0 Circulation
   (1) Restrict fluids
c0 Pharmacologic
   (1) Analgesics
d0 Non-pharmacologic
   (1) Positioning
   (2) Endotracheal intubation and positive pressure ventilation for internal splinting effect
e0 Transport considerations
   (1) Appropriate mode
   (2) Appropriate facility
f0 Psychological support/ communication strategies
C0 Sternal fracture

1 Epidemiology
   a0 Incidence
      (1) 5-8% in blunt chest trauma
      (2) Deceleration compression injury
          (a) Steering wheel
          (b) Dashboard
      (3) Blow to chest
      (4) Severe hyperflexion of thoracic cage
      (5) Occur at or below the manubriosternal junction
   b0 Morbidity/ mortality
      (1) 25-45% mortality
      (2) High association with myocardial or lung injury
          (a) Myocardial contusion
          (b) Myocardial rupture
          (c) Pulmonary contusion

2 Pathophysiology
   a0 Associated injuries cause morbidity and mortality
      (1) Pulmonary and myocardial contusion
      (2) Flail chest
      (3) Vascular disruption of thoracic vessels
      (4) Intraabdominal injuries
      (5) Head injuries
   b0 Rarely is fracture displaced posteriorly to directly impinge on heart or vessels

3 Assessment findings
   a0 Localized pain
   b0 Tenderness over sternum
   c0 Crepitus
   d0 Tachypnea
   e0 ECG changes associated with myocardial contusion
   f0 History of blunt trauma

4 Management
   a0 Airway and ventilation
   b0 Circulation
      (1) Restrict fluids if pulmonary contusion is suspected

5 Pharmacologic
   a0 Analgesics

6 Non-pharmacologic
   a0 Allow chest wall self-splinting

7 Transport considerations
   a0 Appropriate mode
   b0 Appropriate facility

8 Psychological support/ communication strategies

IV Injury to the lung
A0 Simple pneumothorax

1 Epidemiology
   a0 Incidence
      (1) 10-30% in blunt chest trauma
      (2) Almost 100% with penetrating chest trauma
   b0 Morbidity/ mortality
(1) Extent of atelectasis
(2) Associated injuries

2 Pathophysiology
a0 Lung 1-3 cm away from the chest wall
b0 May have stable amount of accumulation of air
c0 Pulmonary function may be good
d0 Internal wound allows air to enter the pleural space
e0 Small tears self-seal, larger one may progress
f0 Paper bag syndrome
g0 If standing air will accumulate in the apices, check there first for diminished breath sounds otherwise, if supine it accumulates in the anterior chest
h0 Trachea may tug towards the effected side
i0 Ventilation/ perfusion mismatch

3 Assessment findings
a0 Tachypnea
b0 Tachycardia
c0 Respiratory distress
d0 Absent or decreased breath sounds on affected side
e0 Hyperresonance
f0 Decreased chest wall movement
g0 Dyspnea
h0 Chest pain referred to shoulder or arm on affected side
i0 Slight pleuritic chest pain

4 Management
a0 Airway and ventilation
   (1) Positive pressure ventilation if necessary
   (2) Monitor for development of tension pneumothorax
b0 Non-pharmacologic
   (1) Needle thorocostomy
c0 Transport consideration
   (1) Appropriate mode
   (2) Appropriate facility

5 Psychological support/ communication strategies

B0 Open pneumothorax

1 Epidemiology
a0 Incidence
   (1) Penetrating trauma
b0 Morbidity/ mortality
   (1) Profound hypoventilation could result
   (2) Death related to delayed management

2 Pathophysiology
a0 Open defect in the chest wall
   (1) Allows communication between pleural space and atmosphere
   (2) Prevents development of negative intrapleural pressure
   (3) Produces collapse of ipsilateral lung
   (4) Inability to ventilate affected lung
   (5) Ventilation/ perfusion mismatch
      (a) Shunting
      (b) Hypoventilation
      (c) Hypoxia
      (d) Large functional dead space
b0 Air will enter pleural space during inspiratory phase

c0 Air may exit during exhalation phase

d0 Resistance to air flow through respiratory tract may be greater than through open wound resulting in ineffective respiratory effort

e0 One way flap valve may let air in but not out resulting in built up pressure in pleural space

f0 Direct lung injury may be present

g0 Vena cava kinked from swaying of mediastinum

h0 Preload decreased from knifing of inferior vena cava

3 Assessment findings

a0 To and fro air motion out of defect

b0 Defect in the chest wall

c0 Penetrating injury to the chest which does not seal itself

d0 Sucking sound on inhalation

e0 Tachycardia

f0 Tachypnea

g0 Respiratory distress

h0 Subcutaneous emphysema

i0 Decreases breath sounds on affected side

4 Management

a0 Airway and ventilation

(1) Positive pressure ventilation if necessary

(2) Monitor for development of tension pneumothorax

b0 Non-pharmacologic

(1) Occlude open wound

(2) Tube thoracostomy - in hospital management

b0 Transport consideration

(1) Appropriate mode

(2) Appropriate facility

5 Psychological support/ communication strategies

C0 Tension pneumothorax

1 Epidemiology

a0 Incidence

(1) Penetrating trauma

(2) Blunt trauma

b0 Morbidity/ mortality

(1) Profound hypoventilation could result

(2) Death related to delayed management

(3) Immediate life-threatening chest injury

2 Pathophysiology

a0 Defect in airway allowing communication with pleural space

b0 Blunt trauma

(1) Penetration by rib fracture

(2) Sudden increase in intrapulmonary pressure

(3) Bronchial disruption from shear forces

C0 Air trapped in pleural space with build up of pressure

d0 Lung collapse on affected side with mediastinal shift to contralateral side

e0 Lung collapse leads to right-to-left intrapulmonary shunting and hypoxia

f0 Reduction in cardiac output

(1) Increased intrathoracic pressure
(2) Deformation of vena cava reducing preload (decreased venous return to heart)

3 Assessment findings
a0 Unilateral decreased or absent breath sounds
b0 Dyspnea
c0 Tachypnea
d0 Respiratory distress
e0 Extreme anxiety
f0 Cyanosis
g0 Bulging of intercostal muscles
h0 Tachycardia
i0 Hypotension
j0 Narrow pulse pressure
k0 Subcutaneous emphysema
l0 Jugular venous distention
m0 Tracheal deviation
n0 Hyperresonance

4 Management
a0 Airway and ventilation
   (1) Positive pressure ventilation if necessary
b0 Circulation
   (1) Relieve tension pneumothorax to improve cardiac output
c0 Non-pharmacologic
   (1) Occlude open wound
   (2) Needle thoracentesis
      (a) Equipment
      (b) Technique
      (c) Assess the need for a second or third needle insertion
   (3) Tube thoracostomy - in hospital management
d0 Transport consideration
   (1) Appropriate mode
   (2) Appropriate facility
e0 Psychological support/communication strategies

D0 Hemothorax

1 Epidemiology
a0 Incidence
   (1) Associated with pneumothorax
   (2) Blunt or penetrating trauma
   (3) Rib fractures are frequent cause
b0 Morbidity/mortality
   (1) Life-threatening injury that frequently requires urgent chest tube and/or surgery
   (2) Hemothorax associated with great vessel or cardiac injury
      (a) 50% will die immediately
      (b) 25% live five to ten minutes
      (c) 25% may live 30 minutes or longer

2 Pathophysiology
a0 Accumulation of blood in the pleural space
b0 Bleeding from
   (1) Penetrating or blunt lung injury
   (2) Chest wall vessels
(3) Intercostal vessels
(4) Myocardium
c) Pulmonary parenchyma is low-pressure vascular system
d) Bleeding from pulmonary contusion generally causes 1000 to 1500 cc blood loss
e) Massive hemothorax indicates great vessel or cardiac injury
f) Collapse of ipsilateral lung
g) Respiratory insufficiency dependent on amount of blood
h) Hypoxia
i) Hypotension and inadequate perfusion may result from blood loss
j) Chest cavity can hold 2,000 to 3,000 ml of blood
k) Classified by amount of blood loss
l) Tissue pressure effects of legs, arms and abdomen versus thorax
   (1) La Place law
   (2) Extraluminal pressure in legs
   (3) Extraluminal pressure in thorax
m) An intercostal artery can easily bleed 50 ccs per minute
n) Intrapulmonary hemorrhage
   (1) Bronchus
   (2) Parenchyma

3. Assessment findings
   a) Tachypnea
   b) Tachycardia
   c) Dyspnea
d) Respiratory distress
   e) Hypotension
   f) Narrow pulse pressure
   g) Pleuritic chest pain
   h) Pale, cool, moist skin
   i) Dullness on percussion
   j) Decreased breath sounds

4. Management
   a) Airway and ventilation
      (1) Positive pressure ventilation if necessary
   b) Circulation
      (1) Re-expand the affected lung to reduce bleeding
   c) Non-pharmacological
      (1) Needle chest decompression
      (2) Tube thoracostomy - in hospital management
d) Transport considerations
   (1) Appropriate mode
   (2) Appropriate facility
e) Psychological support/communication strategies

E. Hemopneumothorax
   1. Pathophysiology
      a) Pneumothorax with bleeding in pleural space
   2. Assessment
      a) Findings and management same as hemothorax
   3. Management
      a) Management is the same as a hemothorax

F. Pulmonary contusion
   1. Epidemiology
1. Incidence
   (1) Blunt trauma to chest
      (a) Most common injury from blunt thoracic trauma
      (b) 30-75% with blunt trauma have pulmonary contusion
   (2) Associated commonly with rib fracture
   (3) High energy shock waves from explosion
   (4) High velocity missile wounds
   (5) Rapid deceleration
   (6) High incidence of extrathoracic injuries
   (7) Low velocity - ice pick

2. Morbidity / mortality
   (1) Missed due to high incidence of other associated injuries
   (2) Mortality between 14-20%

2. Pathophysiology
   a. Three physical mechanisms
      (1) Implosion effect
         (a) Overexpansion of air in lungs secondary to positive-pressure concussive wave
         (b) Rapid excessive stretching and tearing of alveoli
      (2) Inertial effect
         (a) Strips alveoli from heavier bronchial structures when accelerated at varying rates by concussive wave
      (3) Spalding effect
         (a) Liquid-gas interface is disrupted by shock-wave
         (b) Wave releases energy
         (c) Differential transmission of energy causes disruption of tissue
   b. Alveolar and capillary damage with interstitial and intraalveolar extravasation of blood
   c. Interstitial edema
   d. Increased capillary membrane permeability
   e. Gas exchange disturbances
   f. Hypoxemia and carbon dioxide retention
   g. Hypoxia causes reflex thickening of mucous secretions
      (1) Bronchiolar obstruction
      (2) Atelectasis
   h. Blood is shunted away from unventilated alveoli leading to further hypoxemia

3. Assessment findings
   a. Tachypnea
   b. Tachycardia
   c. Cough
   d. Hemoptysis
   e. Apprehension
   f. Respiratory distress
   g. Dyspnea
   h. Evidence of blunt chest trauma
   i. Cyanosis

4. Management
   a. Airway and ventilation
      (1) Positive pressure ventilation if necessary
   b. Circulation
(1) Restrict intravenous fluids (use caution restricting fluids in hypovolemic patients)

c. Transport considerations
   (1) Appropriate mode
   (2) Appropriate facility

d. Psychological support/ communication strategies

V. Myocardial injuries
   A. Pericardial tamponade
      1. Epidemiology
         a. Incidence
            (1) Rare in blunt trauma
            (2) Penetrating trauma
            (3) Occurs in less than 2% of chest trauma
         b. Morbidity/ mortality
            (1) Gunshot wounds carry higher mortality than stab wounds
            (2) Lower mortality rate if isolated tamponade is present

   2. Anatomy and physiology
      a. Pericardium
         (1) Tough fibrous sac
         (2) Encloses heart
         (3) Attaches to great vessels at the base of heart
         (4) Two layers
            (a) Visceral forms epicardium
            (b) Parietal regarded as sac itself
         (5) Purposes
            (a) Anchor heart
            (b) Restricts excess movement
            (c) Prevents kinking of great vessels
         (6) Parietal layer is acutely nondispensable but can chronically distend by as much as 1,000 to 1,500 ml
         (7) Space between visceral and parietal layer is "potential space"
         (8) Space normally filled with 30-50 ml of straw-colored fluid secreted by visceral layer
            (a) Lubrication
            (b) Lymphatic drainage
            (c) Immunologic protection for heart

   3. Pathophysiology
      a. Rapid accumulation of fluid over a period of minutes to hours leads to increases in intrapericardial pressure
      b. Increased intrapericardial pressure
         (1) Compresses heart and decreases cardiac output due to restricted diastolic expansion and filling
         (2) Hampers venous return
      c. Myocardial perfusion decreases due to pressure effects on walls of heart and decreased diastolic pressures
      d. Ischemic dysfunction may result in infarction
      e. Removal of as little as 20 ml of blood may drastically improve cardiac output

   4. Assessment findings
      a. Tachycardia
      b. Respiratory distress
c. Narrow pulse pressure
d. Pulsus paradoxus
e. Cyanosis
   (1) Head
   (2) Neck
   (3) Upper extremities
f. Beck’s triad - advanced stage seen in only 30% of patients
   (1) Hypotension
   (2) Neck vein distention
   (3) Muffled heart tones
g. Kussmaul’s sign
h. ECG changes

5. Management
a. Airway and ventilation
b. Circulation
   (1) Fluid challenge
c. Non-pharmacological
   (1) Pericardiocentesis - in hospital management
d. Transport considerations
   (1) Appropriate mode
   (2) Appropriate facility
e. Psychological support/ communication strategies

B. Myocardial contusion (blunt myocardial injury)
1. Epidemiology
a. Incidence
   (1) 16-76% of blunt trauma
b. Morbidity/ mortality
   (1) Significant cause of morbidity and mortality in the blunt trauma patient

2. Pathophysiology
a. Hemorrhage with edema and fragmented myocardial fibers
b. Cellular injury
c. Vascular damage may occur
d. Hemopericardium may occur from lacerated epicardium or endocardium
e. Fibrinous reaction at contusion site may lead to
   (1) Delayed rupture
   (2) Ventricular aneurysm
f. Areas of damage are well demarcated
g. Conduction defects

3. Assessment findings
a. Associated injuries
   (1) One to three rib fractures
   (2) Sternal fracture
b. Retrosternal chest pain
c. ECG changes
   (1) Persistent tachycardia
   (2) ST elevation, T wave inversion
   (3) Right bundle branch block
   (4) Atrial flutter, fibrillation
   (5) Premature ventricular contractions
   (6) Premature atrial contractions
d. New cardiac murmur
e. Pericardial friction rub (late)

4. Management
   a. Airway and ventilation
      (1) Oxygen therapy
   b. Circulation
      (1) Intravenous fluid volume
   c. Pharmacological
      (1) Antiarrhythmics
      (2) Vasopressors
   d. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   e. Psychological support/communication strategies

C. Myocardial rupture
   1. Associated with immediate trauma or delayed for 2-3 weeks
   2. Associates with blunt trauma
   a. Compression between sternum and vertebrae
   3. Penetrating trauma
   a. Rib
   b. Missile
   c. Sternal bone
   4. History of trauma with a presentation of
   a. Congestive heart failure
   b. Cardiac tamponade
   5. Immediate onset of congestive heart failure following trauma
   a. Rupture of cardiac valves
   b. Intraventricular septal rupture
   6. Management is supportive

VI. Vascular injuries
A. Aortic dissection/rupture
   1. Epidemiology
      a. Incidence
         (1) Blunt trauma
            (a) Motor vehicle crash
            (b) Falls
         (2) 15% of all blunt trauma deaths
   2. Morbidity/mortality
      a. 85-95% die instantaneously
      b. 10-15% survive to arrive at hospital
         (1) 33% of survivors die within six hours
         (2) 33% of survivors die within twenty-four hours
         (3) 33% survive three days or longer
   3. Pathophysiology
      a. Shear injury
      b. Separation of the aortic intima and media
      c. Blood enters media through a small intima tear
      d. Tear due to effect of high speed deceleration on portions of the aorta at points of relative fixation
      e. Increased intraluminal pressure results from impact
      f. Thinned out layer may rupture
g. Descending aorta at the isthmus just distal to left subclavian artery is most common site of rupture (ligamentum arteriosum)

h. Ruptures of ascending aorta much less common

4. Assessment findings
   a. Retrosternal or interscapular pain
   b. Dyspnea
   c. Dysphagia
   d. Ischemic pain of the extremities
   e. Upper extremity hypertension with absent or decreased amplitude of femoral pulses
   f. Harsh systolic murmur over precordium or interscapular region

5. Management
   a. Airway and ventilation
   b. Circulation
      (1) Do not over hydrate
   c. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   d. Psychological support/ communication strategies

B. Penetrating wounds of the great vessels
   1. Usually involve
      a. Chest
      b. Abdomen
      c. Neck
   2. Wounds are accompanied by
      a. Massive hemothorax
      b. Hypovolemic shock
      c. Cardiac tamponade
      d. Enlarging hematomas
   3. Hematomas may cause compression of any structure
      a. Vena cava
      b. Trachea
      c. Esophagus
      d. Great vessels
      e. Heart
   4. Management
      a. Manage hypovolemia
         (1) PASG not recommended
      b. Relief of tamponade if present
      c. Expeditious transport

VII. Other thorax injuries
A. Diaphragmatic injury
   1. Epidemiology
      a. Incidence
         (1) Blunt trauma
         (2) Penetrating trauma
         (3) Frequently encountered injury
      b. Morbidity/ mortality
         (1) Could be life-threatening
   2. Pathophysiology
a. High-pressure compression to abdomen with resultant intra-abdominal pressure increase
b. Can produce very subtle signs and symptoms
c. Bowel obstruction and strangulation
d. Restriction of lung expansion
   (1) Hypoventilation
   (2) Hypoxia
e. Mediastinal shift
   (1) Cardiac compromise
   (2) Respiratory compromise

3. Assessment findings
a. Tachypnea
b. Tachycardia
c. Respiratory distress
d. Dullness to percussion
e. Scaphoid abdomen
f. Bowel sounds in affected hemithorax
g. Decreased breath sounds

4. Management
a. Airway and ventilation
   (1) Positive pressure ventilation if necessary
   (2) Caution IPPB may worsen the injury
b. Non-pharmacologic
   (1) Do not place patient in Trendelenburg position
c. Transport consideration
   (1) Appropriate mode
   (2) Appropriate facility
d. Psychological support/communication strategies

B. Esophageal injury
1. Epidemiology
a. Incidence
   (1) Penetrating trauma most frequent cause
   (2) Rare in blunt trauma
b. Morbidity/mortality
   (1) Could be life-threatening if missed

2. Pathophysiology
a. Missile and knife wounds penetrate esophagus
b. Can perforate spontaneously
   (1) Violent emesis
   (2) Carcinoma
   (3) Anatomic distortions produced by diverticulae or gastric reflux

3. Assessment findings
a. Pain
b. Fever
c. Hoarseness
d. Dysphagia
e. Respiratory distress
f. Cervical esophageal perforation
   (1) Local tenderness
   (2) Subcutaneous emphysema
   (3) Resistance of neck on passive motion
g. Intrathoracic esophageal perforation
   (1) Mediastinal emphysema
   (2) Mediastinitis
   (3) Subcutaneous emphysema
   (4) Mediastinal crunch
   (5) Splinting of chest wall
h. Respiratory distress
i. Shock

4. Management
   a. Airway and ventilation
   b. Transport consideration
      (1) Appropriate mode
      (2) Appropriate facility
   c. Psychological support/communication strategies

C. Tracheo-bronchial injuries
1. Epidemiology
   a. Incidence
      (1) Rare injury - less than 3% of chest trauma
      (2) Penetrating trauma
      (3) Blunt trauma
   b. Morbidity/mortality
      (1) High mortality rate - greater than 30%

2. Pathophysiology
   a. Majority occur within 3 cm of carina
   b. Tear can occur anywhere along tracheal/bronchial tree
   c. Rapid movement of air into pleural space
   d. Tension pneumothorax refractory to needle decompression
   e. Continuous flow of air from needle of decompressed chest
   f. Severe hypoxia

3. Assessment
   a. Tachypnea
   b. Tachycardia
   c. Massive subcutaneous emphysema
   d. Dyspnea
   e. Respiratory distress
   f. Hemoptysis
   g. Signs of tension pneumothorax that doesn't respond to needle decompression

4. Management
   a. Airway and ventilation
   b. Circulation
   c. Transport consideration
      (1) Appropriate mode
      (2) Appropriate facility

D. Traumatic asphyxia
1. Epidemiology
   a. Incidence
   b. Morbidity/mortality

2. Pathophysiology
   a. Sudden compressional force squeezes the chest
   b. Blood backs up into the head and neck
   c. Jugular veins engorge, capillaries rupture
3. Assessment
   a. Cyanosis to the face and upper neck
   b. Jugular venous distention
   c. Swelling or hemorrhage of the conjunctiva
   d. Skin below area remains pink
   e. Hypotension when pressure released

4. Management
   a. Airway and ventilation
   b. Circulation
      (1) Expect hypotension once compression is released
   c. Pharmacological
      (1) Sodium bicarbonate should be guided by ABGs in hospital
   d. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility

VIII. Integration
UNIT TERMINAL OBJECTIVE
4-8 At the completion of this unit, the paramedic student will be able to integrate pathophysiologic principles and the assessment findings to formulate a field impression and implement the treatment plan for the patient with suspected abdominal trauma.

COGNITIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-8.1 Describe the epidemiology, including the morbidity/mortality and prevention strategies for a patient with abdominal trauma. (C-1)
4-8.2 Describe the anatomy and physiology of organs and structures related to abdominal injuries. (C-1)
4-8.3 Predict abdominal injuries based on blunt and penetrating mechanisms of injury. (C-2)
4-8.4 Describe open and closed abdominal injuries. (C-1)
4-8.5 Explain the pathophysiology of abdominal injuries. (C-1)
4-8.6 Describe the assessment findings associated with abdominal injuries. (C-1)
4-8.7 Identify the need for rapid intervention and transport of the patient with abdominal injuries based on assessment findings. (C-1)
4-8.8 Describe the management of abdominal injuries. (C-1)
4-8.9 Integrate the pathophysiological principles to the assessment of a patient with abdominal injury. (C-3)
4-8.10 Differentiate between abdominal injuries based on the assessment and history. (C-3)
4-8.11 Formulate a field impression for patients with abdominal trauma based on the assessment findings. (C-3)
4-8.12 Develop a patient management plan for patients with abdominal trauma based on the field impression. (C-3)
4-8.13 Describe the epidemiology, including the morbidity/mortality and prevention strategies for solid organ injuries. (C-1)
4-8.14 Explain the pathophysiology of solid organ injuries. (C-1)
4-8.15 Describe the assessment findings associated with solid organ injuries. (C-1)
4-8.16 Describe the treatment plan and management of solid organ injuries. (C-1)
4-8.17 Describe the epidemiology, including the morbidity/mortality and prevention strategies for hollow organ injuries. (C-1)
4-8.18 Explain the pathophysiology of hollow organ injuries. (C-1)
4-8.19 Describe the assessment findings associated with hollow organ injuries. (C-1)
4-8.20 Describe the treatment plan and management of hollow organ injuries. (C-1)
4-8.21 Describe the epidemiology, including the morbidity/mortality and prevention strategies for abdominal vascular injuries. (C-1)
4-8.22 Explain the pathophysiology of abdominal vascular injuries. (C-1)
4-8.23 Describe the assessment findings associated with abdominal vascular injuries. (C-1)
4-8.24 Describe the treatment plan and management of abdominal vascular injuries. (C-1)
4-8.25 Describe the epidemiology, including the morbidity/mortality and prevention strategies for pelvic fractures. (C-1)
4-8.26 Explain the pathophysiology of pelvic fractures. (C-1)
4-8.27 Describe the assessment findings associated with pelvic fractures. (C-1)
4-8.28 Describe the treatment plan and management of pelvic fractures. (C-1)
4-8.29 Describe the epidemiology, including the morbidity/mortality and prevention strategies for other related abdominal injuries. (C-1)
4-8.30 Explain the pathophysiology of other related abdominal injuries. (C-1)
4-8.31 Describe the assessment findings associated with other related abdominal injuries. (C-1)
4-8.32 Describe the treatment plan and management of other related abdominal injuries. (C-1)
4-8.33 Apply the epidemiologic principles to develop prevention strategies for abdominal injuries. (C-2)
4-8.34 Integrate the pathophysiological principles to the assessment of a patient with abdominal injuries. (C-3)
4-8.35 Differentiate between abdominal injuries based on the assessment and history. (C-3)
4-8.36 Formulate a field impression based upon the assessment findings for a patient with abdominal injuries. (C-3)
4-8.37 Develop a patient management plan for a patient with abdominal injuries, based upon field impression. (C-3)

**AFFECTIVE OBJECTIVES**
At the completion of this unit, the paramedic student will be able to:

4-8.38 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for abdominal trauma. (A-3)
4-8.39 Advocate the use of a thorough scene survey to determine the forces involved in abdominal trauma. (A-3)
4-8.40 Value the implications of failing to properly diagnose abdominal trauma and initiate timely interventions to patients with abdominal trauma. (A-2)

**PSYCHOMOTOR OBJECTIVES**
At the completion of this unit, the paramedic student will be able to:

4-8.41 Demonstrate a clinical assessment to determine the proper treatment plan for a patient with suspected abdominal trauma. (P-1)
4-8.42 Demonstrate the proper use of PASG in a patient with suspected abdominal trauma. (P-1)
4-8.43 Demonstrate the proper use of PASG in a patient with suspected pelvic fracture. (P-1)
I. Introduction
   A. Epidemiology
      1. Increased incidence of morbidity and mortality
         a. Due to delay to surgical intervention
         b. Death occurs as a result of increased hemorrhage due to delay
            (1) Solid organ injuries
            (2) Hollow organ injuries
            (3) Abdominal vascular injuries
            (4) Pelvic fractures
   2. Prevention strategies
   B. Anatomy review
      1. Boundaries of the abdomen
         a. Diaphragm
         b. Anterior abdominal wall
         c. Pelvic skeletal structures
         d. Vertebral column
         e. Muscles of the abdomen and flanks
      2. Surface anatomy of the abdomen
         a. Quadrants
            (1) Upper
               (a) Right
               (b) Left
            (2) Lower
               (a) Right
               (b) Left
         b. Xiphoid
         c. Symphysis pubis
         d. Umbilicus
      3. Intraperitoneal structures
         a. Liver
         b. Spleen
         c. Stomach
         d. Small bowel
         e. Colon
         f. Gallbladder
         g. Female reproductive organs
      4. Retroperitoneal structures
         a. Central structures
            (1) Duodenum
            (2) Pancreas
            (3) Major vascular structures
         b. Lateral structures
            (1) Kidneys
            (2) Ureters
            (3) Posterior ascending and descending colon
         c. Pelvic structures
            (1) Rectum
            (2) Ureters
            (3) Pelvic vascular plexus
5. Physiology review
   a. Injury to abdominal structures causes morbidity and mortality primarily as a result of hemorrhage
   b. Injury may be subtle
   c. High index of suspicion
   d. Solid organs
      (1) Hemorrhage
      (2) Shock
   e. Hollow organs
      (1) Spillage of contents
      (2) Peritonitis
   f. Vascular structures
      (1) Hemorrhage
      (2) Shock

C. Mechanism of injury review
1. Index of suspicion
2. Blunt mechanisms
   a. Compression forces
   b. Shear forces
   c. Deceleration forces
   d. Motor vehicle collisions
      (1) Head-on or frontal impact
         (a) Down and under path
         (b) Up and over path
      (2) Rear impact
      (3) Lateral or side impact
      (4) Rotational impact
      (5) Rollover
      (6) Restrained (type of restraint) or unrestrained
      (7) Seat belt injuries
      (8) Steering wheel injuries
   e. Motorcycle collisions
   f. Pedestrian injuries
   g. Falls
   h. Assault
   i. Blast injuries
3. Penetrating mechanisms
   a. Energy imparted to the body
      (1) Low velocity
         (a) Knife
         (b) Ice pick
      (2) Medium velocity
         (a) Gunshot wounds
         (b) Shotgun wounds
      (3) High velocity
         (a) High power hunting rifles
         (b) Military weapons
         (c) Ballistics
II. General system pathophysiology, assessment, and management
   A. Pathophysiology of abdominal injuries
      1. Hemorrhage
         a. No external signs
         b. Rapid blood loss
         c. Hypovolemic shock
         d. Blood is not chemical irritant to peritoneum (therefore, no peritonitis)
      2. Spillage of contents
         a. Enzymes
         b. Acids
         c. Bacteria
         d. Chemical irritation to peritoneum (peritonitis)
         e. Localized pain sensation via somatic nerve fibers
         f. Muscular spasm secondary to peritonitis (rigid abdomen)
   B. Assessment
      1. Focused history and physical examination
         a. General
            (1) Head injury and/or intoxicants (drugs/ethanol) mask signs and symptoms
            (2) Hemoperitoneum (solid organ or vascular injuries)
               (a) Blood not chemical irritant to peritoneum
               (b) Adult abdomen will accommodate 1.5 liters with no abdominal distention
               (c) Often present even with normal abdominal exam
               (d) Unexplained shock
               (e) Shock out of proportion to known injuries
            (3) Peritonitis (hollow organ injury)
               (a) Pain (subjective symptom from patient)
               (b) Tenderness (objective sign with percussion/palpation)
               (c) Guarding/rigidity
               (d) Distention (late finding)
            (4) Abrasions
            (5) Ecchymosis
            (6) Visible wounds
            (7) Mechanism of injury
            (8) Unexplained shock
         b. Critical findings
            (1) Rapid assessment and transport
            (2) Detailed assessment
            (3) On-going assessment
         c. Noncritical findings
            (1) Focused history and physical examination
            (2) Other interventions and transport considerations
      2. Comprehensive assessment
         a. Vital signs
            (1) Indications of shock
b. Inspection
   (1) Abrasions
   (2) Ecchymosis
      (a) Seat belt sign
   (3) Distention
   (4) Obvious external blood loss
   (5) Wounds
   (6) Impaled object
   (7) Evisceration

c. Auscultation - not useful out-of-hospital assessment tool

d. Percussion (tenderness)

e. Palpation
   (1) Tenderness
   (2) Guarding/ rigidity
   (3) Pelvic stability/ tenderness

f. Absence of signs and/ or symptoms does not rule-out abdominal injuries

g. Not necessary to determine definitively if abdominal injuries are present

h. Examine the back

3. Differential diagnosis and continued management

C. Management/ treatment plan

1. Surgical intervention only effective therapy
2. No definitive therapy possible out-of-hospital
3. Rapid evaluation
4. Initiation of shock resuscitation
5. Rapid packaging and transport to nearest appropriate facility
   a. Facility must have immediate surgical capability
   b. Rapid transport
      (1) Defeated if hospital cannot provide immediate surgical intervention
6. Crystalloid fluid replacement
   a. En route to hospital
7. Airway support
8. Breathing support
9. Circulatory support
   a. Control obvious hemorrhage
   b. Tamponade bleeding
   c. Manage hypotension
      (1) Fluid resuscitation

10. Patient packaging
11. Transport
   a. Indications for rapid transport
      (1) Critical findings
      (2) Surgical intervention required to control hemorrhage and/ or contamination
      (3) High index of suspicion for abdominal injury
      (4) Unexplained shock
      (5) Physical signs of abdominal injury
      (6) Hemorrhage continues until controlled in the operating room
      (7) Survival determined by length of time from injury to definitive surgical control of hemorrhage
      (8) Any delay in the field negatively impacts this time period
   b. Indications for transport to trauma center
c. Indications for transport to acute care facility

d. Indications for no transport required

III. Specific injuries

A. Solid organ injuries

1. Epidemiology

   a. Morbidity/ mortality
      (1) Secondary to blood loss
      (2) Result of blunt and penetrating injuries

b. Prevention strategies

c. Anatomy and physiology review

d. Pathophysiology

e. Assessment
   (1) Initial assessment
   (2) Focused history and physical examination
      (a) Critical findings
         i) Presence of shock
         ii) Mechanism of injury
         iii) Obvious external signs of abdominal trauma
         iv) Unexplained shock
         v) Shock out of proportion to known injuries
         vi) Presence of physical signs of acute abdomen
            a) Rigidity
            b) Guarding
            c) Distention
         vii) Rapid assessment and transport
         viii) Detailed assessment
         ix) On-going assessment
      (b) Non-critical findings
         i) Focused history and physical examination
         ii) Other interventions and transport considerations
         iii) On-going assessment
   (3) Comprehensive assessment
      (a) Vital signs
      (b) Inspection
      (c) Percussion
      (d) Palpation
   (4) Differential diagnosis and continued management

2. Liver injuries

   a. Morbidity and mortality
      (1) Result of blood loss
   b. Injuries result of
      (1) Blunt trauma
      (2) Penetrating trauma
3. Splenic injuries
   a. Most frequently injured organ
      (1) Blunt trauma
      (2) Commonly associated with other intra abdominal injuries
      (3) May present with left shoulder pain
         a) Result of diaphragm irritation

4. Kidney injuries
   a0 Often presents with hematuria
   b0 Back pain

5. Pancreas
   a0 Most common with penetrating injuries
   b0 May also occur as a result of pancreas being compressed against vertebral column by
      (1) Steering wheels
      (2) Handle bars
      (3) Other structures stronger then the pancreas
   c0 Products of pancreas have an irritation effect on peritoneum
   d0 Auto-digestion of tissue

6. Diaphragm
   a0 Injury often insidious
   b0 Herniation of abdominal contents into chest may occur

B0 Hollow organ injuries

1. Epidemiology
   a0 Morbidity/ mortality
      (1) Secondary to blood loss and content spillage
      (2) Result of blunt and penetrating injuries
   b0 Prevention strategies
   c0 Anatomy and physiology review
   d0 Pathophysiology
   e0 Assessment
      (1) Initial assessment
      (2) Focused history and physical examination
         (a) Critical findings
            i Presence of shock
            ii Mechanism of injury
            iii Obvious external signs of abdominal trauma
            iv Unexplained shock
            v Shock out of proportion to known injuries
            vi Presence of physical signs of acute abdomen
               a65535 Rigidity
               b65535 Guarding
               c65535 Distention
            vii Rapid assessment and transport
            viii Detailed assessment
            ix On-going assessment
         (b) Non-critical findings
            i Focused history and physical examination
            ii Other interventions and transport considerations
            iii On-going assessment
(3) Comprehensive assessment
   (a) Vital signs
   (b) Inspection
   (c) Percussion
   (d) Palpation
(4) Differential diagnosis and continued management

f0 Management/ treatment plan
   (1) Airway support
   (2) Breathing support
   (3) Circulatory support
   (4) Patient packaging
   (5) Transport
   (6) Psychological support/ communications strategies

2 Small and large intestines
a0 Most often injured as a result of
   (1) Penetrating injuries
b0 Can occur with deceleration injuries

3 Stomach
a0 Most often injured as a result of
   (1) Blunt trauma
   (2) Full stomach prior to incident increases risk of injury

4 Duodenum
a0 Most often injured as a result of
   (1) Blunt trauma
b0 Recognition often delayed

5 Bladder
a0 Most often injured as a result of
   (1) Blunt trauma
   (2) Full bladder prior to incident may increase risk of injury
b0 Associated with pelvic injury

C0 Abdominal vascular injuries
1 Epidemiology
   a0 Morbidity/ mortality
   b0 Prevention strategies

2 Anatomy and physiology review

3 Pathophysiology

4 Assessment
   a0 Initial assessment
   b0 Focused history and physical examination
      (1) Critical findings
         (a) Rapid assessment and transport
         (b) Detailed assessment
         (c) On-going assessment
      (2) Non-critical findings
         (a) Focused history and physical examination
         (b) Other interventions and transport considerations
         (c) On-going assessment
   c0 Comprehensive assessment
      (1) Vital signs
      (2) Inspection
(3) Percussion
(4) Palpation
d0 Differential diagnosis and continued management
5 Management/ treatment plan
a0 Airway support
b0 Breathing support
c0 Circulatory support
d0 Patient packaging
e0 Transport
f0 Psychological support/ communications strategies
D0 Pelvic fractures
1 Epidemiology
   a0 Morbidity/ mortality
   b0 Prevention strategies
2 Anatomy and physiology review
3 Pathophysiology
4 Assessment
   a0 Initial assessment
   b0 Focused history and physical examination
      (1) Critical findings
         (a) Rapid assessment and transport
         (b) Detailed assessment
         (c) On-going assessment
      (2) Non-critical findings
         (a) Focused history and physical examination
         (b) Other interventions and transport considerations
         (c) On-going assessment
      (3) Associated injuries
         (a) Bladder
         (b) Urethra
c0 Comprehensive assessment
   (1) Vital signs
   (2) Inspection
      (a) Check perineum for
         i Ecchymosis
         ii Blood
      (b) Check meatus of penis for blood
   (3) Palpation
d0 Differential diagnosis and continued management
5 Management/ treatment plan
a0 Airway support
b0 Breathing support
c0 Circulatory support
   (1) PASG
d0 Patient packaging
e0 Transport
f0 Psychological support/ communications strategies
E0 Other related abdominal injuries
1 Abdominal wall injuries
   a0 Eviscerations
      (1) Epidemiology
(a) Morbidity/ mortality
(b) Prevention strategies
(2) Anatomy and physiology review
(3) Pathophysiology
(4) Assessment
(a) Initial assessment
(b) Focused history and physical examination
   i Critical findings
      a65535 Rapid assessment and transport
      b65535 Detailed assessment
      c65535 On-going assessment
   ii Non-critical findings
      a65535 Focused history and physical examination
      b65535 Other interventions and transport considerations
      c65535 On-going assessment
(c) Comprehensive assessment
   i Vital signs
   ii Inspection
   iii Percussion
   iv Palpation
(d) Differential diagnosis and continued management
(5) Management/ treatment plan
(a) Airway support
(b) Breathing support
(c) Circulatory support
(d) Patient packaging
   i Do not replace organs back into abdomen
   ii Protect organs from further damage
   iii Cover with sterile saline moistened dressing
(e) Transport
(f) Psychological support/ communications strategies
UNIT TERMINAL OBJECTIVE
4-9 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement the treatment plan for the patient with a musculoskeletal injury.

COGNITIVE OBJECTIVE
At the completion of this unit, the paramedic student will be able to:

4-9.1 Describe the incidence, morbidity, and mortality of musculoskeletal injuries. (C-1)
4-9.2 Discuss the anatomy and physiology of the musculoskeletal system. (C-1)
4-9.3 Predict injuries based on the mechanism of injury, including: (C-3)
   Direct
   Indirect
   Pathologic
4-9.4 Discuss the types of musculoskeletal injuries: (C-1)
   a. Fracture (open and closed)
   21. Dislocation/ fracture
   22. Sprain
   23. Strain
4-9.5 Discuss the pathophysiology of musculoskeletal injuries. (C-1)
4-9.6 Discuss the assessment findings associated with musculoskeletal injuries. (C-1)
4-9.7 List the six "P"s of musculoskeletal injury assessment. (C-1)
4-9.8 List the primary signs and symptoms of extremity trauma. (C-1)
4-9.9 List other signs and symptoms that can indicate less obvious extremity injury. (C-1)
4-9.10 Discuss the need for assessment of pulses, motor and sensation before and after splinting. (C-1)
4-9.11 Identify the need for rapid intervention and transport when dealing with musculoskeletal injuries. (C-1)
4-9.12 Discuss the management of musculoskeletal injuries. (C-1)
4-9.13 Discuss the general guidelines for splinting. (C-1)
4-9.14 Explain the benefits of cold application for musculoskeletal injury. (C-1)
4-9.15 Explain the benefits of heat application for musculoskeletal injury. (C-1)
4-9.16 Describe age associated changes in the bones. (C-1)
4-9.17 Discuss the pathophysiology of open and closed fractures. (C-1)
4-9.18 Discuss the relationship between volume of hemorrhage and open or closed fractures. (C-3)
4-9.19 Discuss the assessment findings associated with fractures. (C-1)
4-9.20 Discuss the management of fractures. (C-1)
4-9.21 Discuss the usefulness of the pneumatic anti-shock garment (PASG) in the management of fractures. (C-1)
4-9.22 Describe the special considerations involved in femur fracture management. (C-1)
4-9.23 Discuss the pathophysiology of dislocations. (C-1)
4-9.24 Discuss the assessment findings of dislocations. (C-1)
4-9.25 Discuss the out-of-hospital management of dislocation/ fractures, including splinting and realignment. (C-1)
4-9.26 Explain the importance of manipulating a knee dislocation/ fracture with an absent distal pulse. (C-1)
4-9.27 Describe the procedure for reduction of a shoulder, finger or ankle dislocation/ fracture. (C-1)
4-9.28 Discuss the pathophysiology of sprains. (C-1)
4-9.29 Discuss the assessment findings of sprains. (C-1)
4-9.30 Discuss the management of sprains. (C-1)
4-9.31 Discuss the pathophysiology of strains. (C-1)
4-9.32 Discuss the assessment findings of strains. (C-1)
4-9.33 Discuss the management of strains. (C-1)
4-9.34 Discuss the pathophysiology of a tendon injury. (C-1)
4-9.35 Discuss the assessment findings of tendon injury. (C-1)
4-9.36 Discuss the management of a tendon injury. (C-1)
4-9.37 Integrate the pathophysiological principles to the assessment of a patient with a musculoskeletal injury. (C-3)
4-9.38 Differentiate between musculoskeletal injuries based on the assessment findings and history. (C-3)
4-9.39 Formulate a field impression of a musculoskeletal injury based on the assessment findings. (C-3)
4-9.40 Develop a patient management plan for the musculoskeletal injury based on the field impression. (C-3)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-9.41 Advocate the use of a thorough assessment to determine a working diagnosis and treatment plan for musculoskeletal injuries. (A-3)
4-9.42 Advocate for the use of pain management in the treatment of musculoskeletal injuries. (A-3)

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-9.43 Demonstrate a clinical assessment to determine the proper treatment plan for a patient with a suspected musculoskeletal injury. (P-1)
4-9.44 Demonstrate the proper use of fixation, soft and traction splints for a patient with a suspected fracture. (P-1)
DECLARATIVE

I. Introduction
   A. Epidemiology
      1. Incidence
         a. 70-80% of polytrauma patients suffer musculoskeletal injuries
         b. Blunt trauma
         c. Penetrating trauma
      2. Mortality/ morbidity
         a. Upper extremity injury
            (1) Contribute to long-term impairment
            (2) Rarely life-threatening
         b. Lower extremity injury
            (1) Associated with higher magnitudes of injury
            (2) More significant blood loss
            (3) More difficult to manage in polytrauma patient
            (4) Femur and pelvic injuries may constitute life threats
      3. Risk factors
      4. Prevention strategies
         a. Proper sports training
         b. Wearing seat belts
         c. Child safety seats
         d. Airbags
         e. Gun safety and education
         f. Motorcycle driver education
         g. Fall prevention
         h. Highrise window guards
         i. Other means of preventing musculoskeletal trauma
      5. Review of musculoskeletal anatomy
         a. Skin
            (1) Layer
            (2) Thickness
         b. Subcutaneous
            (1) Fat
            (2) Fascia
         c. General breakdown of the skeletal system
            (1) Axial skeleton
               (a) Forms the central (longitudinal) axis of the body, includes the following bones
                  i) Skull
                  ii) Vertebral column
                  iii) Bony thorax
               (b) Appendicular skeleton
               (c) Pectoral girdle - bones that attach the upper limbs to the axial skeleton
                  i) Clavicle
                  ii) Scapula
(d) Pelvic girdle - consists of the paired bones of the pelvis that attach the lower limbs to the axial skeleton, and the sacrum

(2) Vessels
   (a) Arteries
      i) Axillary
      ii) Brachial
      iii) Radial
      iv) Ulnar
      v) Hand arcade
      vi) Digital
      vii) Femoral
      viii) Popliteal
      ix) Dorsalis pedis
      x) Posterior tibial
      xi) Anterior tibial
      xii) Foot arcade
      xiii) Digital

(3) Muscles
   (a) Latissimus dorsi
   (b) Trapezius
   (c) Rhomboids
   (d) Deltoid
   (e) Triceps
   (f) Biceps
   (g) Forearm extensors
   (h) Intrinsic muscles of hand
   (i) Hamstring group
   (j) Quadriceps group
   (k) Adductor group
   (l) Gastrocnemius solius
   (m) Intraosseous

(4) Tendons
   (a) Extensors
   (b) Flexors

(5) Bones
   (a) Components of a longbone
      i) Diaphysis
         a) Long, narrow shaft
         b) Very dense, compact bone
         c) Yellow bone marrow that stores fat
      ii) Periosteum
         a) Outer covering for long bones
         b) Vascular and full of nerves
         c) Haversian canals allow circulation of blood
      iii) Epiphysis
         a) Articulated, widened end
         b) Cancellous bone filled with red blood marrow
         c) Responsible for growth in the infant and child
d) Weakest point in a child’s bone and weaker than a child’s ligaments
   iv) Metaphysis
      a) Area between the epiphysis and diaphysis

(6) Scapulae
   (a) Upper division
   (b) Lower division
   (c) Glenoid fossa

(7) Clavicle
   (a) Claviculo-sternal joint
   (b) Acromio-clavicular joint

(8) Humerus
   (a) Head
      i) Anatomical neck
      ii) Surgical neck
   (b) Tuberosities
   (c) Shoulder joint
   (d) Neck
   (e) Shaft
   (f) Medial condyle
   (g) Lateral condyle
   (h) Elbow

(9) Radius
   (a) Elbow
   (b) Head
   (c) Shaft
   (d) Wrist

(10) Ulna
    (a) Elbow
    (b) Olecranon
    (c) Shaft
    (d) Wrist

(11) Carpals
     (a) Articulation
     (b) Wrist
     (c) Metacarpal joint

(12) Metacarpals
     (a) Articulations
     (b) Shaft

(13) Phalanges
     (a) Metacarpal-phalange joint
     (b) Proximal intraphalange joint
     (c) Distal intraphalange joint

(14) Pelvis
     (a) Ilium
     (b) Ischium
     (c) Pubis
     (d) Acetabulum
(15) Femur
   (a) Hip joint
   (b) Head
   (c) Neck
   (d) Trochanters
      i) Greater trochanter
      ii) Lesser trochanter
   (e) Shaft
   (f) Medial and lateral condyles
(16) Tibia
   (a) Knee joint
   (b) Articular surfaces/ plateaus
   (c) Shaft
   (d) Medial malleolus
(17) Fibula
   (a) Head
   (b) Shaft
   (c) Lateral malleolus
(18) Talus
   (a) Ankle joint
   (b) Articulation
(19) Calcaneus
   (a) Heel
   (b) Articulation
(20) Tarsals
   (a) Articulations
   (b) Arch
(21) Metatarsal
   (a) Arch
   (b) Articulations
(22) Phalanges
   (a) Shaft
   (b) Joints

d. Function
   (1) Flexion
   (2) Extension
   (3) Rotation

e0 Age associated changes in bones
   (1) Morphological changes
      (a) Water content of intervertebral disks decreases
      (b) Increased risk of disk herniation
      (c) Loss of 1/2 to 3/4 inch in stature is common
      (d) Bone tissue disorders shorten the trunk
      (e) Vertebral column gradually assumes an arc shape
      (f) Costal cartilages ossify making the thorax more rigid
      (g) Shallow breathing due to rigid thoracic cage
      (h) Facial contours change
   (2) Fractures
(a) Bones are more prone to fracture since they are more porous and brittle
(b) Vertebral and femoral neck fractures are most common
(c) Degree of bone disorder (osteoporosis) is related to incidence of fracture

6 Physiology

a0 Purpose of the muscles
(1) Cardiac muscle
   (a) Contracts rhythmically on its own
   (b) Generates electrical impulses
      i Automaticity
      ii Excitability
      iii Conductivity
(2) Smooth muscle
   (a) Found in lower airways, blood vessels, intestines
   (b) Under control of automatic nervous system
   (c) Can relax or contract to alter the inner lumen diameter
(3) Skeletal muscle
   (a) Under conscious control
   (b) Major muscle mass of the body, allows mobility

b0 Muscular support of skeleton
(1) Tendons
   (a) Bands of connective tissue binding muscles to bones (M-T-B)
   (b) Allows for power of movement across the joints
(2) Cartilage
   (a) Connective tissue covering the epiphysis
   (b) Act as surface for articulation
   (c) Allow for smooth movement at joints
(3) Ligaments
   (a) Connective tissue which support joints
   (b) Attach to bone ends
   (c) Allow for stable range of motion

c0 Purpose of the bones
(1) Acts as a structural form, protects vital organs
(2) Acts as point of attachment for tendons, cartilage, and ligaments
(3) Structure for muscles to allow movement
(4) Stores salts and metabolic materials
(5) Produces red blood cells

d0 Structural classifications of joints
(1) Fibrous
   (a) Sutures - immovable
      i An immovable joint with one exception
      ii All bones of the skull are united by sutures
   (b) Syndesmoses
   (c) Gomphoses
(2) Cartilaginous
   (a) Defined
   (b) Synchondroses
Symphysis
(a) Defined - fluid filled chamber which lubricates articulated surfaces
(b) Types of synovial joints
   i  Plane
   ii Hinge
   iii Pivot
   iv Condyloid
   v  Saddle
   vi Ball and socket

Movements allowed by synovial joints
(1)  Gliding
(2)  Angular movements
   (a)  Flexion
   (b)  Extension
   (c)  Abduction
   (d)  Adduction
   (e)  Circumduction
(3)  Rotation

The interrelationship of the musculoskeletal system working together to move a complex joint (e.g., the knee)

Musculoskeletal pathophysiology-adult
A0  Problems associated with musculoskeletal injuries
  1  Hemorrhage
  2  Instability
  3  Loss of tissue
  4  Simple lacerations and contamination
  5  Interruption of blood supply
  6  Long term disability
B0  Fractures
  1  Types
     a0  Open (compound)
     b0  Closed (simple)
  2  Location
     a0  Humerus
     b0  Radius
         (1)  Silver fork deformity
     c0  Ulna
     d0  Metacarpal
     e0  Phalange
     f0  Pelvis
         (1)  Complications
             (a)  Hemorrhage
             (b)  Associated organs
             (c)  Pregnancy complications
             (d)  Associated dislocations
Musculoskeletal Trauma:

- Femur:
  - Head
  - Neck
  - Intertrochanteric
  - Subtrochanteric
  - Shaft
  - Condylar
  - Supra condylar

- Tibia:
  - Plateau
  - Shaft
  - Ankle

- Fibula:
  - Shaft
  - Isolated
  - Ankle

- Ankle:
  - Dislocation/ fracture
  - Malleal fracture
  - Tri malleolar

- Foot:
  - Calcanei
  - March fracture
  - Meta tarsal dislocation
  - Phalanges

3 X-ray descriptions of fractures
- Greenstick
- Oblique
- Transverse
- Comminuted
- Spiral
- Impacted
- Epiphyseal fractures (in children)

C0 Relate kinematics to the following injuries
1 Open fractures - break where protruding bone causes a soft tissue injury
   - Some bones are very close to the surface - reach down and touch your shin
   - EMS objective not to turn a closed fracture into an open fracture
2 Closed fractures - break in the bone which has not yet penetrated the soft tissue
   - May not be as obvious, yet serious potential for other injuries
3 Comminuted fractures - a break which involves several breaks in the bone causing bone fragment damage; consider the combined blood loss and potential for other injuries
4 Greenstick fractures - a bone break in which the bone is bent but only broken on the outside of the bend; children are most likely to have these
5 Spiral fracture - a bone break caused by a twisting motion
6 Oblique fracture - a bone break at a slanting angle across the bone
7 Transverse fracture - a broken bone that occurs at right angles to the long part of the bone involved
Dislocations - a bone moved from its normal position at a joint and may have associated fractures
Sprains - an injury to the tendons, muscles or ligaments around a joint, marked by pain, swelling, and dislocation of the skin over the joint
Strains - damage, usually muscular, that results from excessive physical effort
Joint injury - may be a fracture, dislocation or sprain
Stress fracture - a bone break, especially one or more of the foot bones, caused by repeated, long-term, or abnormal stress

Pathological fractures
Vascular injuries
Dislocations and subluxations
1 Subluxation
   a0 Partial dislocation of a joint with great damage and instability
2 Luxation
   a0 Complete dislocation of a joint
3 Dislocation
   a0 Frank displacement of bone ends at the joint
Specific injuries
Acromio clavicular
Shoulder
Elbow
Wrist
Metacarpal-phalange
Phalange
Hip
   (1) Posterior
   (2) Anterior
   (3) Associated with fracture
Knee
   (1) Posterior
   (2) Anterior
   (3) Patella
Ankle
   (1) Posterior
   (2) Fracture association
Foot
   (1) Posterior
   (2) Fracture association
Hand
Lacerations
Protection
Hemostasis
Dressing
Hematoma
Sprains and strains
Sprain
   a0 Tearing of the ligaments surrounding a joint
   b0 Grades
      (1) Grade I
      (2) Grade II
Grade III sprains can present the same as a fracture.

Typical blood loss in an uncomplicated fracture during the first two hours:
- Tibia/ fibula: 550 ml
- Femur: 1000 ml
- Pelvis: 2000 ml

Complications associated with fractures:
- Can exsanguinate from a fracture involving an artery laceration (e.g., femoral)
- Major blood loss can occur at the beak point
- Decreased distal pulse
- Diminished distal sensory or motor function
- Crushing injury
- Amputation/ avulsion

Inflammatory and degenerative conditions:
- Bursitis and tendinitis
- Arthritis
  - Osteoarthritis
  - Rheumatoid arthritis
  - Gouty arthritis

Musculoskeletal assessment:
- Four classes of patients with musculoskeletal trauma:
  - Patients with life/ limb-threatening injuries or conditions, including life/ limb-threatening musculoskeletal trauma
  - Patients with other life/ limb-threatening injuries and only simple musculoskeletal trauma
  - Patients with life/ limb-threatening musculoskeletal trauma and no other life/ limb-threatening injuries
  - Patients with only isolated, non-life/ limb-threatening injuries

Conduct the initial survey first to determine if there are any life-threats:
- Care for life-threatening conditions first
- Never overlook life/ limb-threatening musculoskeletal trauma
- Never allow a horrible looking, but noncritical musculoskeletal injury to distract you

The six “p”s of musculoskeletal assessment:
- Pain
  - Pain on palpation (tenderness)
  - Pain upon movement
- Pallor - pale skin or poor capillary refill
- Paresthesia - pins and needles sensation
- Pulses - diminished or absent
- Paralysis - inability to move
- Pressure

Assessment of musculoskeletal injury:
- General findings - inspect and palpate DCAP-BTLS
  - Deformity
b0 Contusions
c0 Abrasions
d0 Penetrations or punctures
e0 Burns
f0 Tenderness
g0 Lacerations
h0 Swelling

2 Specific findings - inspect and palpate
a0 Position found
b0 Hematoma
c0 Dislocation
d0 Cyanosis
e0 Motion - reduced or abnormally enlarged range
f0 Bleeding
g0 Guarding or self-splinting
h0 Crepitus

E0 Assessment findings - palpation
1 Tenderness or pain
2 Deformation
3 Crepitation
4 Swelling/ skin tension
5 Pulses
6 Capillary refilling
7 Innervation

F0 Special sports considerations
1 Mechanism of injury
a0 Football
b0 Basketball
c0 In-line skating
d0 Skiing or snow boarding
e0 Wrestling
f0 Soccer
g0 Rock climbing

2 Special sports injuries
a0 Shoulder
b0 Elbow
c0 Wrist
d0 Clavicle
e0 Knee
f0 Ankle
g0 Foot
h0 Tibia/ fibula

3 Interfacing with athletic trainers

IV Management
A0 General principles
1 Splint joint above and below as well as bone ends
2 Immobilize open and closed fracture the same
3  Cover open fracture to minimize contamination
4  Check pulses, sensation, and motor function before and after splinting
5  Stabilize with gentle in-line traction to position of normal alignment
6  Immobilize where they are found not in the exact position the limb is found
   a0  It makes most sense to move a long bone injury into a “splintable” straight position
   b0  Joint injuries are only moved if there is no distal pulse
7  Immobilize dislocation/ fractures in position of comfort and good vascular supply
8  Immobilize joints as found
9  Application of cold
   a0  Reduce swelling
   b0  Reduce pain
10  Compression
11  Elevation of extremities

B0  Splints - rigid, formable, traction
  1  Cardboard
  2  Wood
  3  Air
  4  Traction
     a0  History
     b0  Principle
     c0  Types
        (1)  Unipolar
        (2)  Bipolar
  5  Vacuum
  6  Pillow/ blanket
  7  Short spinal immobilization devices
     a0  Refer to spinal injury section
  8  Long spinal immobilization devices
     a0  Ultimate body splint
     b0  Refer to spinal injury section

C0  Dislocation/ fractures
  1  Realignment
     a0  Typically dislocated joints should be immobilized in the position of injury and transported for reduction
     b0  Delayed or prolonged transport requires a different approach
     c0  An attempt to reposition any dislocated joint into anatomical position should be made if distal circulation is impaired and if transportation is long or prolonged
     d0  Check circulation and nerve function before and after any manipulation of any injured bone or joint
     e0  Discontinue an attempt at repositioning if
        (1)  Pain is increased significantly by manipulation, and/ or
        (2)  Resistance to movement is encountered
  2  Limb-threatening injuries
     a0  Knee dislocation/ fracture
     b0  Dislocation/ fracture of the ankle
     c0  Subcondular fractures of the elbow
3 Always assess pulses, sensation, and motor function before and after manipulating the injury.

4 Specific techniques for specific joints

a0 Finger realignment

b0 Hip realignment

1. One attempt if there is severe neurovascular compromise
2. As soon as possible after the injury
3. Do not attempt if associated with other severe injuries
4. Analgesics
5. Procedure

(a) Traction
(b) Hip 90 degrees
(c) Knee 90 degrees
(d) Along shaft of femur
(e) Steady and slow to relax muscle spasm
(f) Success
i. "Pop" into joint
ii. Sudden relief of pain
iii. Leg can easily and painlessly be returned to full extension

(g) Immobilization, full extension, long backboard, reevaluation of pulses and innervation
(h) Immobilization, comfortable flexion not to exceed 90 degrees, pillows, chair, cardboard, supine position of patient

co Knee realignment - do not confuse with a patella dislocation, this is a limb-threatening injury

1. One attempt if there is severe neurovascular compromise
2. As soon as possible after the injury
3. An attempt to reposition a dislocation of the knee into anatomical position should be made if transport time is delayed or prolonged greater than two hours, even if distal circulation is normal
4. Do not attempt if associated with other severe injuries
5. Analgesics
6. Procedure

(a) Apply gentle and steady traction and then move the injured joint into normal position
(b) Full extension
(c) Steady pull to relax muscle spasm
(d) Success
i. "Pop" into joint
ii. Loss of deformity
iii. Relief of pain
iv. Knee is now more mobile
(e) Immobilization, full extension, backboard, long board splints, no traction, assess pulses, position of greatest comfort, slight flexion

do Ankle realignment

1. One attempt if there is severe neurovascular compromise
2. As soon as possible after the injury
(3) Do not attempt if associated with other severe injuries
(4) Analgesic
(5) Procedure
   (a) Pull traction on the talus while stabilizing the tibia
   (b) Slow and steady to relax spasm
   (c) Success, sudden rotation to normal position
   (d) Immobilization, as per fracture, check distal pulse
e. Shoulder realignment
   (1) One attempt if there is severe neurovascular compromise
   (2) As soon as possible after the injury
   (3) Do not attempt if associated with other severe injuries or back injuries
   (4) Analgesic
   (5) Procedure
      (a) Pull traction in the anatomical position only

D. Specific fracture pointers and immobilization techniques
1. Pelvis
   a. Backboard and PASG
   b. Treat the hypoperfusion as pelvic fractures cause severe hemorrhage, losing greater than 2 liters of blood into the pelvic cavity
2. Femur
   a. Traction splinting procedure
      (1) Direct manual stabilization of the injured leg
      (2) Assess distal motor ability, sensory response, and circulation
      (3) Rule out any contraindication to traction splinting
      (4) Direct application of manual traction if elevating the leg from the ground
      (5) Adjust and position splint at the injured leg
      (6) Apply proximal securing device (e.g., ischial strap)
      (7) Apply distal securing device (e.g., ankle hitch)
      (8) Apply mechanical traction
      (9) Position and secure support straps
      (10) Re-evaluate the proximal/ distal circulation
      (11) Reassess distal motor ability, sensory response, and circulation
      (12) Secure patient’s torso and traction splint to long backboard for transport
   b. PASG and long backboard
   c. Long backboard and long board splints
   d. Opposite extremity and long backboard
   e. Fractures of the proximal femur present similar to the anterior hip dislocation
   f. Midshaft or distal femur fractures can have soft tissue, vascular and nerve damage
3. Tibia/ fibula
   a. Pneumatic splint
   b. Long board splint procedure
      (1) Take body substance isolation
      (2) Direct application of manual stabilization
      (3) Assess distal motor ability, sensory response, and circulation
      (4) Measure splint
      (5) Apply splint
      (6) Immobilize joints above and below the injury site
(7) Secure the entire injured extremity in a distal to proximal direction
(8) Immobilize hand/ foot in the position of function
(9) Reassess distal motor ability, sensory response, and circulation

c. Splinting to the opposite leg
d. Cardboard

4. Ankle - same as tibia/ fibula fractures, generally involves the distal tibia and fibula
a. Pillow splint and leg immobilization
b. Air splint

c. Splinting to the opposite leg

5. Foot
a. Pneumatic
b. Cardboard
c. Ladder splint

6. Shoulder dislocation/ fracture
a. Anterior - arm close to the chest and hollow shoulder
b. Posterior - arm may be over the head
c. Splinting - be creative, improvise to hold the injury in place (e.g., blanket roll)
   (1) Use a rolled blanket with a cravat through the center
   (2) Position the roll under the elevated arm and secure it like a sling with the cravat through the blanket
   (3) Swathe the arm to prevent upward movement
   (4) If the arm is over the head - splint in position, or pull traction along the long axis of the arm

7. Knee
a. High incidence of vascular and nerve damage
b. Any fracture within three inches of a joint should be treated similar to a dislocation
c. Use triangulation with cravats and two long padded splints
d. SAM splints are not strong enough for the knee while some ladder splints if properly padded will be effective with immobilization of the hip and ankle
e. Do not use a traction splint
f. If found straight use two board splints or cardboard splint

8. Humerus
a. Difficult to stabilize
b. Potential for severe circulatory problems
c. If the patient has a potential neck injury do not tie a sling around the neck
d. Use a sling and swathe with splints surrounding the humerus or splint with the extremity extended

9. Elbow
a. High probability for blood vessel and nerve damage
b. Especially dangerous in children (supracondylar fractures)
c. Volkman’s contracture may result
d. Padded wire splint and sling and swathe

10. Forearm fracture
a. May involve radius, ulna, or both
b. Colle’s fracture of the wrist presents with the wrist in a “silver fork” position
c. Splint like a lower leg fracture described above

11. Hand and wrist fractures
a. Common with direct trauma
b. Noticeable deformity
c. Significant pain
d. High incidence for nerve and vessel damage
e. Splint on a padded board splint with the hand in position of function

12. Epiphyseal fractures
   a. Weakest part a child’s joint
   b. Presents as a sprain in an adult
   c. May result in a permanent angulation or deformed extremities
   d. May cause premature arthritis

E. Application of cold/heat
   1. Cold in the first 48 hours to reduce swelling
   2. Heat after 48 hour to increase circulation

F. Referral of minor musculoskeletal injuries
   1. Evaluate the need for immobilization
   2. Evaluate the need for an x-ray
   3. Evaluate the need for a physician follow-up visit versus ED visit
   4. Contact medical control for advisement

V. Integration