Author(s): Patrick Carter, Daniel Wachter, Rockefeller Oteng, Carl Seger, 2009-2010.

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Advanced Emergency Trauma Course

Orthopedic Trauma

Presenter: Patrick Carter, MD

Ghana Emergency Medicine Collaborative
Patrick Carter, MD • Daniel Wachter, MD • Rockefeller Oteng, MD • Carl Seger, MD
Objectives

- General Principles of Fracture Management
  - Fracture Mechanisms
  - Salter-Harris Fractures
  - Fracture Complications

- Upper Extremity Injuries
  - Shoulder
  - Arm
  - Forearm
  - Wrist
  - Hand

- Lower Extremity Injuries
  - Pelvis
  - Hip
  - Femur
  - Lower leg
  - Ankle
  - Foot
GENERAL PRINCIPLES OF ORTHOPEDIC INJURIES
Fracture Mechanisms

- Direct Trauma
  - “Tapping” Fracture – E.g. Nightstick
    - Linear fracture with two fragments and little or no soft tissue damage
  - Crush Fracture
    - Comminuted or transverse fracture
    - Extensive soft tissue damage
  - Penetrating Fracture (seen with GSW or missile wounds)
    - High velocity injuries with fragmentation of bone
    - Bone fragments act as secondary missiles, causing cavitation and extensive soft tissue injury
    - Also Low velocity injuries with mild fragmentation

- Indirect Trauma
  - Traction Fracture
    - Bone is pulled apart = Transverse fracture
  - Angulation Fracture
    - Bending along the long axis of the bone = Transverse fracture with concave surface
  - Compression Fracture
    - Compression on long axis of the bone from axial loading = T or Y fractures
  - Spiral Fracture
    - Results from rotational stress and results in an oblique fracture
Types of Fractures

- **Complete Fractures**
  - Fracture involving both cortical surfaces

- **Incomplete Fractures**
  - Only one cortex is disrupted
  - Two types:
    - Torus fracture = Buckle fracture = Buckling of one cortex
    - Greenstick fracture = Break in one cortex and bending or bowing of other cortex

- **Closed Fractures**
  - No communication with external environment

- **Open Fractures**
  - Communication with external environment through break in skin and soft tissue
  - High risk for infection (Osteomyelitis)
Complete vs. Incomplete Fracture

- Complete Fracture
- Incomplete Fracture
  - Torus Fracture
  - Greenstick Fracture

Complete Fracture

Incomplete Fracture

Torus Fracture

Greenstick Fracture

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http://www.portfolio.mvm.ed.ac.uk/studentwebs/session4/45/samplecases_files/greenstick%20fracture%20of%20the%20ulna.jpg
Closed vs. Open Fractures

- **Closed Fracture**
  ![Image of closed fracture](http://commons.wikimedia.org/wiki/File:Left_wrist_fracture.jpg)

- **Open Fracture**
  ![Image of open fracture](http://commons.wikimedia.org/wiki/File:Left_wrist_fracture.jpg)
Types of Fractures

- **Pathologic Fractures**
  - Bone weakness secondary to underlying disease process
  - Suspect when trivial injury results in fracture
  - E.g. Paget’s disease, Tumor, Osteogenesis Imperfecta, Rickets, Scurvy

- **Stress Fractures**
  - Also termed “march” or “fatigue” fracture
  - Repeat of cyclical stress results in a fracture, typically in lower extremities
  - Typically accompanied by a sudden increase in level of training

- **Joint Disruption**
  - Dislocation = Complete disruption of articular surface
  - Subluxation = Incomplete disruption of articular surface
Other Types of Fractures

- **Pathologic Fractures**
  - Fx. through bone cyst

- **Stress Fractures**
  - Stress Fx. 3rd metatarsal

http://www.hawaii.edu/medicine/pediatrics/pemxray/v6c01.html

http://www.customfootandarch.com/foot-problems/Stress_Fract.html
Salter-Harris Fractures

- Epiphyseal growth plate is weaker than supporting ligaments
  - Growth Plate (Physis) is made up of cartilage cells that are weaker than the supporting ligaments

- Salter-Harris fractures are fractures involving long bones in children and involve the growth plate or joint surface
  - Most common in children 10-16 (80%)
  - More common in males due to delayed skeletal maturation and increased physical activity compared with females of same age

- May lead to growth complications
  - Blood supply to the growth plate comes through the epiphysis and the worse the injury to the epiphysis, the greater the likelihood of growth disturbances

- Fractures are categorized on scale 1-5 and increasing number indicates increasing potential for growth complications
Salter-Harris Classification

- **Type 1** = Fracture through Epiphyseal Plate
  - Results in separation of epiphysis
  - Good Prognosis

- **Type 2** = Fracture of Metaphysis with extension through Epiphyseal plate
  - Most common type in children > 10 y/o
  - Good Prognosis

- **Type 3** = Fracture of the Epiphysis with extension into the Epiphyseal plate
  - Totally Intra-articular fracture
  - Open reduction necessary

- **Type 4** = Fracture through Epiphysis, Metaphysis and Epiphyseal plate
  - Complete intra-articular fracture
  - Open reduction necessary
  - Growth disturbance likely if not perfect reduction

- **Type 5** = Crush Fracture of the Epiphyseal plate
  - Most common in knee and ankle
  - X-ray can be deceptively normal looking
  - Poor prognosis because blood supply to epiphysis is disrupted
Salter Harris Classification

- How to remember the classification?
  - SALTER Mnemonic
  - S = Slip through the growth plate
  - A = Above the level of the growth plate
  - L = Lower than the growth plate
  - T = Through the growth plate
  - R = Ram the growth plate
Salter-Harris Classification

Dr Frank Gaillard (MBBS, FRANZCR) (Wikipedia)

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Complications of Fractures

- Immediate Complications
- Intermediate Complications
- Long Term Complications
Immediate Complications

- **Hemorrhage**
  - Can be extensive especially with Pelvic Fractures

- **Vascular Injuries**
  - Anterior Shoulder Dislocation = Axillary Artery
  - Extension Supracondylar Fracture = Brachial Artery
  - Posterior Elbow Dislocation = Brachial Artery
  - Knee Dislocation = Popliteal Artery

- **Nerve Injuries**
  - Anterior Shoulder Dislocation = Axillary Nerve Injury
  - Humeral Shaft Fractures = Radial Nerve Injury
  - Supracondylar Fracture = Medial, Radial and Ulnar Nerve Injury
  - Medial Epicondyle = Ulnar Nerve Injury
  - Post Elbow Dislocation = Ulnar/Medial Nerve Injury
  - Olecranon = Ulnar Nerve Injury
  - Acetabular Fracture = Sciatic Nerve Injury
  - Posterior Hip Dislocation = Sciatic Nerve Injury
  - Anterior Hip Dislocation = Femoral Nerve Injury
  - Knee Dislocation = Peroneal/Tibial Nerve Injury
  - Lateral Tibial Plateau Fracture = Peroneal Nerve Injury

- **Soft Tissue/Visceral Injuries**
Intermediate/Long Term Complications

- **Intermediate Complications**
  - Compartment Syndrome
  - Fat Embolism

- **Long-Term Complications**
  - Reflex Sympathetic Dystrophy
  - Volkmann’s Ischemic Contracture
  - Non-union
  - Avascular Necrosis
  - Angulation Deformities
  - Infection
  - Joint Stiffness
  - Post-traumatic Ossification or Arthritis
Compartment Syndrome

- Results from crush injury and fractures to long bones – distal radius, tibial shaft
- Swelling and bleeding in compartment increases pressure to above that able to maintain normal perfusion of affected area
- Most common = Anterior Tibial Compartment
- Symptoms = Pain, Pallor, Paresthesias, Pulseness, Paralysis (5 P’s)
- Diagnosis = Compartment Pressures
  - Indication for surgery = 40-50 mmHg
- Treatment = Fasciotomy

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THE SHOULDER AND UPPER ARM
Shoulder Anatomy

The Shoulder Joint

- Acromion
- Acromioclavicular (AC) joint
- Clavicle
- Bursa
- Rotator Cuff Tendons:
  - Supraspinatus
  - Subscapularis
  - Teres Minor
  - Infraspinatus (behind, not shown)
- Humerus
- Biceps muscle
- Gleno-humeral joint
- Scapula

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Joint Injuries

- Sternoclavicular Joint Injuries
- Acromioclavicular Joint Injuries
- Glenohumeral Joint Dislocation
Sternooclavicular Joint Injuries

1. Sternoclavicular Ligament

2. Costoclavicular Ligament

Gray’s Anatomy (Wikipedia)
Sternoclavicular Joint Injuries

Classification

- 1st Degree = Sprain = Partial tear of sternoclavicular and costoclavicular ligaments with mild subluxation
- 2nd Degree = Subluxation = Complete tear of sternoclavicular ligament with partial tear of costoclavicular ligament
  - Clavicle subluxates from the manubrium on x-ray
- 3rd Degree = Dislocation = Complete tear of both sternoclavicular and costoclavicular ligaments with complete dislocation of clavicle from the manubrium
  - Anterior = Most common
  - Posterior = True Emergency – 25% will have concurrent life-threatening injuries to adjacent mediastinal structures

Mechanism of Injury

- Direct force over sternoclavicular joint (posterior dislocation)
- Fall onto shoulder with anterior or posterior dislocation
Sternoclavicular Joint Injuries

- **Signs/Symptoms**
  - Tenderness and pain over joint
  - Pain with movement of shoulder
  - Patients with posterior dislocation = shortness of breath, dysphagia or choking due to compression of mediastinal structures

- **X-rays** = Regular x-rays or CT for extensive injuries

- **Treatment**
  - 1\textsuperscript{st} Degree = Sling x 3-4 days, Analgesia
  - 2\textsuperscript{nd} Degree = Figure of Eight Clavicular Strap or Arm Sling, Orthopedic Follow-up
  - 3\textsuperscript{rd} Degree = Immediate Orthopedic consultation and rapid reduction
    - Posterior dislocation may require reduction in operating theatre
    - Posterior dislocation may need to be reduced with traction on clavicle with towel clip
    - Apply figure of eight strap or arm sling
Acromioclavicular Joint

1. Acromioclavicular Ligaments

2. Coracoclavicular Ligaments

Gray’s Anatomy (Wikipedia)
Acromioclavicular Joint Injuries

- Classification (AC = Acromioclavicular, CC = Coracoclavicular)
  - 1\textsuperscript{st} Degree = Sprain = Partial tear of AC ligament, No injury to CC ligament
  - 2\textsuperscript{nd} Degree = Subluxation = Complete tear of AC ligament, CC ligament stretched or incompletely torn
  - 3\textsuperscript{rd} Degree = Dislocation = Complete tears of AC and CC ligaments with dislocation of clavicle
  - 4\textsuperscript{th} Degree = Displacement
    - Type IV = Displacement Posteriorly
    - Type V = Displacement Superiorly
    - Type VI = Displacement Inferiorly

- Mechanism of Injury
  - Fall on outstretched arm
  - Fall on shoulder with arm adducted (most common)

- Signs/Symptoms
  - Tenderness/Swelling over the joint
  - Pain with movement of affected extremity
  - Upward displacement of clavicle (seen with type 3 or worse)
Acromioclavicular Joint Injuries

- **X-rays**
  - AP views of clavicle
  - Stress views not commonly used anymore and do not alter course of treatment
  - Findings
    - 1\textsuperscript{st} degree = Radiographically normal
    - 2\textsuperscript{nd} degree = Increased distance between clavicle and acromion (< 1 cm)
    - 3\textsuperscript{rd} degree = Increased distance between the clavicle and acromion (> 1 cm)

- **Treatment**
  - Type 1 = Sling x 1-2 weeks
  - Type 2 = Sling, Orthopedic referral
  - Type 3 = Immobilize in sling, Prompt orthopedic referral within 72 hours
  - Type 4-6 = Sling, Prompt orthopedic referral, Likely will require surgical management
Acromioclavicular Separation - III


Clavicle

Acromion
Glenohumeral Joint Dislocation

- **Shoulder Dislocation** = Most Common dislocation seen in the ED
- **Classification**
  - Anterior (95-97%)
    - Subcoricoid, Subglenoid, Subclavicular, Intrathroracic
  - Posterior (2-4%)
    - Most commonly missed major dislocation of the body
    - Subacromial (98%), Subglenoid, Subspinous

- **Mechanism of Injury**
  - Anterior = Abduction, Extension and External Rotation
  - Posterior = Seizure or Electric Shock
    - Fall on forward-flexed, adducted and internally rotated arm

- **Signs and Symptoms**
  - Prominence of acromion process and flattening of normal contour of the shoulder (anterior)
  - Anterior flatness, posterior fullness and prominence of the coracoid process (posterior)

- **X-rays**
  - Standard Series = AP Shoulder + Transcapular lateral or Y view
  - Y view is diagnostic in posterior dislocation and without Y view, may be missed
Glenohumeral Joint Dislocations

- **Anterior Dislocation**
  - Inferior displaced humerus

- **Posterior Displacement**
  - AP = Internal Rotation of humerus = “Light bulb sign”
  - Y view = Humeral head displaced


http://www.learningradiology.com/caseofweek/caseoftheweekpix/cow105arrows.jpg
Glenohumeral Joint Dislocation

Treatment
- Reduction using a variety of techniques
- Shoulder dislocation with associated fracture should be referred to orthopedics for reduction
- Make sure to evaluate vascular and nerve exam post reduction and obtain a post-reduction film
- After reduction, patient should be placed in shoulder immobilizer and orthopedic follow-up arranged

Complications
- Recurrence = Most common complication
  - Age related (younger the patient, the more likely of a reoccurrence)
- Bony Injuries
  - Hill-Sachs Deformity = Compression fracture or groove of posterolateral aspect of humeral head
    - Results from impact of humeral head on the anterior glenoid rim as it dislocates or reduces
  - Avulsion of greater tuberosity (Increased in patients > 45 y/o)
  - Bankart’s Fracture = Fracture of the glenoid lip
- Nerve Injuries
  - May occur during dislocation or reduction and most neuropraxias will recover over time
    - Axillary nerve (most common) or Musculocutaneous nerve
- Rotator Cuff Tears
- Axillary Artery Injury (rare) – suspect in elderly patients with weak pulse or rapidly expanding hematoma
Complications

- Hill Sachs Deformity
- Bankart’s Fracture
Shoulder Reduction Techniques

- External Rotation Method (Hennipen Technique)
  - Gentle external rotation
  - If no success, slowly lift abducted arm, lifting humeral head into joint

http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html
Shoulder Reduction Techniques

- Traction-Counter traction

http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html

http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html
Shoulder Reduction Techniques

- Scapular Manipulation

http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html
Shoulder Reduction Techniques

- Stimson or Hanging Weight

http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html
Shoulder Reduction Techniques

- Kocher Method

http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html
Rotator Cuff Injuries

- Rotator cuff is made up of 4 muscles that insert tendons into the greater and lesser tuberosity of the muscles and allows abduction and internal/external rotation of the shoulder
  - SITS MUSCLES = Subscapularis, Supraspinatous, Infraspinatous, Teres minor
- Mechanisms of Injury
  - Acute tear = Forceful abduction of the arm against resistance (e.g. fall on outstretched arm)
  - Chronic tear = 90% = Results from subacromial impingement and decreased blood supply to the tendons (worsens as patient ages)
- Clinical Picture
  - Typically affects males at 40 y/o or later
  - Pain over anterior aspect of shoulder, tearing quality to pain, typically worse at night
  - PE with weak and painful abduction or inability to initiate abduction (if complete tear)
    - Drop arm test – inability to hold arm in 90 degrees abduction
  - Tenderness on palpation of supraspinatus over greater tuberosity
- Imaging
  - In ED, plain film x-rays indicated to exclude fracture and may show degenerative changes and superior displacement of humeral head
  - MRI is diagnostic (not typically done in ED setting)
- Treatment
  - Sling Immobilization, Analgesia, Ortho Referral
  - Complete tears require early surgical repair (< 3 weeks)
  - Chronic tears are managed with immobilization, analgesia and orthopedic follow-up for rehabilitation exercises and possible steroid injection
Fractures

- Clavicle Fractures
- Scapular Fractures
- Humeral Fractures
Clavicle Fractures

- Classification
  - Middle 1/3
    - Most common area to fracture (especially in children)
  - Distal 1/3
    - May be associated with ruptured coracoclavicular joint with medial elevation
  - Medial 1/3
    - Uncommon, requires strong injury forces
    - Consider intrathoracic injury (i.e. Subclavian Artery or Vein Injury)

- Mechanism = Fall on outstretched shoulder or direct clavicle trauma

- Symptoms/Signs = Pain, Swelling over fractured region

- Imaging = CXR or dedicated Clavicle films

- Treatment
  - Indications for surgical repair
    - Displaced distal third
    - Open
    - Bilateral
    - Neurovascular Injury
  - Treatment = Sling, Orthopedic Follow-up
    - Non-operative management is successful in 90%
Clavicle Fracture

Wikipedia
Scapular Fractures

- High Energy Mechanism
  - Look for associated injuries
- Classification (by location of fracture)
  - Body
  - Neck
  - Glenoid
- Mechanism of Injury
  - Direct blow to the scapula
  - Trauma to the shoulder
  - Fall on outstretched arm
- Clinical Features
  - Pain over back side of shoulder
  - Shoulder pain increased with abduction of the arm
- Imaging
  - Routine shoulder x-rays will demonstrate most scapular fractures
  - Axillary lateral view – helpful with fractures of glenoid fossa, acromion, coracoid process
  - CXR – to rule out associated lung or pulmonary injury
- Treatment
  - Sling immobilization x 2 weeks, Early range of motion exercises
  - Orthopedic referral for ORIF for severely displaced or angulated fractures

Glenoid
Body
Neck

Gray’s Anatomy (Wikipedia)
Humeral Fractures

Types

- Proximal Humerus Fractures
- Mid-shaft Humerus Fractures
Proximal Humerus Fractures

- **Classification = Neer Classification System**
  - Classification by amount of displacement of four segments
    - Displacement = separation > 1 cm or angulation > 45°
    - Anatomic Neck
    - Surgical Neck
    - Greater Tuberosity
    - Lesser Tuberosity
  - **Major Categories**
    - One part fracture – No displacement (80-85%) of fractures
    - Two part fracture – Displacement of one fragment
    - Three part fracture – Displacement of two individual fragments from remaining humerus
    - Four part fracture – Displacement of all four segments

- **Mechanism of Injury**
  - Fall on outstretched arm (most common)
  - Direct blow to lateral aspect of arm

- **Clinical Presentation = Upper arm and shoulder pain after fall**
  - Most commonly seen in elderly
Proximal Humerus Fracture

http://www.wheelessonline.com/image4/i1/prxh1.jpg
Proximal Humerus Fractures

- Imaging = Plain film x-ray imaging

- Treatment
  - One part fractures
    - Immobilization with shoulder immobilizer sling and swath, Analgesia, Ortho follow-up
  - Two/Three/Four Part fractures = Immobilize and emergent orthopedic referral
    - Many will require surgical repair

- Complications
  - Adhesive capsulitis = Frozen Shoulder = Most Common – Prevent with early mobilization
  - Neurovascular Injuries = Axillary nerve and artery, brachial plexus
  - Posterior Dislocations = Will frequently accompany lesser tuberosity fractures
  - Avascular necrosis of humeral head especially with anatomic neck fractures
Mid-shaft Humerus Fractures

- Classification
  - Typically involve middle 1/3 of the humeral shaft

- Mechanism of Injury
  - Direct Blow (Most common)
  - Fall on outstretched arm or elbow
  - Pathologic Fracture (especially Breast Cancer)

- Clinical Presentation
  - Pain and deformity over affected region
  - Associated Injuries
    - Radial Nerve injury = Wrist Drop = Inability of extend wrist, fingers, thumb, Loss of sensation over dorsal web space of 1st digit
      - Neuropraxia at time of injury will often resolve spontaneously
      - Nerve palsy after manipulation or splinting is due to nerve entrapment and must be immediately explored by orthopedic surgery
    - Ulnar and Median nerve injury (less common)
    - Brachial Artery Injury
Mid-shaft Humerus Fractures

- Imaging = Standard x-ray imaging

- Treatment
  - Most managed non-operatively (either):
    - Coaptation splint (sugar tong) plus sling and swath
    - Hanging cast
  - Operative management for patients:
    - Neurovascular compromise, pathologic fractures

- Complications
  - Delayed union
  - Adhesive capsulitis

THE ELBOW AND FOREARM
Elbow Injuries

- Elbow Fractures
  - Supracondylar Fractures
  - Olecranon Fractures
  - Condylar Fractures
  - Articular Surface Fractures
  - Epicondylar Fractures

- Dislocations
  - Posterior Elbow Dislocation
  - Anterior Elbow Dislocation
  - Radial Head Subluxation (Nursemaid’s Elbow)
Radiographic Elbow Evaluation

- Elbow radiographic evaluation can be difficult
- True Lateral X-ray = Hourglass or Figure of 8 at distal Humerus
- Fat Pad Signs
  - Posterior Fat Pad Sign = Never seen on normal x-ray imaging
    - Indicates distension of joint capsule by effusion with likely occult fracture
    - Often associated with occult radial head fracture
  - Anterior Fat Pad Sign = Small one may be present on normal x-rays
    - Increased anterior fat pad (sail sign) is abnormal and may indicate fracture
- Anterior Humeral Line
  - Line drawn along anterior surface of humerus and extending through the elbow
  - Normally, transects the middle of the capitellum but with Supracondylar fractures, transects the anterior 1/3 of the capitellum or passes completely anterior to the capitellum
- Radial-Capitellar Line
  - Line drawn through the middle of the radius
  - Normally, transects the middle of the capitellum
  - Abnormal line may indicate radial head dislocation or subtle fracture
- Radial Head Evaluation
  - Carefully inspect the radial head.
  - Fracture may be subtle and only clue may be slight cortical irregularity
- Distal Humerus Evaluation
  - Careful inspection and evaluation of anterior humeral head line
Elbow Radiographic Evaluation

- Anterior Fat Pad “Sail Sign”
- Posterior Fat Pad
- Anterior Humeral Line
- Radial-capitellar Line

http://faculty.washington.edu/alexbert/MEDEX/Winter/ch261fg5.jpg
http://www.wheelessonline.com/images/elbow1.jpg
http://uwmsk.org/static/residentprojects/NormalRadialLineLateral.jpg
Supracondylar Fractures

Supracondylar Extension Fractures (Most Common Type)
- Mechanism of injury = Fall on outstretched arm with elbow in extension
- Imaging = Distal humerus fractures and humeral fragment displaced posteriorly
  - Sharp fracture fragments displaced anteriorly with potential for injury of brachial artery and median nerve
- Treatment
  - Emergent Orthopedic Consultation
  - Non-displaced fracture = Immobilization in posterior splint
    - May be discharged home with close follow-up
  - Displaced fracture = Prompt reduction with percutaneous pin fixation or internal fixation by orthopedic surgeon
    - If vascular compromise on evaluation, ED physician should attempt reduction
- Complications
  - Compartment syndrome of forearm (Volkmann’s ischemia)
  - Median Nerve Injury = Weakness of Flexor Muscles of Hand and loss of two point discrimination of the fingertips
    - Neuropraxias at time of injury should resolve over time
Supracondylar Fracture

Supracondylar Flexion Fractures
- Mechanism of Injury = Direct blow to posterior aspect of flexed elbow
- Imaging = Distal humerus fracture displaced anteriorly
- Treatment
  - Non-displaced fractures are treated with splint immobilization and early orthopedic follow-up
  - Displaced fractures require emergent orthopedic consultation for reduction and percutaneous pinning
- Complications
  - Fractures are frequently open
  - Vascular injury is rare
  - Ulnar nerve injury is most common complication
Other Elbow Fractures

- **Olecranon Fracture**
  - **Mechanism** = Direct blow to point of Elbow
  - **Clinical Feature**
    - Swelling/tenderness over Olecranon
    - Inability to extend elbow against gravity
  - **Associated Injury** = Ulnar Nerve
  - **Treatment**
    - Non-displaced = Elbow immobilization in 30 degrees flexion
    - Fractures > 2 mm displacement = Emergent Ortho Referral
    - Open reduction with internal fixation

- **Condylar Fracture**
  - Distal Humerus comprised of medial and lateral condyles, each with articular and non-articular surface
  - **Articular Surfaces**
    - Trochlea (medial condyle)
    - Capitellum (lateral condyle)
  - **Non-articular surface**
    - Medial and Lateral Epicondyle
  - Condylar fractures involve both the articular surface and the non-articular surface
    - Lateral condyle fractures are most common
  - **Treatment**
    - Nondisplaced or minimally displaced = Immobilization in 90° elbow flexion with forearm supination or pronation, Outpatient ortho referral
    - Displaced Fractures (> 3 mm) = Surgical Fixation
Other Elbow Fractures

- **Articular Surface Fracture**
  - Trochlea and Capitellum
  - Mechanism = Typical fracture is associated with posterior elbow dislocation or from fall on outstretched hand
  - Treatment
    - Non-displaced fracture = Splint immobilization
    - Displaced (even minimal) = Emergent orthopedic referral and surgical repair

- **Epicondylar Fracture**
  - Seen most commonly in children
  - Medial Epicondyle
    - Avulsion fracture of medial condyle often accompanies posterior elbow dislocation
    - Associated ulnar nerve injury
    - Treatment
      - Nondisplaced = Immobilization
      - Displaced (> 3-5 mm or intra-articular) = Orthopedic referral and surgical reduction
  - Lateral Epicondyle
    - Rare, typically the result of direct blow
    - Most are non-displaced and treated with immobilization
Elbow Dislocations

- **Posterior (Most Common)**
  - Mechanism of Injury = Fall on extended and abducted arm
  - Clinical Findings = Marked swelling with posterior prominence of Olecranon
  - Imaging = Lateral view of elbow
  - Associated Injuries
    - Fractures (30-60% of cases)
    - Ulnar or Median nerve injury
    - Brachial artery injury – Consider angiography if suspect arterial injury
  - Treatment = Reduction
    - Traction distally at wrist with assistant immobilizing the humerus
    - While maintaining traction, flex the elbow and apply posterior pressure to the humerus
    - Elbow will exhibit “clunk” when reduced
    - Reassess ROM of elbow and neurovascular status
    - Immobilize in long-arm posterior splint in 120 degrees of flexion (i.e. full flexion)
    - Observe for delayed vascular compromise

- **Anterior (Uncommon)**
  - Mechanism of Injury = Blow to Olecranon with elbow in flexion
  - Clinical Findings = Elbow in full flexion
  - Associated Injuries = Much higher incidence of vascular impingement
  - Treatment
    - With humerus immobilized by second assistant, downward and backward pressure is applied to proximal forearm while in-line traction is applied to the wrist
Elbow Dislocation

Anterior Elbow Dislocation

http://tw.myblog.yahoo.com/doctor--anjenl/article?
mid=776&prev=778&next=774&l=f&fid=79

Posterior Elbow Dislocation

Radial Head Subluxation

- Nursemaid’s elbow = Subluxation of radial head beneath the annular ligament
- Mechanism of injury = Longitudinal traction on hand or forearm with arm in pronation
- Clinical Findings = Child with arm dangling at side and unwilling to use it
- X-rays not necessary
- Treatment = Reduction
  - Thumb over radial head with concurrent supination of forearm and flexion of elbow
  - Extension and pronation (another option for reduction)
Radial Head Subluxation
Forearm Injuries

- Radial Head Fracture
- Galeazzi Fracture
- Nightstick Fracture
- Monteggia’s Fracture
- Both bone Forearm Fracture
Radial Head Fracture

- **Mechanism of Injury** = Fall on outstretched hand
- **Clinical Finding** = Tenderness and swelling over the radial head
- **Imaging**
  - May not be seen on initial x-ray
  - Evaluate for anterior or posterior fat pad which suggests diagnosis
- **Associated Injuries**
  - Essex-Lopresti Lesion = Distal radio lunar dissociation
  - Articular surface of capitellum frequently injured
- **Treatment**
  - Non-displaced = Sling immobilization, Ortho follow-up
  - Comminuted/Displaced Fractures = Immobilization in posterior long arm splint
    - Early orthopedic referral (2-5 days) for screw fixation or radial head excision, which will be done if:
      - Marked comminution of fracture
      - Angulation of articular surface
      - > 2 mm offset in two part fracture
      - Fracture involving more than 1/3 of articular surface

Galeazzi Fracture

- Distal Radius Fracture
  - Distal radio-ulnar dislocation

- Mechanism of Injury
  - Direct blow to back of wrist
  - Fall on outstretched hand

- Complication = Ulnar nerve injury

- Treatment = ORIF

http://www.learningradiology.com/caseofweek/caseoftheweekpix2/cow157lg.jpg
Monteggia’s Fracture

- Proximal 1/3 Ulnar Fracture
  - Dislocation of radial head
- Mechanism of Injury = Direct blow to posterior aspect of ulna
  - Fall on outstretched hand
- Imaging = Elbow/Forearm x-rays
  - Radial head dislocation missed in 25% of cases
  - Carefully examine the alignment of radial head
- Associated Injury = Radial Nerve Injury
- Treatment
  - ORIF (Adults)
  - Closed Reduction/Splinting (Children)

http://www.radiology.co.uk/srs-x/cases/074/d.htm
Galeazzi vs. Monteggia

Galeazzi
Radial Fracture
Ulnar Fracture
Monteggia

GMUR

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Nightstick Fracture

- Isolated fracture of ulnar shaft
- Mechanism = Direct blow to ulna with patient raising forearm to protect face
- Treatment
  - Non-displaced = Immobilization in cast
  - Displaced
    - >10 degrees angulation or displacement > 50% of ulna
    - Orthopedic referral - ORIF

http://radiographics.rsna.org/content/24/4/1009/F31.small.gif
Both Bone Forearm Fracture

- Fracture of both ulnar and radius
  - Usually displaced fracture
- Mechanism of Injury = Direct blow to forearm
- Associated Injury
  - Peripheral Nerve Deficits
  - Development of compartment syndrome
- Treatment
  - Non-displaced (rare) = Immobilization in bivalved cast
  - Displaced – ORIF
    - Closed reduction may be possible in children
- Complications
  - Compartment Syndrome
  - Malunion
Volkmann’s Ischemic Contracture

- Complication of elbow and forearm fractures or casting that is too tight (compartment syndrome)
- Pressure on Brachial artery results in ischemia of muscles of forearm, typically flexor compartment
- Results in forearm pronation, flexion of wrist and digits and paralysis of intrinsic muscles
- Patient complains of pain out of proportion of injury, digit swelling and paresthesias
- Irreversible damage in 6 hours (see image)
- Consider in any patient presenting with pain and numbness in hand after casting has been performed

Treatment
- Removal of cast
- Surgical decompression with fasciotomy
WRIST AND HAND INJURIES
Hand and Wrist Injuries

- Wrist Injuries
  - Fractures
  - Dislocations
  - Overuse Syndromes
    - DeQuervain’s Tenosynovitis
    - Carpal Tunnel Syndrome
    - Guyon’s Canal Syndrome

- Hand Injuries
  - Fractures
  - Dislocations
  - Infections of the Hand/Bites
  - High Pressure Injection Injuries
  - Tendon Injuries
  - Amputated Digits
Distal Forearm/Wrist Fractures

- **Colles’ Fracture**
  - Transverse fracture of distal radius with dorsal displacement of distal fragment
  - Mechanism = Fall on outstretched hand
  - Most common fracture in adults > 50 years old
  - Exam = Classic Dinner Fork Deformity
  - Associated Injuries
    - Ulnar styloid fracture
    - Median Nerve Injury
  - Treatment
    - Non-displaced Fracture
      - Sugar Tong Splint, Referral to Orthopedic Surgery
    - Displaced Fracture
      - Prompt reduction – Finger traps and manipulation under conscious sedation or with hematoma block
      - Immobilization in Sugar tong splint
      - Referral to Orthopedic Surgery
Distal Forearm/Wrist Fractures

- **Smith Fracture (Reverse Colles)**
  - Transverse fracture of distal radius with volar displacement
  - Mechanism = Fall on outstretched arm with forearm in supination
  - Associated Injury = Median Nerve Injury
  - Treatment
    - Reduction with finger traps and manipulation
    - Immobilization in sugar tong or long arm splint
    - Orthopedic referral
Distal Forearm Fractures

- Colles’ Fracture
- Smith Fracture

[Images of Colles’ and Smith fractures]

http://www.radiologyassistant.nl/images/thmb_47764b731fc2dTEK-colles2.jpg

http://www.radiologyassistant.nl/images/thmb_478115d48934dSmith%27.jpg
Wrist Fractures

- Carpal Injuries
  - Scaphoid Fracture (Most Common)
    - Mechanism = fall on outstretched hand
    - Imaging – Initial x-rays may fail to demonstrate fracture
      - > 10% of cases
      - Repeat Imaging in 2 weeks will often show fracture
    - Clinical findings = tenderness in anatomical snuff box
  - Treatment
    - Non-displaced or clinically suspected fracture
      - Thumb spica Splint
    - Displaced Fracture = ORIF
    - Complications
      - Avascular necrosis or proximal fragment
      - Delayed union or malunion
Wrist Fractures

- Scaphoid Fracture
Wrist Fractures

- Carpal Fractures
  - Triquetrum Dorsal Chip Fracture (2nd most common)
    - Mechanism = Fall on outstretched hand
    - Exam = Tenderness on palpation distal to ulnar styloid on dorsal aspect of wrist, painful flexion
    - Best visualized on lateral view of wrist
    - Treatment = Volar splint
  - Lunate Fracture
    - Mechanism = Fall on outstretched hand
    - Exam = Pain over mid-dorsum of wrist increased with axial loading of 3rd digit
    - Plain x-rays are often normal
    - Treatment = Immobilization in thumb spica splint, orthopedic referral
    - Complications
      - Kienbock’s disease = Avascular necrosis of proximal segment
Carpal Fractures

- Triquetrum Fracture
- Carpal Bone Review

[Image of X-ray of wrist showing triquetrum and carpal bones]

Carpal Dislocations

- Mechanism of Injury = Violent Hyperextension
- Treatment = Orthopedic Consultation
- Lunate Dislocation
  - Pain, swelling and loss of flexion of wrist, hand and arm when held in anatomic position
  - X-ray
    - AP View = “Piece of Pie” sign
    - Lateral View = “Spilled teacup sign”
- Perilunate Dislocation
  - May be associated with Scaphoid fracture
Lunate vs. Peri-lunate Dislocation

- 4 C’s Need to line up on normal x-ray

http://www.radiologyassistant.nl/en/42a29ec06b9e8
Lunate vs. Peri-lunate Dislocation

- **Lunate Dislocation**
  - Capitate is centered over the radius and the lunate is tilted out
  - Tea cup deformity

- **Peri-lunate Dislocation**
  - Lunate is centered over the radius and capitate is tilted out

http://www.radiologyassistant.nl/images/thmb_4308223ad4bb7lunate-peri-lunate.jpg
Carpal Dislocations

- Scapholunate Dislocation
  - Most common ligamentous injury of hand and is commonly missed
  - Pain with wrist hyperextension, snapping sensation with radial/ulnar deviation
  - Radiographic signs
    - Scaphoid is foreshortened and has a dense ring shaped image around its distal edge (signet ring sign)
    - Widening of space between the lunate/scaphoid
      - > 3 mm, Terry Thomas sign
  - Treatment = Thumb spica, Hand Referral

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Scapholunate Dislocation

- Terry Thomas Sign


http://faculty.washington.edu/alexbert/MEDEX/Winter/ch262fg4.jpg
Overuse Syndromes

- **Carpal Tunnel Syndrome**
  - Entrapment of Median nerve
  - Tinel’s sign = Tapping over volar wrist produces paresthesias
  - Phalen’s sign = Hyperflexion of wrist = Paresthesias
  - Risk Factors = Pregnancy, Hypothyroid, DM, RA
  - Treatment = Splinting, Rest, Surgical Decompression

- **DeQuervain’s Tenosynovitis**
  - Overuse syndrome with inflammation of extensor tendons of thumb
  - Characterized by pain along radial aspect of wrist that is exacerbated with use of thumb
  - Finkelstein’s test = Ulnar deviation of fisted hand produces pain
  - Treatment = NSAIDS, Splint, Rest

- **Guyon’s Canal Syndrome**
  - Ulnar nerve entrapment syndrome
  - Numbness and tingling in ring and small finger
  - Causes = repetitive trauma (handle bar neuropathy), cyst
  - Treatment = Splint, Surgical Decompression
Hand Fractures

- **Distal Phalanx** (15-30% of hand fractures)
  - Mechanism is typically crush or shearing forces
  - Classified as Tuft, Shaft or Intra-articular fractures
  - Fractures at base may be associated with flexor or tendon injuries
  - Treatment is typically protective splinting (hairpin splint or finger splint)

- **Proximal and Middle Phalanx**
  - No tendon attachments
  - Mechanism
    - Direct blow = transverse or comminuted fracture
    - Twisting Mechanism = Spiral fracture
  - Fractures are typically stable
  - Treatment
    - Stable and Nondisplaced impacted or transverse fx = Buddy taping
    - Stable fractures with no angulation or rotation = Radial or Ulnar gutter splint
    - Unstable fractures = Internal fixation with Kirschner wires
Hand Fractures

- **Metacarpal Fractures**
  - **Head**
    - Mechanism = Direct blow or projectile injury with comminuted fracture
    - If laceration is present over MCP = Suspect Fight bite
    - Any displacement gives poor outcome
    - Treatment = Ice, Elevation, Immobilization in soft bulky dressing, Referral to hand surgery
  - **Neck (Most common)**
    - Mechanism = Direct impaction force
    - Boxer’s fracture = 5th MC neck fracture
    - Fractures are typically unstable with volar angulation and/or rotation
    - Acceptable angulation depends on digit
      - 2nd and 3rd MC < 15 degrees angulation acceptable
      - 4th < 20 degrees angulation acceptable
      - 5th < 40 degrees angulation acceptable
    - Rotation Exam = Look for malalignment of plane of fingernails in flexed position
  - Treatment
    - Anatomic reduction if unacceptable angulation or rotational deformity
    - Splint with wrist in 20 degree extension and MP flexed at 90 degrees
Hand Fractures

- Metacarpal Fractures (Cont’d)
  - **Shaft**
    - Mechanism = Direct Blow or indirect blow with application of a rotational force
    - Rotational deformity is more common than neck fractures
    - Rotational deformity is unacceptable for 2nd and 3rd MC
    - If anatomic reduction is necessary, operative fixation is typically required
  - **Treatment**
    - Nondisplaced fractures = gutter splint
    - Displaced or angulated fractures = Elevation, Ice, Immobilization and Consultation for reduction and follow-up
  - **Base**
    - Mechanism = Direct blow or force applied to hand
    - Stable injuries
    - Often associated with carpal bone fractures
    - Treatment = Bulky hand dressing or volar splint
Metacarpal Fractures

- Metacarpal fractures
- Boxer’s Fracture

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http://upload.wikimedia.org/wikipedia/commons/2/2a/Metacarpal_fractures.jpg

http://glovegame.com/gallery/boxersfracture.jpg
Hand Fractures

**Bennett’s Fracture**
- Intra-articular fracture of thumb base with subluxation or dislocation of MC joint
- Axial loading injury with hand closed
- Treatment
  - Ice, Elevation
  - Immobilization in thumb spica splint
  - Emergent Orthopedic Consultation
    - Anatomic reduction necessary (ORIF)

**Rolando’s Fracture**
- Comminuted T or Y shaped fracture involving the joint surface
- Axial loading injury with hand closed
- Treatment
  - Ice, Elevation
  - Immobilization in thumb spica splint
  - Emergent Orthopedic Consultation
    - Requires ORIF
  - Worse prognosis

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Intra-articular Thumb Fractures

- Bennett’s Fracture
- Rolando’s Fracture

http://www.learningradiology.com/caseofweek/caseoftheweekpix/cow70bennets.jpg
Finger Dislocation

- DIP = Uncommon
- PIP = Common
  - Dorsal dislocation very common, usually due to axial load and hyperextension
  - Reduction = Distraction and slight hyperextension with repositioning
  - Splint at 30 degrees flexion for 3 weeks
  - Can’t reduce = Volar plate entrapment
- MCP
  - Less common than PIP
  - Mechanism is typically due to hyperextension forces that rupture the volar plate and cause dorsal dislocation
  - Simple dislocations can typically be managed with closed reduction and splinting in flexion, referral to hand surgeon
  - Complex dislocations characterized by volar plate entrapment in joint space and makes closed reduction in these cases nearly impossible
    - Requires open reduction and repair
Gamekeeper’s Thumb

- Ulnar Collateral Ligament tear
- Mechanism of Injury
  - Acute and forceful radial deviation of the thumb (e.g. skiing accidents)
- Examination
  - Tenderness along ulnar aspect of the thumb with weak thumb grasp and pinch
  - Must assess joint stability
    - Apply lateral stress to the MCP joint of injured thumb and compare to normal thumb
    - Presence of > 10-20 degrees of laxity suggests a complete tear
- Imaging = X-rays to r/o fractures
- Treatment
  - Incomplete tear = Thumb spica splint and ortho follow-up
  - Complete tear = Surgical Repair (best if done within 1 week)
  - Hand surgery or ortho referral is recommended for all patients with weakness of pincer function and pint tenderness over volar aspect of thumb MCP
Hand Infections

- Paronychia
- Felon
- Herpetic Whitlow
- Human Bites
- Pyogenic Flexor Tenosynovitis
Paronychia/Felon

- **Paronychia**
  - Infection of lateral nail fold
  - Staph/Step usual causative agents
  - Treatment
    - Incision and Drainage
    - Warm soaks
    - Antibiotics if surrounding cellulitis
  - Complications = Felon

- **Felon**
  - Infection of pulp space of fingertip
  - Staph aureus is typical causative agent
  - Treatment – I+D at point of maximal tenderness
    - Packing for 48-72 hours
    - Warm soaks
    - Antibiotics
  - Complications
    - Flexor tenosynovitis, osteomyelitis

Wikipedia
http://www.womenfitness.net/r_img1/felon.jpg
Herpetic Whitlow

- Viral infection of distal finger
- Caused by HSV I or II
- Clinical Findings – Localized burning, itching and pain preceded development of classic clear herpetic vesicles
- Diagnosis – Clinical
- Treatment
  - Splinting, Elevation, Pain control
  - Oral Antiviral Agent
  - Do not surgically drain

http://www.dartmouth.edu/~thabif/weeklyclinic110501/pictures/12herpeticwhitlow.jpg
Flexor Tenosynovitis

- An infection of flexor tendon sheath that typically results from a puncture wound on volar surface
- Causative agents typically Staph Aureus or Strep
- Diagnosis = 4 Cardinal Kanavel Signs
  - Finger held in slight flexion
  - Symmetric swelling of finger (termed diffuse fusiform swelling)
  - Tenderness along proximal flexor sheath
  - Pain with passive extension of finger

- Treatment
  - Hospitalization and Emergent Orthopedic Consult
  - Surgical Drainage
  - IV antibiotics
  - Elevation and Splinting
  - Tetanus update
Flexor Tenosynovitis
Collar Button Abscess

- Deep web space infection of the hand that involves both palmar and dorsal side of hand
- Purulent fluid spreads between metacarpal bones and erupts dorsally creating a hand abscess
- Volar spread is limited by presence of palmar aponeurosis
- Exam noted with swelling and tenderness, more prominent on palmar surface
- Treatment involves volar and dorsal incision and drainage by orthopedics in the operating room
  - IV antibiotics
Human Bite (Fight Bite)

- Injury results from punching another person in the mouth
  - High potential for severe infection
- Infected wounds have potential for spread to deep palmar space infections, functional loss and need for amputation
- Any wound over MCP joint is considered a fight bite until proven otherwise – patients will often lie about cause of injury
- Causative agents
  - Anaerobes (especially Eikenella corrodens)
  - Staph aureus
  - Neisseria species
- Treatment
  - DO NOT SUTURE – Secondary intention healing
  - Consult Orthopedic Surgeon
  - X-rays to r/o fracture
  - Irrigate wound
  - Splint and elevate the hand
  - Hospitalize the patient and treat with IV Antibiotics (Unasyn)
High Pressure Injection Injuries

- 1-3 mm wound caused by a high pressure injection device (e.g. grease, hydraulic fluid or paint gun)
- Wound is deceptively small but fluid typically travels down tendon sheath and damages flexor tenderness and is also high risk for hand compartment syndrome
- Prognosis = Poor – 70% require some form of amputation
- Treatment
  - X-ray (especially if substance is opaque and for subcutaneous air)
  - Splint, Elevate Extremity
  - Broad Spectrum Antibiotics
  - Update Tetanus
  - Immediate Orthopedic Consult for Surgical Debridement
Hand Injuries

- Fight Bite
- High pressure Injection Injuries

http://www.orthosupersite.com/images/content/OT/200706/60_image5.jpg

Tendon Injuries

- General Principles
  - Note normal posture of hand
  - Examine wound with hand and fingers in the position at the time of injury
    - Aid in determining the location of tendon injury
  - Evaluate the tendon and wound while exhibiting full range of motion of the finger/hand

- Tendon Injuries
  - Flexor Tendon Injuries
  - Extensor Tendon Injuries
Flexion Tendon Injuries

- Injury typically associated with laceration over flexor surface

Examination
- Flexor Digitorum Profundus Tendon
  - Immobilize PIP and MCP joints and assess patient’s ability to flex tip of the finger
  - Inability to flex indicative of a profundus tear
- Flexor Digitorum Superficialis Tendon
  - Hold un-injured fingers in extension and ask patient to flex injured finger (blocks the action of the profundus tendon)
  - Tendon needs to be tested against resistance. 90% tear will still have function but will demonstrate weakness with resistance testing

Treatment
- Repair of full thickness injury in OR
- Partial tear (treatment is controversial) – Many orthopedic surgeons will treat with protective splinting
Jersey Finger

- Closed traumatic disruption of flexor tendon apparatus
- Jersey finger results from flexor digitorum profundus tendon avulsion when one football player grabs the jersey of another and his finger is caught
- Affected patient will be unable to bend finger down to palm of hand and finger will be excessively straight in position of rest
- Treatment = Surgical Repair of tendon apparatus
Extensor Tendon Injuries

- **Mallet Finger**
  - Extensor tendon laceration or disruption of DIP joint
  - Patient is unable to extend DIP joint
  - Mechanism of Injury = Blow to tip of extended finger producing sudden forceful flexion

Treatment

- If no fracture – Splint DIP joint in extension to slight hyperextension for 6-8 weeks
- If fracture = Splint DIP joint and ortho referral for possible surgical pinning with Kirschner wire fixation

- **Complication** = Untreated Mallet finger results in “swan neck deformity”
  - Hyperextension of PIP joint in addition to mallet flexion deformity of DIP joint
Extensor Tendon Injuries

- **Boutonniere Deformity**
  - Rupture of central slip of the extensor tendon hood at the PIP joint
    - May be associated with avulsion fracture
  - Characterized by flexion of the PIP joint and hyperextension of DIP joint
    - Why? Lateral bands of extensor hood split and become PIP flexors
  - Mechanism is typically a direct blow (forced flexion) or laceration of the PIP joint region
  - Deformity not always present immediately and often develops over time (1-2 weeks)
  - Treatment = Splint the PIP joint in extension
    - Refer to Orthopedic Surgeon for possible operative repair
Extensor Tendon Injuries

- Mallet Finger
- Boutonniere Deformity
Amputated Digits

Preservation of Amputated Digit
- Irrigate amputated part with normal saline to remove gross contamination
- Wrap in sterile gauze moistened with saline
- Place in sterile water tight container
- Store the container in ice water

Criteria for Re-implantation
- Young, healthy patient with normal vital signs
- Sharply incised wound with minimal associated tissue destruction
- Amputated thumb
- Multiple digit amputation
- Hand or forearm amputation
- Amputation in child

Contraindications to reimplantation
- Absolute Contraindications
  - Unstable patient with severe life threatening injuries
  - Severe crush injury
- Relative Contraindications
  - Severely damaged part
  - Severely contaminated part
  - Single digit amputation
    - other than thumb
  - Avulsion Injury
  - Serious underlying medical illness that would impair wound healing
  - Prolonged warm ischemia (> 12 hrs)
  - Prior injury to affected part
  - Emotionally unstable patient
LOWER EXTREMITY INJURIES
Pelvic Fractures

- **Mechanism of Injury**
  - Motor Vehicle Accidents
  - Falls
  - Crush Injuries
  - Take-down injuries (Car vs. Pedestrian)

- **Classification (Young Classification)**
  - **AP Compression**
    - Type 1 – Disruption of pubic symphysis (< 2.5 cm), No posterior pelvis injury
    - Type 2 – Disruption of pubic symphysis (> 2.5 cm), Ligamentous injury
    - Type 3 – Complete disruption of pubic symphysis and posterior ligamentous complex with hemipelvic displacement
  - **Lateral Compression**
    - Type 1 – Posterior Compression of SI joint without ligamentous disruption, oblique ramus fracture
    - Type 2 – Rupture of posterior sacroiliac ligament, pivotal internal rotation of hemipelvis with crush injury to sacrum and oblique ramus fracture
    - Type 3 – Type 2 + AP compression injury to contralateral hemipelvis
Pelvic Anatomy

Gray’s Anatomy (Wikipedia)

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Pelvic Fractures

- Imaging = Plain film, CT imaging
  - CT superior in evaluating acetabulum, posterior arch and SI joint

- Specific pelvic fractures
  - Pubic Rami (Most common pelvic fracture)
    - Straddle injury = fracture of all 4 pubic rami
  - Iliac Crest
    - Duverney fracture = Pelvic wing fracture
    - Ilium fracture = Pelvic ring disruption
  - Malgaigne Fracture = Multiple fractured Pelvis
    - Pubic rami bilaterally and ilium or sacrum
Pelvic Fracture

- AP Compression Type Injury
- Lateral Compression Type Injury

http://emedicine.medscape.com/article/394515-overview

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Pelvic Fractures

Associated Injuries
- Hemorrhage
  - 1st cause of death from pelvic fx
  - Up to 6L of blood in retroperitoneum
  - 50% of patients require transfusion
- Urethral and Bladder Injuries
  - Most commonly associated injuries
- Vaginal Laceration or rupture
- Nerve Injury
- Ruptured Diaphragm
- Rectal Injuries
- Thoracic Aortic Rupture
  - 8 times more likely in patients with pelvic fractures

Treatment
- Evaluation for secondary injuries
- Avoid excessive movement
- Antishock pelvic clamp in patients with evidence of fracture and instability
- Type I – Conservative treatment
- Type 2 – Single Ring Fractures
  - Conservative treatment
- Type 3 – Double Ring Fractures
  - Unstable, Immobilize, External or Internal Fixation, Orthopedic Consultation, Embolization of hemorrhage
- Type 4 – Acetabulum fracture = Displaced fractures require surgical repair

Complications
- Sepsis
- Thromboembolic complications
- Malunion or Delayed Union
- Chronic Pain
Pelvic Binder


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Hip Fractures

- **Classification**
  - Intracapsular
    - Femoral Head, Subcaptital or Neck Fracture
  - Extracapsular
    - Trochanteric, Intertrochanteric or Subtrochaneteric

- **Clinical Presentation**
  - External rotation, flexion, shortened leg
  - Pain with attempted ROM – especially internal/external rotation

- **Imaging**
  - Plain films will diagnose most hip fractures
  - CT or MRI for patients with occult fracture
    - Patients with negative plain films who cannot ambulate should be examined with CT or MRI imaging

- **Treatment**
  - Orthopedic Consultation
  - ORIF

- **Complications = Bleeding, Aseptic Necrosis**
Hip Fracture Types

http://arthritis-symptom.com/images/Hip-fracture.gif
Hip Fractures

http://images.quickblogcast.com/80618-70584/hip_fRACTURE2.jpg

http://www.health-res.com/EX/07-28-07/hipp301.jpg
Hip Dislocations

- **Anterior Hip Dislocation (10%)**
  - Mechanism of Injury = Extreme abduction pushes femoral head out through tear in anterior capsule from auto accident or fall
  - Clinical Features = Slight abduction, external rotation
  - Associated vascular injuries with diminished femoral or distal pulses indicates need for immediate reduction

- **Posterior Hip Dislocation (80-90%)**
  - Mechanism of Injury = Majority are due to auto-accidents with direct force applied to flexed knee, pushing femoral head through the posterior capsule
  - Clinical Features = Shortened, Adducted and Internally Rotated
  - Associated Physical Findings
    - Acetabular or Femoral Fractures
    - Sciatic Nerve Injury
    - Knee Injury

- **Treatment**
  - Early reduction to avoid Avascular necrosis of the femoral head
  - Closed Reduction should be attempted in ED, operative repair if unsuccessful

- **Complications**
  - Anterior dislocation = Femoral Artery, vein, nerve injury
  - Posterior dislocation = Sciatic Nerve injury

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Hip Dislocation

- Anterior Hip Dislocation

- Posterior Hip Dislocation

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Femur Fracture

- Typically, male patients suffering fall or MVA
- Clinical Presentation – Severe pain, unable to bear weight
- Treatment
  - Hair Traction Splint
  - Orthopedic Consultation
  - ORIF
- Complications
  - Hemorrhage
  - Neurovascular Injury
  - Fat Emboli
Knee Injuries

- **Mechanism**
  - Valgus Stress (Abduction) = MCL, ACL, Medial Meniscus
  - Varus Stress (Adduction) = LCL, Lateral Meniscus
  - Hyperextension Stress = ACL, PCL
  - Anterior/Posterior Stress on the tibia = ACL, PCL
  - Rotational Stress = ACL, MCL

- **Evaluation**
  - Ligamentous stress testing

- **Imaging**
  - X-ray to r/o fracture

- **Treatment**
  - Knee Immobilizer
  - Orthopedic Referral
  - MRI as outpatient if no improvement on re-evaluation
Knee Injury

- **ACL Testing**
  - Lachman’s Test
  - Anterior Drawer Test

- **PCL**
  - Posterior Drawer Test

- **Medial and Lateral Collateral Tests**
  - Knee valgus stress test (MCL)
  - Knee varus stress test (LCL)

- **Meniscal Tests**
  - McMurrey’s Test
  - Apley Compression Test
Football Triad Injury

- Football triad results from lateral aspect of the knee
- Results in:
  - Medial Collateral Ligament Tear
  - Medial Meniscus
  - ACL Tear
- Clinical Presentation: Swelling or pain around knee with moderate to severe pain
- Treatment
  - Knee Immobilization
  - Surgical Repair
Ottawa Knee Rules

- Patient needs an x-ray of knee if:
  - Age > 55 y/o
  - Isolated tenderness of patella
  - Tenderness at head of fibula
  - Inability to flex 90 degrees or inability to bear weight in the ED (at least 4 steps)
  - Rules are valid in children or adults
Knee Injuries

- **Baker’s Cyst**
  - Inflammation of the semi-membranous or medial gastrocnemius bursa produced by protrusion of synovial membrane through the posterior aspect of the knee’s capsule
  - Patients present with knee swelling and local discomfort
  - Exam with tense posterior painful knee with painful fluid filled sac
  - Rupture of the cyst causes pain and swelling (may mimic DVT)
  - Treatment = Correction of underlying joint pathology

- **Osgood-Schlatter’s Disease**
  - Repetitive microscopic injury that produces inflammation of apophysis of the tibial tubercle an leads to partial avulsion and separation of the tibial tubercle
  - Commonly seen in adolescent males who are active in sports
  - Treatment = Ice, NSAIDS, Decreased sports
Knee Dislocation

■ Mechanism of Injury = Violent trauma from MVA or vehicle pedestrian accidents

■ Classification
  • Classified by direction of tibial displacement compared with femur
  • 5 types: Anterior, Posterior, Medial, Lateral, Rotary
  • Most common = Anterior and Posterior (50-60%)

■ Diagnosis
  • Complete disruption of all major ligaments
  • Popliteal artery injury is common (21-32%), especially in anterior/posterior dislocation
  • Peroneal nerve injury is also common (25-35%)
Knee Dislocation

Diagnostic Caveats

- Knee with complete disruption may demonstrate less swelling and pain than a less severely injured knee
- Knee may reduce spontaneously – Any patient who presents with grossly unstable knee following trauma should be assumed to have a spontaneously reduced dislocation

Clinical Management

- Immediate reduction – Longitudinal Traction
- Pulses should be checked before and after reduction
- Following reduction, knee should be immobilized in posterior splint in 15 degrees of flexion
- Arteriogram should be performed in all patients who have had a knee dislocation
- Immediate orthopedic and vascular surgical consultation
- Immediate surgical intervention for Popliteal artery injuries, open dislocations and irreducible dislocations
Patellar Fracture

- **Classification**
  - Transverse fractures most common (50-80%)

- **Mechanism of Injury**
  - Direct blow (e.g. dashboard injury)
  - Forceful contraction of quadriceps muscle

- **Clinical Presentation**
  - Tenderness and swelling over the patella
  - Limited painful knee extension

- **Imaging**
  - AP, Lateral X-rays
  - Sunrise or skyline view

- **Treatment**
  - Nondisplaced fracture with intact extensor mechanism = Immobilization in full extension, Partial weight bearing and orthopedic referral
  - Displaced or loss of extensor function = Orthopedic referral for surgical intervention
Patellar Dislocation

- Lateral subluxation or dislocation is most common

Mechanism of Injury
- Sudden flexion and external rotation of tibia on the femur with contraction of the quadriceps
- Direct blow to the patella with knee in flexion or extension

Clinical Features
- Typically occurs in adolescent females with chronic patellofemoral anatomic abnormalities

Clinical Management
- AP and Lateral x-rays of the knee
- Reduction = Flexion of hip and gentle medial pressure over the lateral aspect of the patella while extending the knee
- Immobilization in full extension
- Crutches
- Orthopedic Referral
- Frequently re-occur

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http://www.conquestchronicles.com/special/the_dislocated_patella
Quadriceps Tendon Rupture

- More common in old debilitated patients or patients on steroids or fluoroquinolones

- Mechanism
  - Typically results from fall onto knee

- Clinical Presentations
  - Forced knee flexion with inability to extend knee
  - Patient may be able to stand but will not be able to walk

- Treatment
  - Early Orthopedic Consultation
  - Complete Rupture = Early Surgical Repair
  - Incomplete Rupture = Immobilization in full extension
Tibial Plateau Fracture

- **Mechanism** = Strong valgus stress with axial loading
  - Fall from height
  - Auto/Pedestrian (bumper vs. knee)

- **Most condylar fractures involve the lateral plateau**

- **Imaging** = X-ray
  - CT may be needed for diagnosis

- **Complications** - Vascular complications
  - Anterior tibial artery
  - Popliteal artery

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http://z.about.com/d/orthopedics/1/0/1/2/tibialplateau2.jpg
Lower Leg Injuries

- **Tibia Fractures**
  - **Mechanism**
    - Torsional injury = Spiral fracture
    - Bending force = Transverse or oblique fracture
    - Direct force from crush injury
  - **Treatment**
    - Avoid Infection – Antibiotics for open fractures, emergent ortho consult if open for subsequent OR irrigation and debridement
    - Most closed fractures that are minimally displaced can be treated with orthopedic reduction and immobilization
    - Most patients require admission for pain control and further fracture care and monitoring for compartment syndrome

- **Fibula Fractures**
  - Isolated fibula fractures typically result from a direct blow
  - Nondisplaced fractures can be treated with immobilization with either elastic wrap (distal fibula), knee immobilizer (proximal fibula) or splinting if significant pain
Lower Leg Injuries

- Tibial Fracture
- Fibular Fracture
Ankle Injuries

- Anatomy
- Ankle Sprains
- Ankle Fractures
- Ankle Dislocation
- Tendon Injuries
  - Achilles Tendon Rupture

Wikipedia

http://www.squidoo.com/anklefootxray

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Ankle Sprain

- **Types**
  - Lateral Collateral Ligament Sprain (85-90%)
    - Inversion and internal rotation injury
  - Medial Collateral Ligament Sprain
    - Eversion and external rotation injury

- **Classification**
  - First Degree
    - Mild localized tenderness
  - Second Degree
    - Moderate swelling and tenderness, moderate functional loss
  - Third Degree
    - Marked tenderness, swelling, inability to bear weight, significant functional loss
Ottawa Ankle Rules

- Patients need ankle x-rays if:
  - Inability to bear weight
    - Either after injury or in ED
  - Bony tenderness along posterior edge of distal 6 cm of lateral or medial malleolus
  - Point tender over navicular bone
Ankle Sprain

- **Associated Injuries**
  - Medial Collateral Ligament Strain often associated with fracture of fibular head (Maisonuneuve fracture)

- **Stress Test for Ankle Stability**
  - Anterior drawer test
    - Indicative of rupture of anterior talofibular ligament
  - Inversion stress (talar) test
    - Only do if anterior drawer test is positive
    - Positive test indicates rupture of both the anterior talofibular and calcaneofibular ligaments
  - External rotation test
    - Pain at the syndesmosis or sensation of lateral talar movement

- **Treatment**
  - Ice, Elevation, Compression
  - Immobilization, Crutches
  - Early orthopedic referral for type 2 or type 3 injuries
  - Type 3 injuries will sometimes need surgical repair
Ankle Fracture

Classification

• Lauge-Hansen Classification (two word)
  - Two word classification scheme
    - First word = Position of the foot
    - Second Word = Motion of the foot
  - Supination-Adduction
  - Supination-External Rotation
  - Pronation-Abduction
  - Pronation-Eversion
  - Pronation-Dorsiflexion

• Danis-Weber Classification
  - Based on the level of fracture of the fibula
  - Type A - Fracture of fibula below the syndesmosis
  - Type B – Fibular fracture at the level of the syndesmosis
  - Type C – Fibular fracture above the level of the syndesmosis

• Radiographic Classification
  - Unimalleolar, Bimalleolar, Trimalleolar
Weber Classification

- Higher level = Greater disruption of syndesmosis – Greater instability

http://www.squidoo.com/anklefootxray

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Ankle Joint Stability

- Ankle joint is a ring which is maintained in stability by bony structures and ligaments.
- Disruption of one part of the ring allows for continued stability of the joint.
- Disruption of two parts of the ring results in instability of the joint.

http://www.squidoo.com/anklefootxray
Ankle Fractures

Bi-malleolar Fracture

Tri-malleolar Fracture

http://www.squidoo.com/anklefootxray

http://imaging.birjournals.org/cgi/content-nw/full/15/4/324/F3
Treatment

- Avulsion fractures with no displacement, smaller than 3 mm in diameter with no evidence of medial ligamentous injury may be treated similarly to sprain.
- All other ankle fractures require immobilization by either cast or surgical reduction with subsequent casting.
- Non-displaced fractures with normal anatomic relationship of ankle:
  - Talus anatomically aligned
  - Joint line has to be parallel to the ground
  - Articular surface must be smooth
- Most fractures with exception of Unimalleolar will require ORIF.
- Orthopedic consultation for non-displaced ankle fractures is based on local preference.
- Displaced fractures require anatomic alignment/reduction and orthopedic reduction.

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Ankle Dislocation

- Dislocation in one of four planes
  - Anterior, Posterior, Lateral, Superior (upward displacement of talus)

- Pure ankle dislocation uncommon
  - Typically associated with malleolus fractures

- Treatment
  - Immediate neurovascular assessment
  - Reduction immediately if evidence of neurovascular compromise or skin tenting
  - Reduction with in-line traction
  - Reassess neurovascular status after reduction

- High incidence of complications
  - Neurovascular Compromise
  - Conversion of closed to open
  - Avascular necrosis

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Achilles Tendon Injury

- Achilles Tendon Rupture
  - Sudden excruciating pain at back of ankle that then lessens after injury
  - Commonly, an injury of sedentary middle aged males (weekend warriors)
  - Mechanism of injury
    - Forceful dorsiflexion of the foot with ankle in relaxed state
    - Direct trauma to taut tendon
  - Examination
    - Swelling of distal calf
    - Palpable defect in tendon proximal to calcaneal insertion
    - Weak plantar flexion
    - Thompson’s squeeze test
  - Diagnosis
    - Clinical with Thompson test
    - Ultrasound or MRI can confirm
  - Treatment
    - Initial Management = Ice, Elevation, Analgesia, Immobilization in posterior splint in plantar flexion
    - Orthopedic follow-up within 48-72 hours
    - Definitive care is controversial (casting vs. surgical repair)

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Foot Injuries

- **Foot Anatomy**
  - Hind part
    - Calcaneus, Talus
  - Midpart
    - Navicular, Cuboid, Cuneiforms
  - Forepart
    - Metatarsals, Phalanges

- **Joints**
  - Hind part – Midpart
    - Chopart Joint
  - Midpart – Forepart
    - Lis Franc Joint

http://www.e-radiography.net/technique/foot/footlat.htm
http://www.e-radiography.net/technique/foot/footdp.htm
Calcaneal Fractures

- Calcaneal Fracture
  - Most frequently fractures tarsal bone
  - Mechanism = Compression/Axial Injury
    - “Jumper’s Fracture”
  - Exam = Swelling, tenderness, Ecchymosis of hind foot with inability to bear weight on fracture
  - Rule of 10’s
    - 10% are bilateral
    - 10% are associated with compression fractures
  - Bohler’s Angle – Formed by intersection of two lines on the lateral film
    - Superior margin of posterior tuberosity through the superior tip of the posterior facet
    - Superior tip of the anterior process through superior tip of the posterior facet
    - Angle normally = 20-40 degrees
    - Angle < 20 degrees = depressed fracture
  - Treatment
    - Early orthopedic consultation
    - Intra-articular or displaced calcaneal fracture = Controversial (immediate reduction vs. non-operative management)
    - Non-displaced or extra-articular fracture = Ice, elevation, immobilization in posterior splint, crutches, orthopedic follow-up
Calcaneal Fracture

- Calcaneal Fracture
- Bohler’s Angle

[Image of Calcaneal Fracture]

[Image of Bohler’s Angle]

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Lisfranc Fracture Dislocation

- **Mechanism of Injury**
  - Axial load = Fall on the plantar flexed foot
  - Compressive forces = Crush Injury
  - Rotational forces = Twisting of body around foot

- **Exam** = Midfoot swelling and pain, Decreased ROM and inability to bear weight

- **Imaging**
  - Evaluate x-ray for normal alignment along the medial aspect of the middle cuneiform with the medial aspect of the base of the 2nd metatarsal
  - 2nd Metatarsal functions as primary stabilizing force and fracture at base of 2nd MT is indicative of disrupted Lisfranc joint (Fleck’s sign)

- **Treatment**
  - Closed reduction under anesthesia or ORIF
  - Orthopedic consultation in ED is required
Lisfranc Fracture-Dislocation

- Normal Lisfranc Joint
- Fracture

Jones Fracture

- Diaphyseal Fracture of 5th Metatarsal
- Mechanism of Injury = Forceful load applied to the ball of the foot – Running or Jumping Sports
- Note: Dancer’s Fracture
  - Avulsion fracture at 5th MT where peroneus brevis attaches
  - Inversion Injury
  - Cast shoe only (Cam Walker Boot)
- Clinical findings
  - Pain over 5th MT
  - Delayed healing compared with avulsion fractures
- Treatment
  - Emergent Orthopedic Consultation
  - Non-displaced fracture = Immobilization in non-weight bearing short leg fracture
  - Displaced fractures = Surgical management
Jones Fracture

- Stress Fracture – 5\textsuperscript{th} MT
- Jones Fx = Diaphysial 5\textsuperscript{th} MT Fx
- Dancer’s Fx = Avulsion of 5\textsuperscript{th} MT

http://api.ning.com/files/WgKj1gJknxFvrvEB9z53mRstmdstzfIdE4KWzFl40-
YZpLDlt5HWpVUaH*SlpD883aRdJYd4SD15pgZEHU3IVuxpxYkFqE9/
RITjonesfracture.jpg

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Questions?
References

