

# **Acute compartment syndrome & Acute joint dislocation**

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# Objectives

- **At the end of this course, students should be able to demonstrate **knowledge**, able to **diagnosis**, and initially **manages** a patient with an **acute compartment syndrome & acute joint dislocation**. This requires the ability to identify, characterize and differentiate through patient inquiry, examination and limited investigation, and outline management of **acute compartment syndrome & acute joint dislocation****

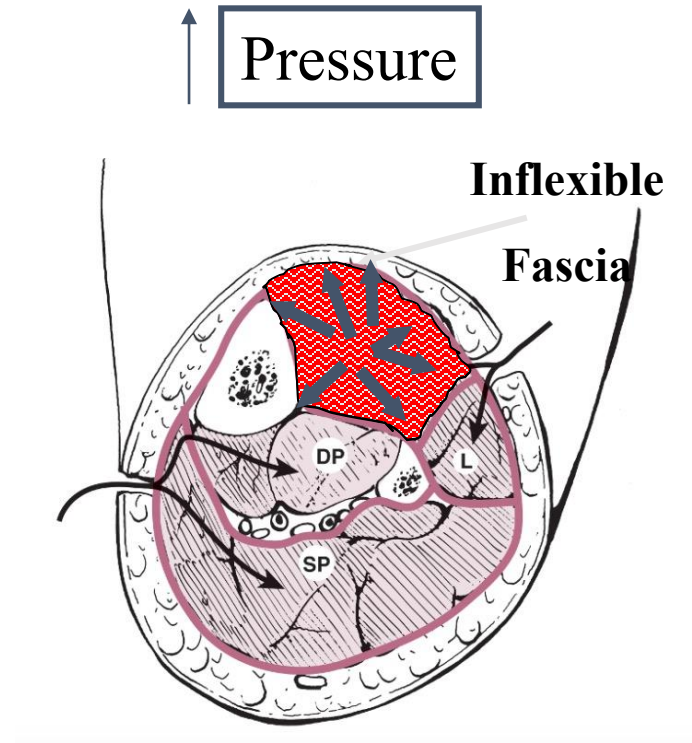
# Acute compartment syndrome

- Review Pathophysiology of Acute Compartment Syndrome
- Review Current Diagnosis and Treatment
  - Risk Factors
  - Clinical Findings
  - Management
  - Complications.

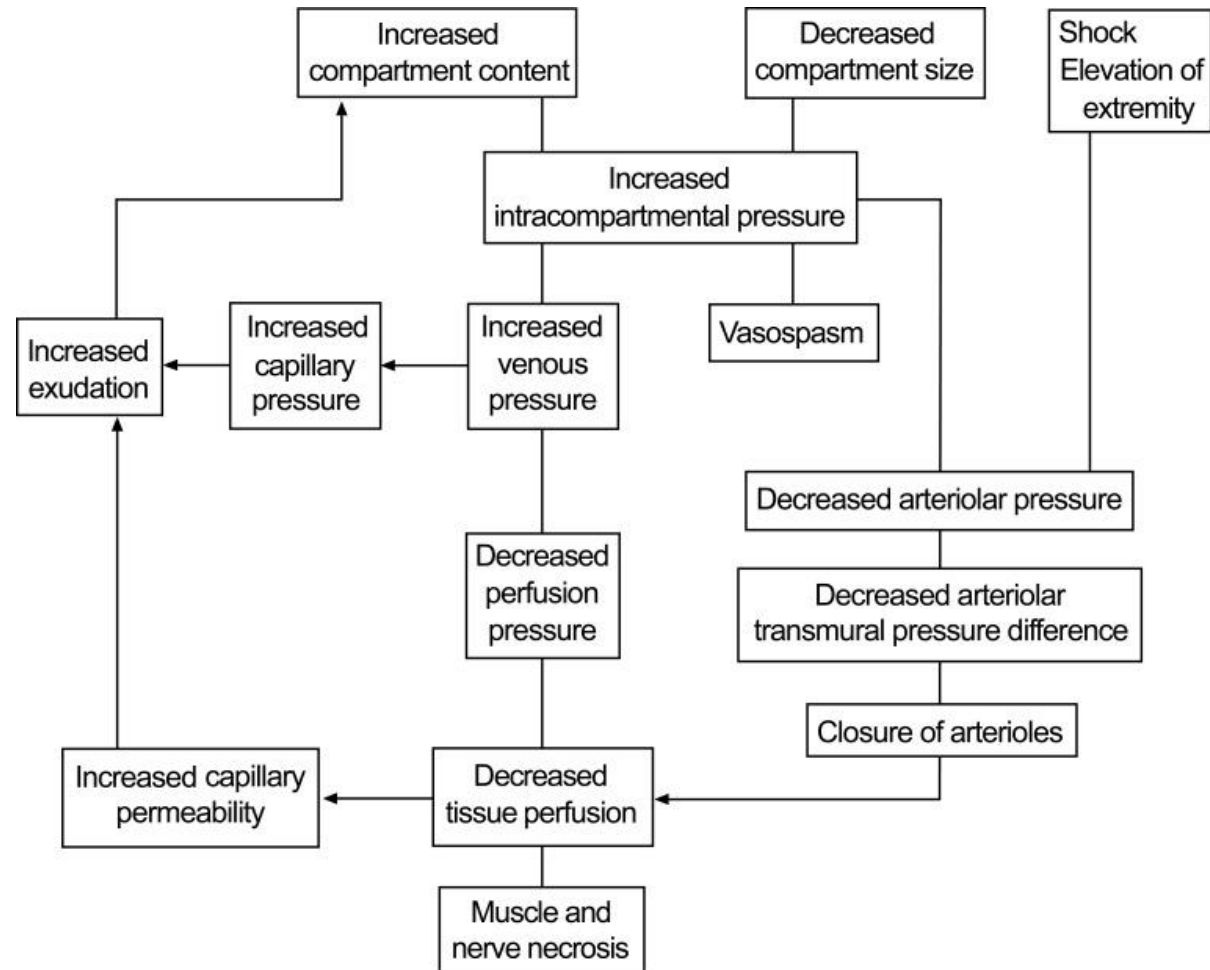
# Type of compartment syndrome

- Acute vs chronic (exertional)
- Adult vs Pediatric

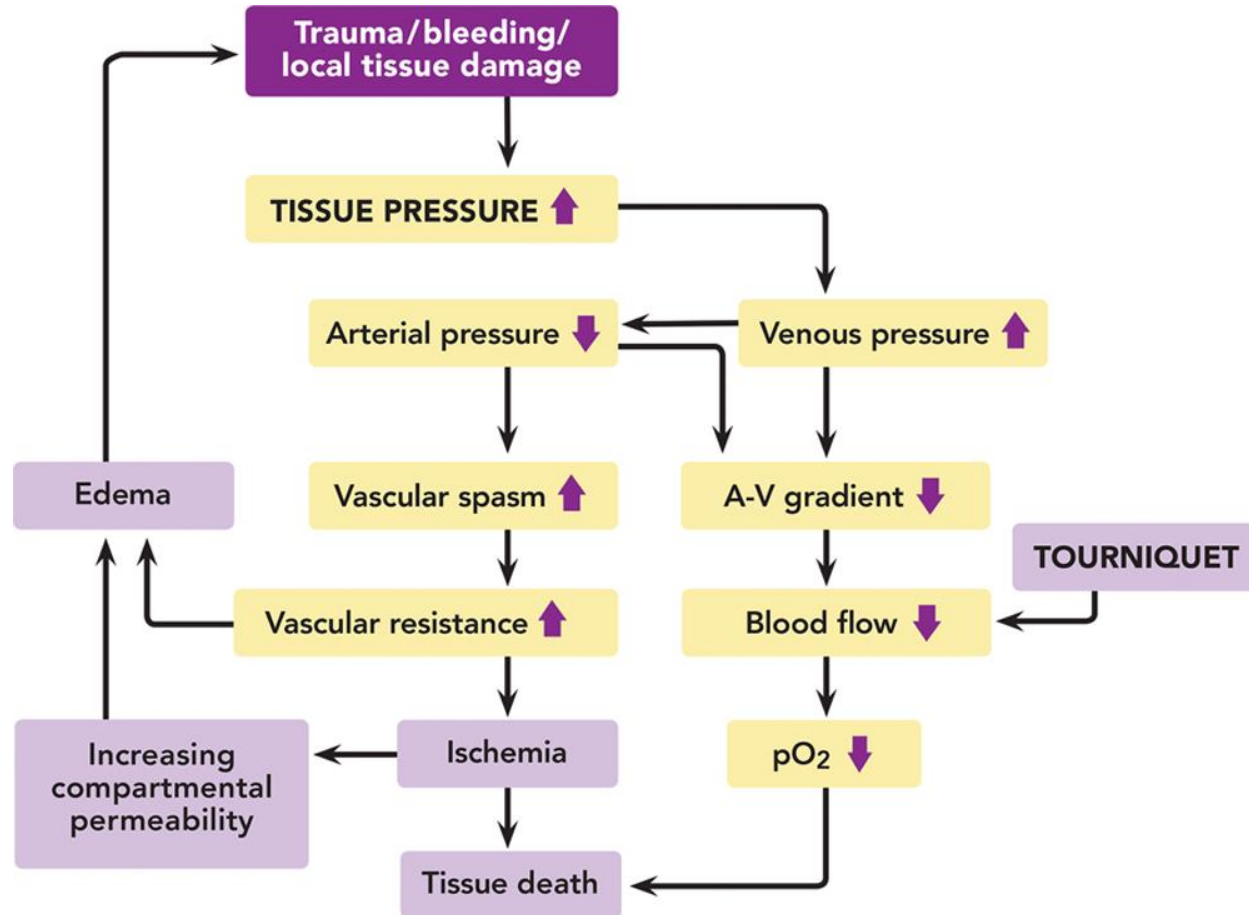
**Acute compartment syndrome** occurs when the tissue pressure within a closed muscle compartment exceeds the perfusion pressure and results in muscle and nerve ischemia. It typically occurs subsequent to a traumatic event, most commonly a fracture.



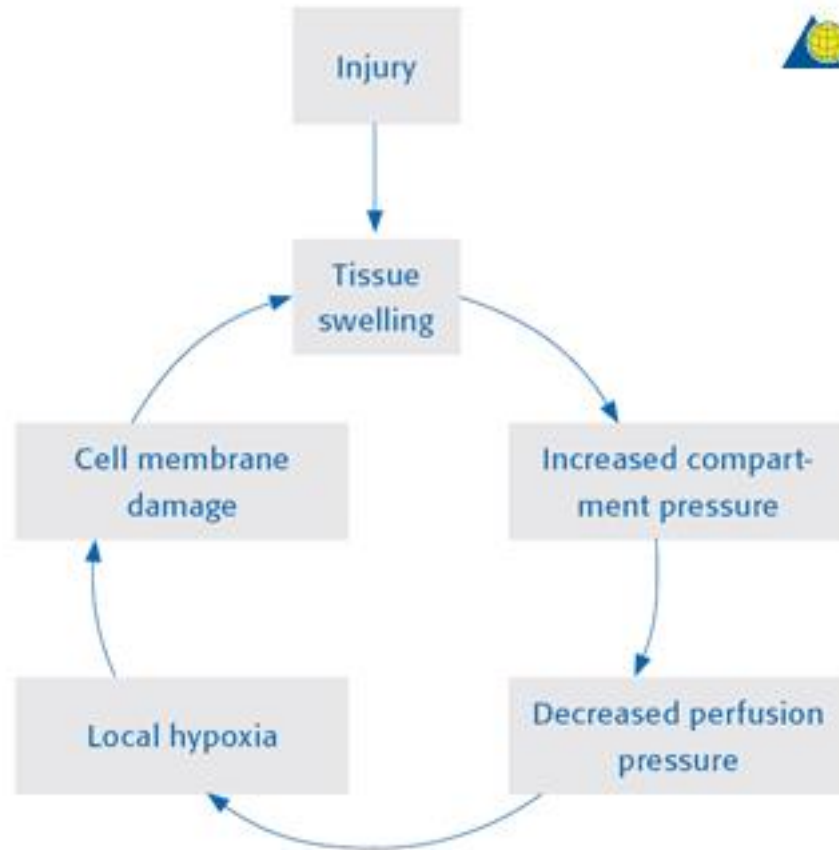
# Pathophysiology



# Pathophysiology



# Compartment syndrome is due to a vicious circle

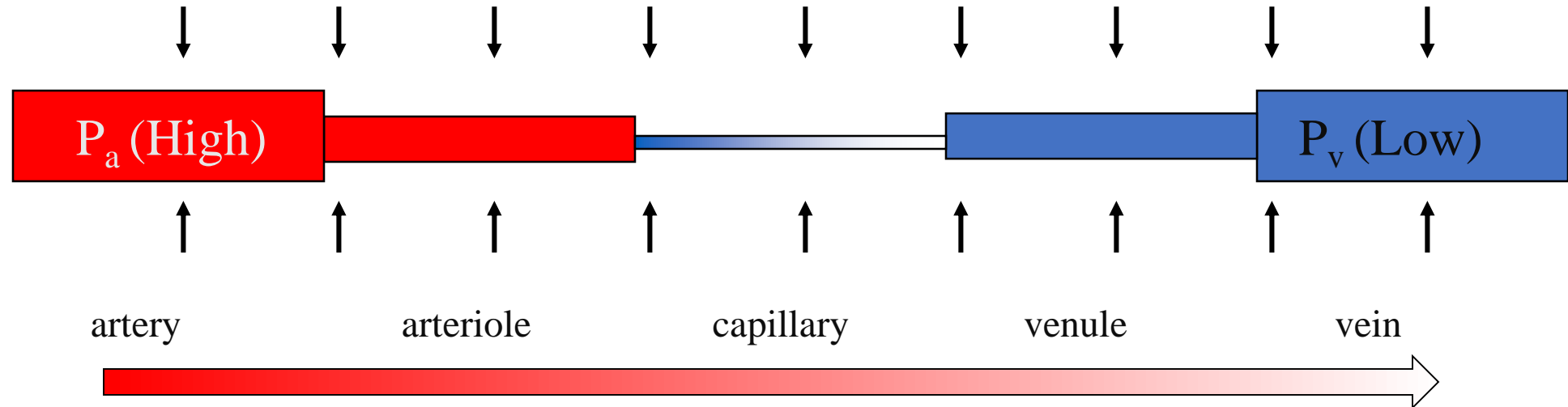


- Autoregulatory mechanisms may compensate:
  - Decrease in peripheral vascular resistance
  - Increased extraction of oxygen
- As system becomes overwhelmed:
  - Critical closing pressure is reached
  - Oxygen perfusion of muscles and nerves decreases
- Cell death initiates a “vicious cycle”
  - increase capillary permeability
  - increased muscle swelling



# Vascular Consequences of Elevated Intracompartment Pressure:

## A-V Gradient Theory



$$\text{Local Blood Flow} = \frac{P_a - P_v}{R}$$

# Etiology

## Increased Volume-internal

- Hemorrhage in to a compartment
  - Fractures (most common cause)
    - Tibia shaft
    - Supracondylar
  - Bleeding disorders
- Swelling from traumatized tissue
  - Crush syndrome
  - Soft tissue injury
- Increased fluid
  - Burns\injections
- Post-ischemic swelling

## Decreased volume-external

- Tight casts / dressings



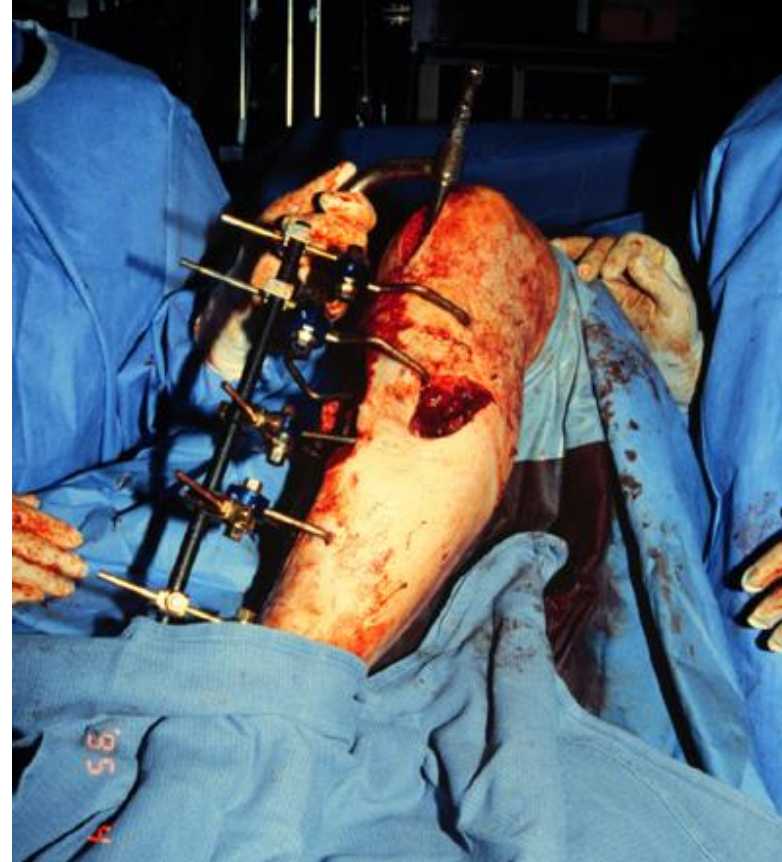
# Arterial Injury

- Post-ischemic swelling
- Reperfusion injury:
  - Ischemia causes damage to cellular basement membrane that results in edema
  - With reestablishment of flow, fluid leaks into the compartment increasing the pressure
  -



# Fracture Treatment Increases IMP

- Splinting/casting
- Manipulation
- Traction
- Spanning Ex Fix
- Nailing



# Incidence of ACS

- 2-10% tibial fractures
- 10% Calcaneal fractures
- 18% Schatzker VI plateau fractures
- 41% foot crush injuries
- 48% Segmental tibia fractures
- 53% Medial knee fx/dislocations



# Diagnosis

- Traditionally based on clinical assessment of the “5 P’ s”:
  - Paresthesia
  - Paresis
  - Pain on stretch
  - Pink Color
  - Pulse present

# Difficult Diagnosis

- Classic signs of the 5P's-***ARE NOT RELIABLE:***
- These are signs of an **ESTABLISHED** compartment syndrome where ischemic injury has already taken place
- These signs may be present in the absence of compartment syndrome.
- Palpable pulses are usually present in acute compartment syndromes unless an arterial injury occurs
- ***Sensory changes-paresthesias and paralysis*** do not occur until ischemia has been present for about ***1 hour or more***

# Pain !

- The ***most important symptom*** of an *impending* compartment syndrome is ***PAIN DISPROPORTIONATE TO THAT EXPECTED FOR THE INJURY and PAIN WITH PASSIVE STRETCH***
- Pain May be worse with elevation
- Patient will not initiate motion on own
- Be careful with coexisting nerve injury
- In severe trauma or when the patient is unconscious pain may, however, be difficult to assess. Pain is also **subjective and** can be nonspecific

**Pain out of proportion to the injury' and 'pain with passive stretching of the muscles in the compartment' are the earliest (sensitive), most reliable indicators of ACS**



# Clinical findings vs timing !

Impending/ Early ACS	Late ACS
<b>Pain</b> out proportion to injury	<b>Pulseless</b>
<b>Pain</b> with passive stretch of muscles in the affected compartment	<b>Paralysis</b>
<b>Paresthesia</b>	<b>Paresthesia /sensation loss</b>

# Pediatric ACS

- 5 Ps is not reliable in children
- 3 As
  - Increasing **A**nalgesic requirement
  - **A**nxiety
  - **A**gitation



# Physical signs of ACS

- Pain with passive stretch of muscles in the affected compartment (early finding)
- A firm & tense compartment with a firm "wood-like" feeling
- Pallor from vascular insufficiency (uncommon)
- Diminished sensation
  - Reduced two-point discrimination or vibration sense may be found in the early stages
- Muscle weakness (onset within approximately two to four hours of ACS)
- Paralysis (late finding)

# Who is at high risk?

- Inability to accurately obtain history and physical exam
  - Head trauma
  - Drug/ETOH intake
  - Pediatric
- Multiply injured patients with hypotension and hypoxia
  - Compartment syndrome can occur at lower absolute pressure

**Beware of polytrauma patient**

# Who is at high risk?

- High energy fractures
  - Severe comminution
  - Joint extension
  - Segmental injuries
  - Widely displaced
  - Bilateral
  - Floating knee
  - Open fractures
- The presence of an ***open fracture does NOT rule out the presence of a compartment syndrome***

# Who is at high risk?

- Impaired sensorium
  - Alcohol
  - Drug
  - Decreased GCS
  - Unconscious
  - Chemically unconscious
  - Neurologic deficit
  - Cognitively challenged

# Who is at high risk?

- Post operative patients on analgesia that may mask the development of pain
  - PCA
  - Spinal
  - Regional block

# Problems with Physical Diagnosis

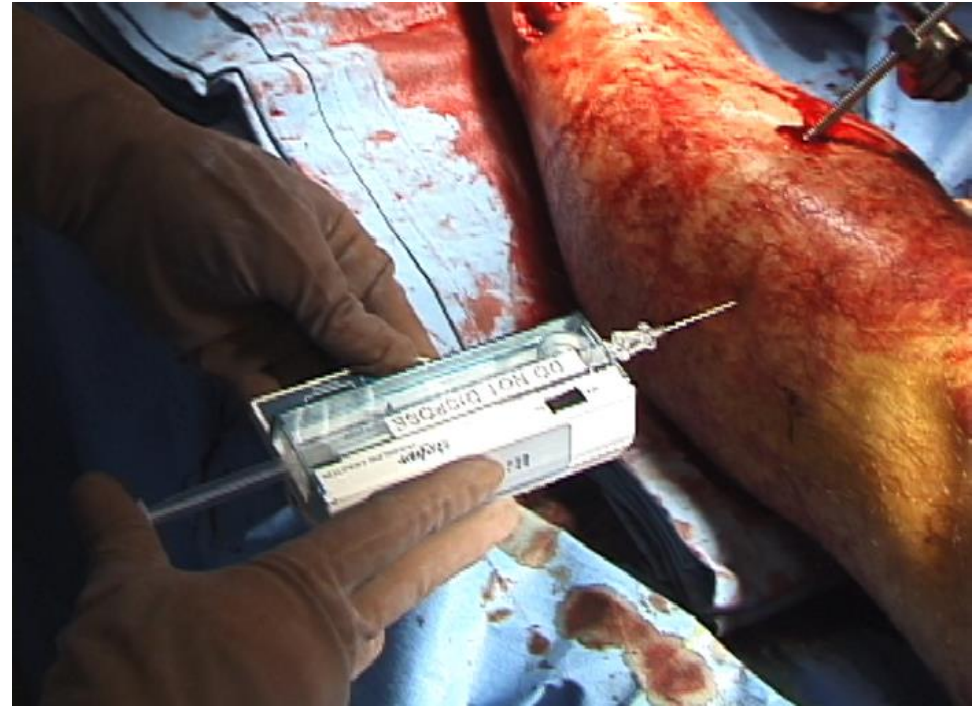
- Literature meta-analysis found that clinical findings have poor sensitivity.
  - Sensitivity of 13-19%
  - Positive predictive value of 11-15%.
  - Specificity = 97% (3% incidence of C.S. in patients without clinical findings)

**High index of clinical suspicion is the most important**

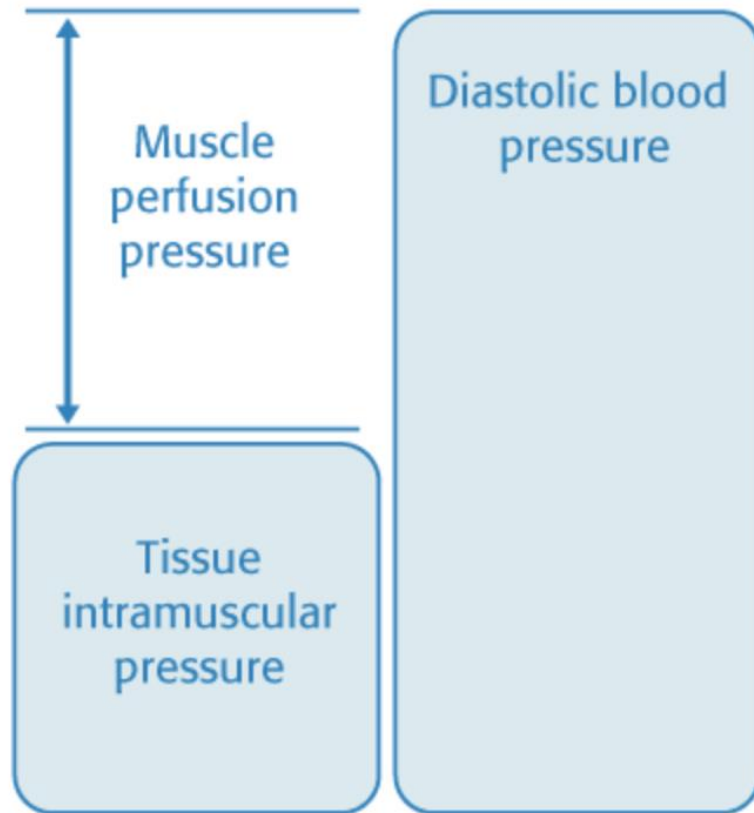


# Intramuscular Pressure (IMP) Measurement

- Adjunct to clinical examination.
- Needed for comatose or otherwise non-evaluable patient:
  - Anesthesia
  - Head Injury
  - Sedated
  - Intoxicated
  - Pediatric pts



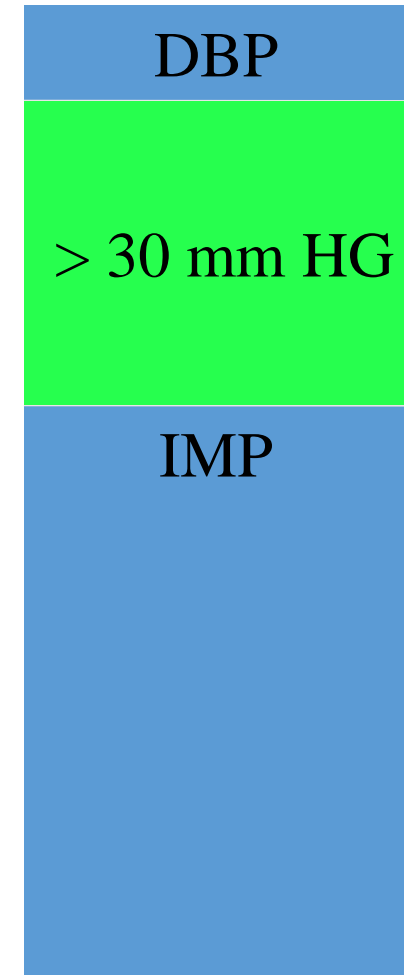
# IMP and DBP !



- Delta pressure !

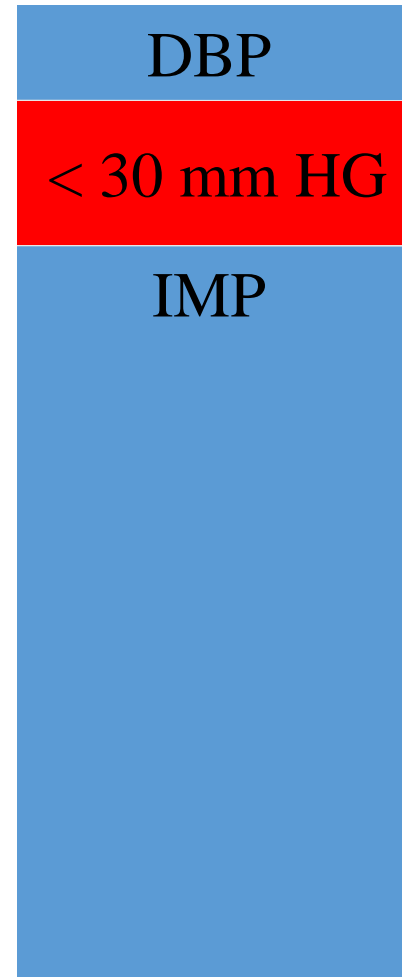
# Perfusion Pressure ( $\Delta P$ ) Vs IMP

- Currently, the “differential pressure” is considered the most reliable indicator of when fasciotomy is not necessary:
  - MAP- IMP < 45 mm Hg
  - **DBP - IMP < 30 mm Hg**
- Absolute IMP > 30mm hg
  - May leads to unnecessary fasciotomies!
  - failure to perform needed fasciotomies!



# Perfusion Pressure ( $\Delta P$ )

- Currently, the “differential pressure” is considered the most reliable indicator of compartment syndrome:
  - MAP- IMP < 45 mm Hg
  - **DBP - IMP < 30 mm Hg**



# Muscle Ischemia

- 4 hours - reversible damage
- 8 hours - irreversible changes
- 4-8 hours - variable
- Myoglobinuria after 4 hours
  - Renal failure
  - Check CK levels
  - Maintain a high urinary output – Alkalinize the urine

# Nerve Ischemia

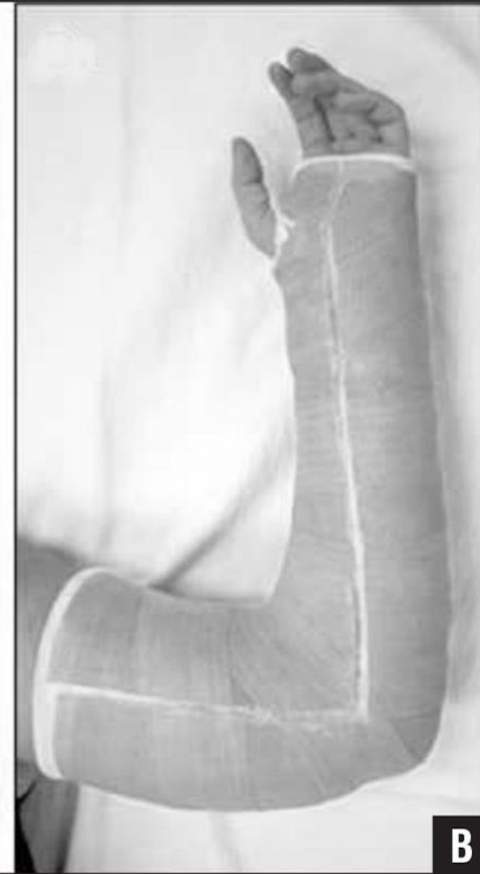
- 1 hour - normal conduction
- 1- 4 hours - neuropraxic damage reversible
- 8 hours - axonotmesis and irreversible change

• Hargens et al. JBJS 1979

# Treatment of impending ACS or High risk patients

1. Immediately assess the patient
2. Identification and removal of external compressive forces, and releasing casts or dressings **down to the skin.**
  1. **Bi-valving the cast and loosening circumferential dressings**
  2. **Leg compartment: keep the ankle in neutral to 30 degree plantar flexion**
  3. **Forearm compartment: avoid deep elbow flexion**
3. The limb **should not be elevated above the hear level** and instead kept at the level of the heart so as not to decrease arterial flow any further.
4. Serial physical examination
5. Maintain normal BP as hypotension may decrease perfusion further and compound any existing tissue injury
6. Early assessment of metabolic acidosis and myoglobinaemia is mandatory to avoid potential renal failure.

# Bi-valving the cast







# Compartment Syndrome

=

# Fasciotomy

*If you think about it, do it!*

# Emergent Fasciotomy

- **Indications**

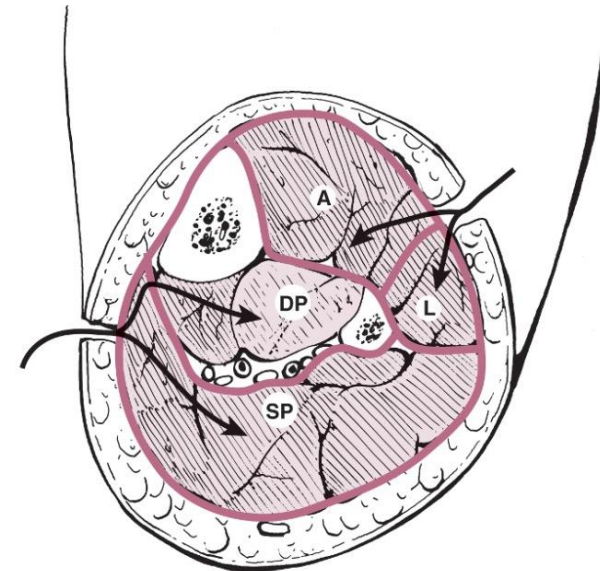
- Clinical presentation consistent with compartment syndrome
- Compartment pressures within 30 mm Hg of diastolic blood pressure (delta p)
- 6 -8 hours of total ischemia time

- **Contraindications**

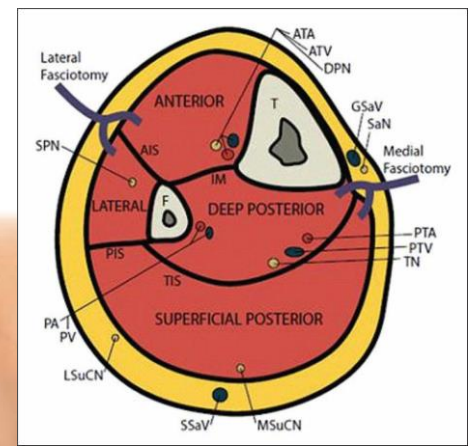
- Missed compartment syndrome (high complications)

# Technique of Fasciotomy

- Longitudinal skin incision that extends the *entire length* of the compartment.
- Release of fascia of involved muscle.
- Skin left open
  - Closure of skin is usually achieved after swelling has subsided
  - Skin grafting is often required
- Second and third look surgeries are often required



# Leg fasciotomy

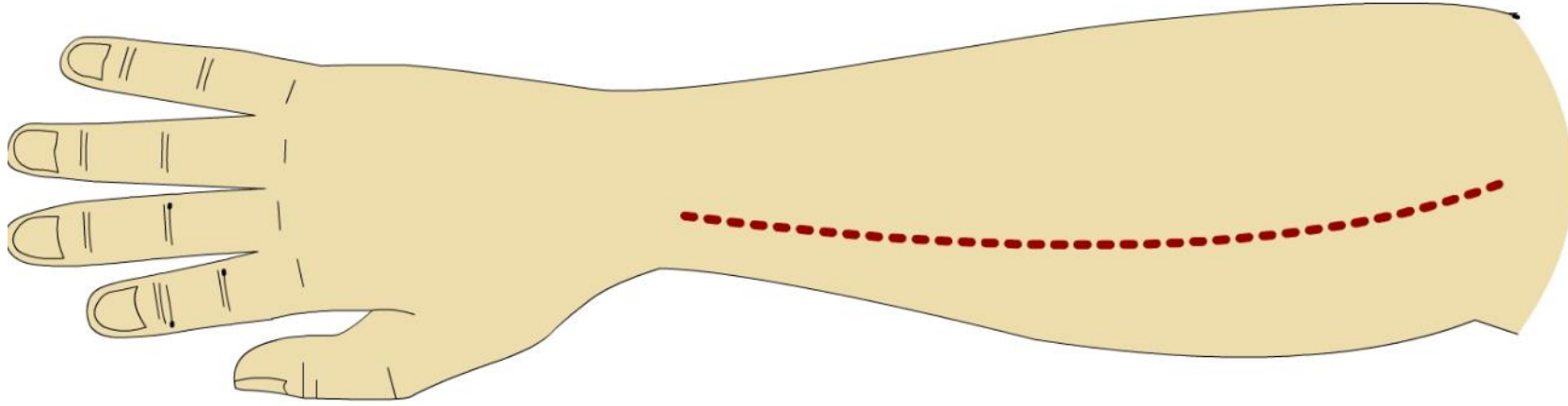


NECROSIS OF  
SOFT TISSUES  
FROM MUSCLE  
SWELLING AND  
LOSS OF BLOOD  
SUPPLY

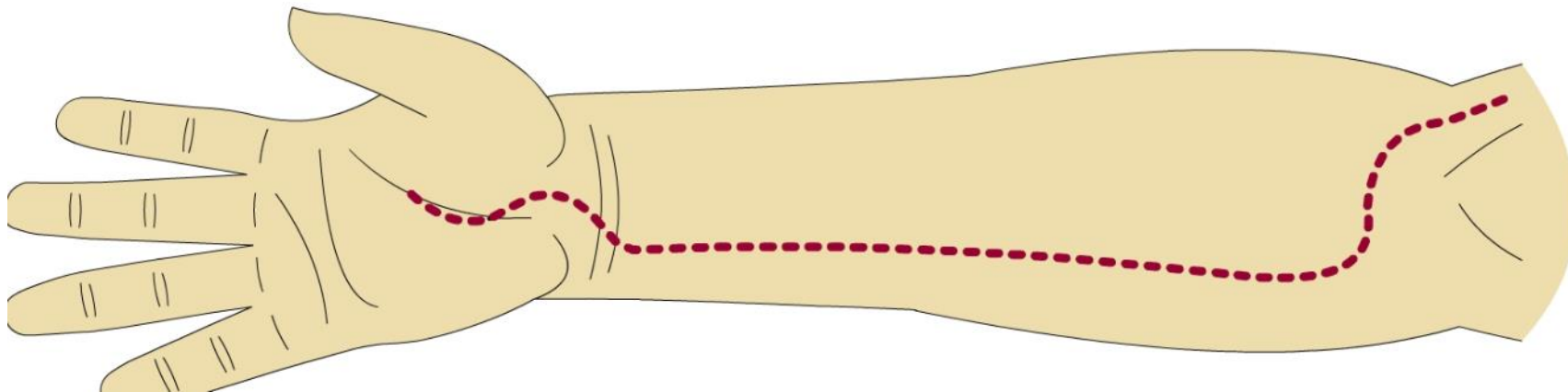


# Forearm Fasciotomy Incisions

Dorsal



Volar



# Complications of Fasciotomy

- Muscle Weakness
- Chronic venous insufficiency
- Tethered scars
- Impaired sensation
- Ulceration
- Costs

# Consequences of ACS

- Ischemic myonecrosis
  - > Myoglobinuria > kidney tubular damage > acute renal failure
  - Loss of function of the involved compartment secondary to **muscle contracture**
- Ischemic neuropathy
  - Paralysis
  - Loss of sensation
- Crush injury
  - Rhabdomyolysis
  - Renal failure

**Delay in Diagnosis/ Treatment is the cause of a poor outcome**





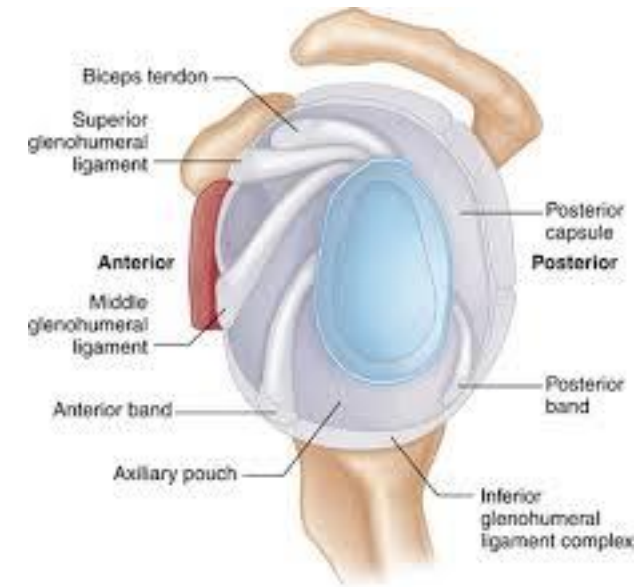
# Acute Joint Dislocation

- Objectives:

1. To describe mechanisms of joint stability
2. To be able diagnose patients with a possible acute joint dislocation
3. to be able to describe general principles of managing a patient with a dislocated joint
4. to describe possible complications of joint dislocations in general and in major joints such as the shoulder, hip and knee

# Acute Joint Dislocation

- Joint stability:
  - Bony stability
    - Shape of the joint (ball and socket vs round on flat)
  - Soft Tissue :
    - Dynamic stabilizer: Tendons/Muscles
    - Static stabilizer: Ligaments ± meniscus/labrum
  
- Complex synergy leading to a FUNCTIONAL and STABLE joint



# Dislocation

# Vs

# Subluxation



# Acute Joint Dislocation

- It takes higher energy to dislocate a joint with bony stability than a joint with mainly soft tissue stability
- Connective tissue disorders may lead to increased joint instability due to abnormal soft tissue stabilizers.
- Dislocation of a major joint should lead to considering other injuries.

# Acute Joint Dislocation

- At risk group:
  - Major trauma victims
  - Athletes and sport enthusiasts
  - Connective tissue disorder patients

# Acute Joint Dislocation

- When a joint is subjected to sufficient force in certain directions it might sustain a fracture, a dislocation or a fracture dislocation
- Different joints have different force vectors that may lead to a dislocation
- A joint might dislocate in different directions

# Acute Joint Dislocation

- A joint dislocation is described by stating the location of the distal segment
  - Anterior shoulder dislocation: anterior displacement of the humeral head relative to the glenoid
  - Posterior hip dislocation: posterior displacement of the femoral head relative to the acetabulum



# Acute Joint Dislocation

- Diagnosis:
  - History of a **traumatic event** ( major trauma or any trauma with the limb in high risk position)
  - **+++Pain** and inability to use the limb
  - Deformity
  - Shortening
  - Malalignment
  - Malrotation
  - Neurovascular compromise



# Acute Joint Dislocation

- Diagnosis:
  - Should check for other injuries (distracting injury)
  - Should always check the distal **neurovascular** status.
  - Should check for **compartment syndrome**

# Acute Joint Dislocation

- Diagnosis:
- X-rays:
  - Should be done urgently without delay if dislocation is suspected
  - Two perpendicular views of the involved joint
  - Occasionally, special views are required such as the axillary view for shoulder dislocation
  - X-rays to the joint above and below

# Acute Joint Dislocation

1. Activate ATLS if high energy trauma or associated with other injuries
2. Analgesia++
3. Quick clinical/NV assessment
4. 2 view x-rays
5. Urgent reduction
6. Check stability and safety zone
7. Re-check neurovascular status after reduction
8. Examine the compartment to R/O CS
9. Post reduction 2 view X-rays
10. Immobilize the joint
11. Consult Orthopaedics

# Principles of joint reduction

1. ++ Analgesia (opioid)
2. +/-IV sedation (to relax the muscles)
  1. Need cardiorespiratory monitoring
3. Need assistant for help
4. Gradual traction + counter-traction in the line of deformity to distract the joint
5. Realignment and rotation to reduce the joint based on direction of dislocation
6. Check ROM and stability of the joint
7. Re-check the NV status
8. Confirm the reduction by 2 view x-rays
9. Immobilize the joint in the most stable position

**Don't attempt to reduce a fracture dislocation in ER, instead consult the Orthopaedic because patient will need urgent open reduction in OR**

# Failed reduction in ER

- Causes:
  - Inadequate analgesia/Sedation
  - Entrapped soft tissue within the joint
  - Associated fracture
  - Wrong technique
  - Associated with significant soft tissue injury for static and dynamic stabilizers
- Action:
  - Urgently consult Orthopaedic surgeon
  - Patient will need Urgent closed reduction under general anesthesia and possible open reduction if closed reduction fails

# Fracture-Dislocation

- A fracture dislocation is usually reduced in an open fashion in the operating room



# Sequelae (complications) of acute dislocation

## Early

- Nerve injury
- Chondral (cartilage) injury
- Osteochondral fracture
- Periarticular fracture
- Vascular injury
- Ligaments tear
- Compartment syndrome

## Late

- Recurrent dislocation
- Instability
- Stiffness
- Avascular necrosis
- Post-traumatic arthritis
- Heterotopic ossification

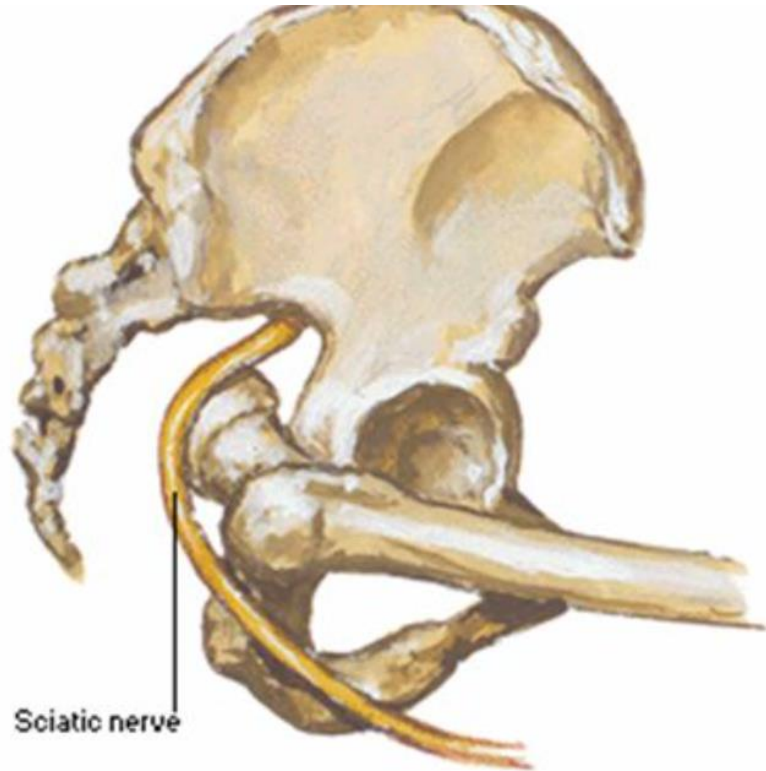
# Nerve injury



Radial nerve

Axillary nerve

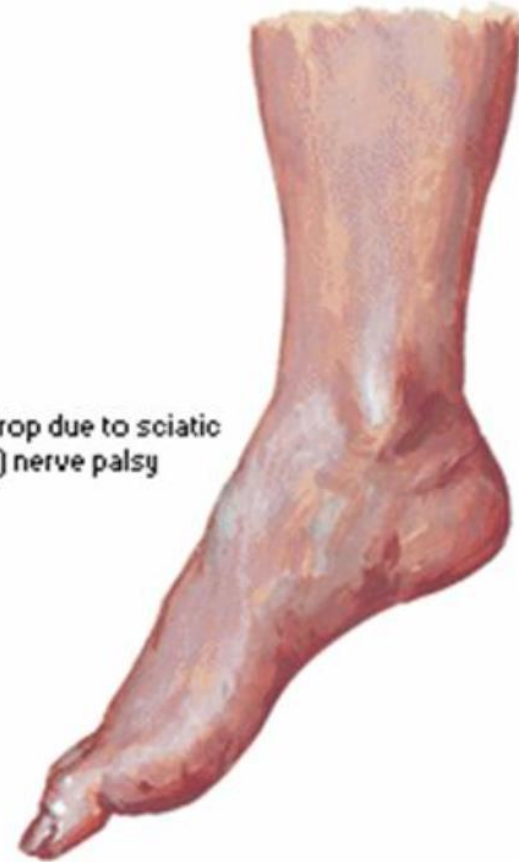
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Sciatic nerve

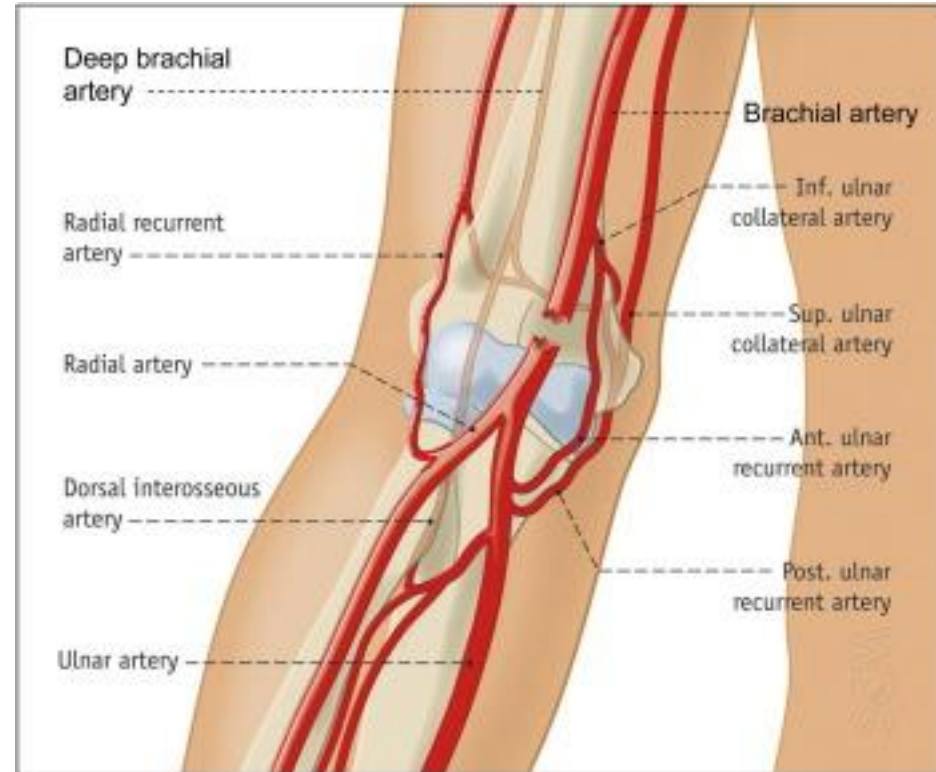
Posterior dislocation of hip. Femoral head may impinge on sciatic nerve, leading to nerve palsy (partial or complete)

Foot drop due to sciatic (fibular) nerve palsy





# Vascular injury

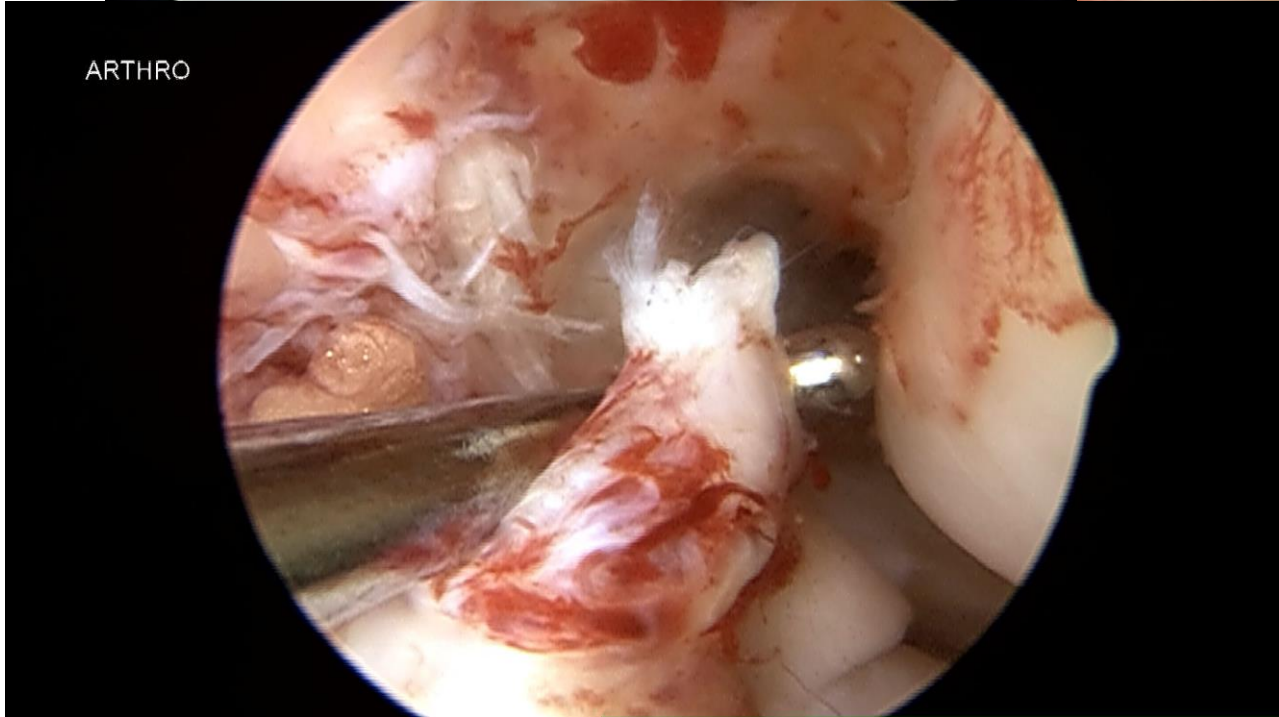


# Chondral injury

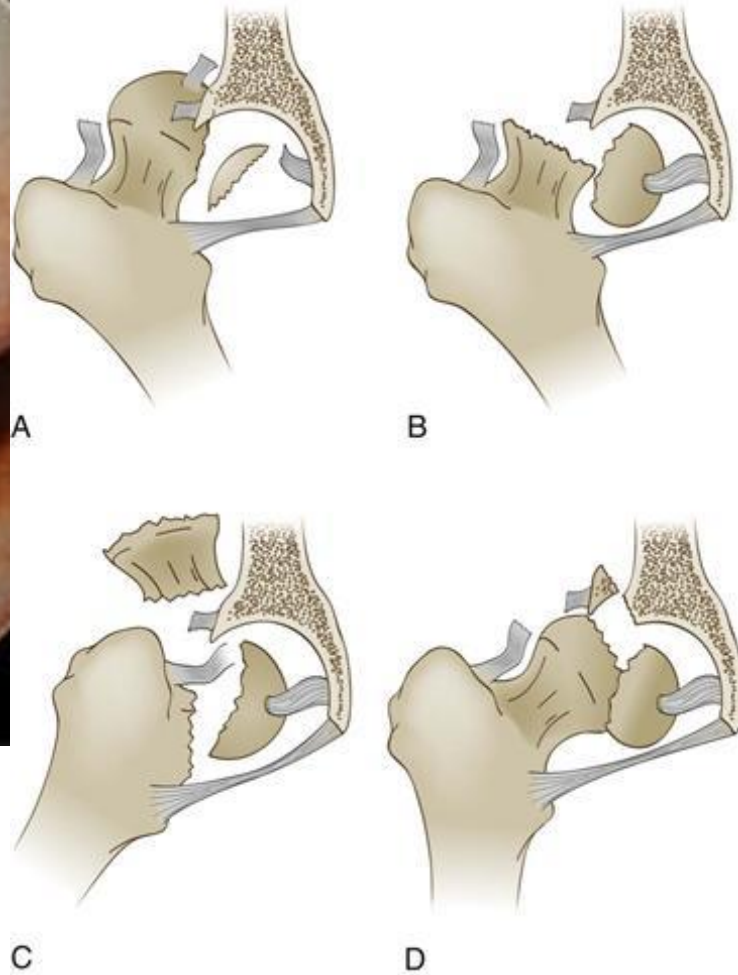
## Osteochondral fracture



ACL and PCL tear



## Hip fracture dislocation



# Sequelae of missed (chronic) dislocated joint

- Irreversible (permanent) nerve palsy
- Chondrolysis
- AVN
- Loss of joint function
- Stiff joint
- Inability to do closed reduction
- Post-traumatic arthritis
- Poor outcome even after successful open reduction

# Hip dislocation

- Posterior dislocation is commonest
- Major trauma with hip flexed (dashboard injury)
- Sciatic nerve injury common
- High incidence of late avascular necrosis
- An orthopedic emergency!!



# Shoulder Dislocation

- Commonest large joint dislocation
- Anterior dislocation is more common
- Patients with seizures prone to posterior dislocation
- May cause chronic instability
- Can result in axillary nerve injury



# Knee Dislocation

- Three or more ligaments
- Severe (high energy) trauma
- May be associated with popliteal artery injury → Limb threatening
- Very serious emergency
- Needs accurate vascular assessment
- May be associated with peroneal nerve injury
- May be associated with fracture/ compartment syndrome
- Most require surgery either early or late or both



