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Orthopedic
441 Team

MED441
KING SAUD UNIVERSITY

Editing File

Compartment Syndrome & Acute Joint Dislocation

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Color Index:

- Main Text
- Important
- 441 Notes
- Old Notes
- Extra

Objectives

Compartment syndrome

- To explain the pathophysiology of CS.
- To Identify patients at risk of developing CS.
- To be able to diagnose and initially manage patients with CS.
- To be able to describe the possible complications of CS.

Acute joint dislocation

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

Resources

Acute Compartment Syndrome
By Armando Hasudungan

Hip Dislocation
By nabil ebraheim

Leg Compartment Syndrome
By Orthobullets

Hip Dislocation
By Orthobullets

Shoulder Dislocation
By Rhesus Medicine

Shoulder Dislocation
By nabil ebraheim

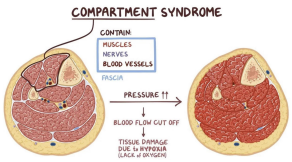
Knee Dislocation
By Orthobullets

Anterior Shoulder Dislocation
By Orthobullets

Posterior Shoulder Dislocation
By Orthobullets

Compartment Syndrome

Definition



Group of muscles and nerves wrapped in a layer of deep fascia

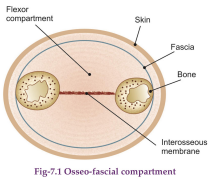
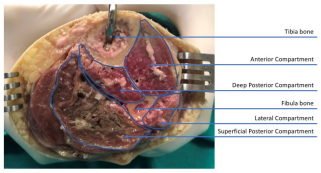


Fig-7.1 Osseo-fascial compartment

- It's a potentially devastating condition in which the pressure within an osteofascial compartment rises to a level that decreases the perfusion gradient across tissue capillary beds, leading to cellular anoxia, muscle ischemia, and death.
- It's an **orthopedic emergency**, in which intercompartmental pressure "tissue pressure within a closed muscle compartment" exceeds perfusion pressure, results in muscle & nerve ischemia which lead to muscle necrosis, and it can develop wherever a compartment is present[1], and it can be either due to increased compartment content or decreased space, can happen with or without fracture (e.g. burn, crush injury, cast, etc..).

Pressure Gradient



- Arteries pressure is greater than > arteriole > capillary bed which is (diffusion/exchange) site > venule > vein[2].

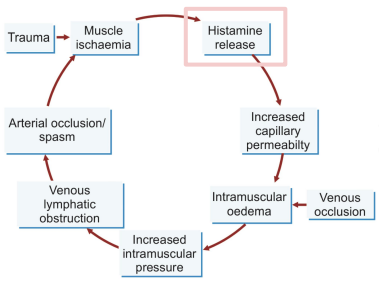
Pathophysiology

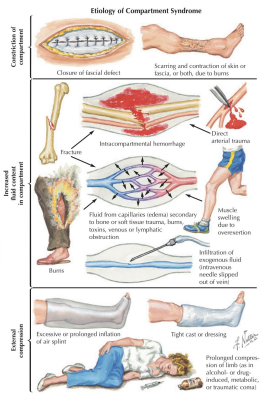
IMPORTANT

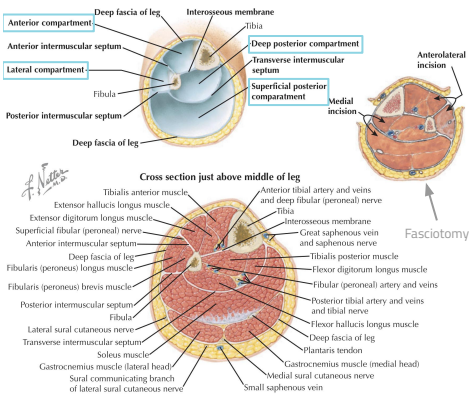
- Risk factor (warfarin, valve replacement) → elevated tissue pressure → absence of diffusion at the capillary bed → cell damage and swelling → further increase in tissue pressure → lack of oxygenation → vicious circle
- **Threshold pressure:** "Absolute measurement"
  - It's CS if the Intercompartmental pressure exceeds 30 mmHg (rigid measurement). Because this pressure is enough to close the capillary bed perfusion pressure.
- **Relative measurement:**
  - Δ P = **DBP - Intercompartment** = <30 (**if less than 30 it is CS**)[3].
  - **Less than 30 mmHg difference** between compartment pressure and preoperative diastolic pressure = it is more relative to perfusion = (clinically relevant)[4], normal CP must be < DBP by 30 mmHg.
- **Examples:**

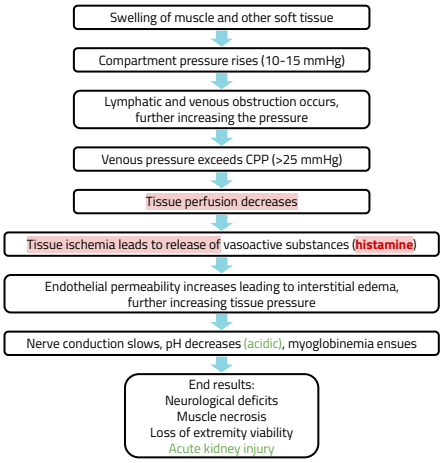
1- Patient's BP was 100/60 and his intracompartmental pressure (IMP) was 25 mmHg, is this CS?
- No, this patient doesn't have CS because (60-25=35) which is not <30 mmHg which means that the compartmental pressure didn't exceed the perfusion pressure (no ischemia).

2- Patient had a diastolic pressure of 50 and Intracompartmental pressure of 25 mmHg, is this CS?
- Yes, because (50-25=25) which is <30 mmHg.









1- It typically occurs following a traumatic event, most commonly a fracture. Also, could happen due to burns or a cast.
2- Very unlikely to have an absent artery pulse because it's unlikely for compartment pressure to be > artery pressure. However, when it reaches the level of perfusion pressure the compartment cascade will begin.
3- First patient 80 years old with BP 90/40 and relative compartment pressure is 20, second patient 20 years old muscular bodybuilder with BP 120/80 and relative compartment pressure is 29. Which one has a high risk of compartment syndrome? **First one** due to low relative compartment pressure and low diastolic pressure.
4- Relative measurement is more important than absolute measurement, because variation between people limits the use of it, since a big muscular guy differs from an old thin lady.

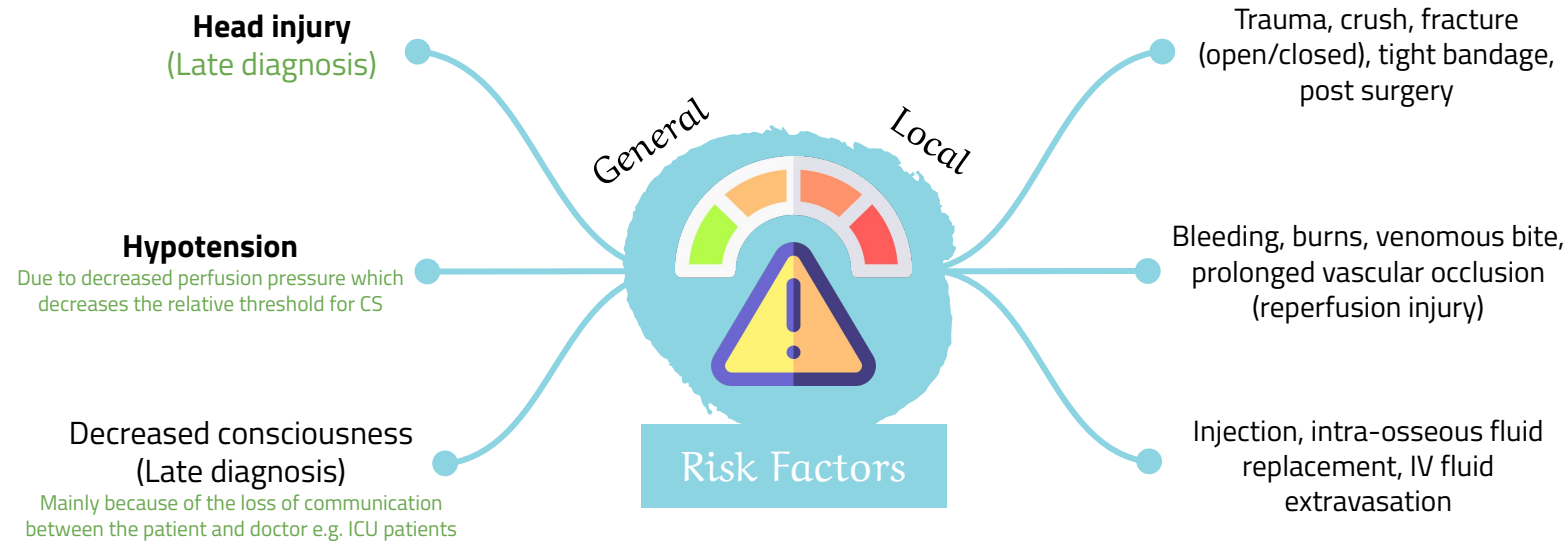
Etiology

Increased Compartmental Volume (internal expanding forces)

- Close soft tissue injury/crush injury. Local hematoma inside
- Close fracture. Internal medullary artery bleeding
- Open fracture[1]. → Higher risk than closed fracture
- Hemorrhage. From medulla
- Vascular injury. Like laceration, popliteal artery damage if waiting for > 6hrs can lead to reperfusion syndrome, which is the damage done by restoration of blood flow to prolonged ischemic tissues, resulting in sudden release of muscle necrosis products into the circulation (e.g. reactive oxygen species, myoglobin, K^+), causing many adverse effects (e.g. AKI, DIC, Arrhythmias, CS, etc..)
- Coagulopathy (anticoagulation therapy).
- Increased capillary permeability after burns (especially circumferential).
- Infusions or high-pressure injections (eg, regional blocks, paint guns). Radiology contrast injection intervention/extravasation
- Reperfusion after prolonged ischemia[2]. (most ischemia → fasciotomy)

Reduced Compartmental Volume (external compressing forces)

- Tight circumferential dressings (artificial) (e.g. can occur with cotton cast padding alone).
- Cast or splint (artificial).
- Prolonged limb compression as in Trendelenburg, lateral decubitus, alcohol or drug abuse[3].



"Young, male, high energy mechanism injury, E.g. Young patient coming with a tibial diaphyseal fracture"

1- It is a common mistake that people make thinking that an open fracture helps in releasing the pressure. In fact, usually the hole is small and isn't enough to overcome the pressure caused by the internal bleeding. The blood also can close the hole by acting like a valve. Moreover, the hole is usually in one compartment and we have more than one (4 in case of the tibia).
2- Damage to the basement membrane can cause leakage of intravascular fluid into the interstitium increasing the intracompartmental volume. The cut off in ischemia is usually 6 hours until the cellular death of the structures (vessels, nerves, ...)
3- It happens more in western countries by getting drunk and not moving for a long time (>24 hrs). This can compress one side of the leg causing a compartment syndrome on the other side.

Orthopedic Conditions

Underlying Condition	% of Cases
Tibial diaphyseal fracture	36
Soft tissue injury	23.2
Distal radius fracture	9.8
Crush syndrome	7.9
Diaphyseal fracture forearm	7.9
Femoral diaphyseal fracture	3.0
Tibial plateau fracture	3.0
Hand fracture(s)	2.5
Tibial pilon fractures	2.5
Foot fracture(s)	1.8

Why tibial fractures are number 1 ?

- Scientifically, it's proven by evidence.
- Logically, the tibia is a large bone placed in a small compartment.

- When you hear in MCQ or OSCE or anywhere "Tibial shaft fracture, young adult, male, pain" immediately think about CS.

Diagnosis

- It's a clinical diagnosis! (No X-ray, US, CT or MRI).
- You need to keep a high index of suspicion to perform immediate surgery and save the patient's limb.

Signs & Symptoms

Anterior compartment of the leg (the most commonly affected compartment)

- Tense swelling.
- Tight (woody compartment):
  - Most reliable clinical sign.
  - Calf muscle would be hard (rigid) and woody (normally soft and fleshy).
- Tender compartment:
  - Movement of anterior or posterior muscles of leg elicits severe pain.

Early

The earliest of the 'classic' features is severe pain (or a 'bursting' sensation) and this may be the only feature seen.

- Very severe **pain**, not responding to analgesics:
  - **Out of proportion** to the injury.
  - Patient cries from the pain.
  - Increase need of analgesics, if the patient respond to analgesics, then it's not CS.
  - This is the most sensitive & 1st symptom.
- Pain increase with passive **stretching** of the muscles in the involved compartment:
  - Dorsiflexion → Posterior compartment.
  - Plantarflexion → Anterior compartment[1].
  - Ischemic muscle is highly sensitive to stretch.
- Pain might be worse with elevation.
- Patient will not initiate motion on their own.
- Presence of risk factor.
- Measurement of the IMP is high.

Late

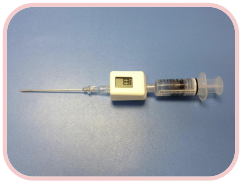
- 4 P's: Paralysis, Paresthesia, Pallor and in severely high pressure Pulselessness.
- Pulselessness is RARE, and it's sign of severity, only severely high compartment pressure causes it because the pressure need to exceed the arterial pressure to occlude it (almost never), don't say it's not CS because there is pulse. The ischemia occurs at the capillary level, so pulses may still be felt and the skin may not be pale!

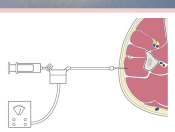
Pediatrics

3 A's: (Increasing Analgesic requirement, Anxiety, Agitation)

IMP (Intramuscular Pressure)

Not used anymore





- We insert a device in the compartment that injects fluid and collect it and provide us with the reading.
- Rarely necessary and might give a false low result, so must be done at the area of the highest expected pressure.
- We can use it as a relative measure if the patient is unconscious and cannot communicate e.g. ICU patients, those who are comatose, have psychiatric problems, or are under the influence of narcotics.
- Issues:
  - Not reliable (if injected in muscle → very high reading).
  - High false positive rate (perform unnecessary procedures).

1- Most common affected compartment.

Management

Initial (Undeveloped CS)

- Maintain normal blood pressure.
- **Remove** any constricting bandage. if there is no improvement within 2 hours of splitting the dressings, fasciotomy should be performed.
- Keep limb **elevated** at heart level.
- Regular close monitoring (observation) (15-30 minute intervals).
- Ice
- Avoid nerve blocks, sedation and strong analgesia to obtain patients feedback. Anything that can block pain response.

Late (Fully Developed CS)

- Remove any constricting bandage. (The first & immediate thing to do)
- Maintain normal blood pressure.
- Keep limb elevated at heart level.
- Diuresis to avoid kidney tubular injury if late. Diuresis isn't for CS it's to protect the kidney from myoglobinuria (That results from rhabdomyolysis "muscle damage").
- Urgent surgical decompression (**Fasciotomy**). The sooner the better, because we're not treating CS we're preventing the sequelae of CS.

Summary

1. Split the cast and dressing down to the skin.
2. Elevate the leg (to the level of the heart).
3. Ice to decrease the swelling.
4. Feel the compartments, if not tight, observe the patient every 2 hours.
5. If compartments are tight, take the patient to OR for emergency fasciotomy.

Fasciotomy

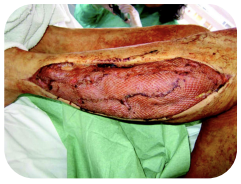
- It is a prophylactic procedure[1] done by releasing the compartment fascia to allow swollen muscles to expand which will decrease IMP and prevent further damage "the deep fascia is the most important to cut".
- This procedure doesn't reverse the damage (so better to have a low threshold), and should be done as soon as possible, and if there's still viable tissue (otherwise infection is likely).

Indications:

- Within 6 hours of total ischemia time (e.g. arterial embolism).
- Significant tissue injury.
- Worsening initial clinical picture.
- Delayed presentation with a picture of developed CS.
- Absolute compartment pressure >30 mmHg or relative pressure (DBP-IMP) <30 mmHg.

Technique[3]:

- Debridement of all necrotic tissue is necessary[2].
- Second and third look surgeries are often required, for reassessment and further debridement.
- Closure of skin is usually done after the swelling subsides.
- Skin grafting is often required.



- Patient has CS for 4 hours → Do fasciotomy.
- Patient has CS for 48 hours → Don't do fasciotomy, because there will be dead muscle and the damage already happened, so the late presentation of CS will not be treated with fasciotomy, we just prevent further complications.

1- It is a prophylactic procedure intended to save what's left of the viable tissue (never wait!). So if someone came with a >24 hours missed CS, there'll be no benefit for the fasciotomy, in general the fasciotomy time is (<24 hours → Do fasciotomy, >24 hours don't do fasciotomy).
2- Leave the skin open for 48 hours for debridement of dead tissue then check before closing the skin incision.
3- **Summary**: Take the patient for faciatomy: we do debridement and removing all dead tissue then we keep the wound open with sterile dressing that says "Do Not Touch", after 48 hours we go in again for a second, third look for dead tissue removing, then we try to close (we try to close only the skin if that didn't work we do a graft).

Complications

IMPORTANT

Renal failure

- Myonecrosis → myoglobinemia → myoglobinuria → AKI (tubular damage)
- We can measure creatinine kinase (CK) to check for rhabdomyolysis, also urine output will be decreased and turned to dark brown (black).

Loss of function

- Flexion contracture
- Paralysis (nerve damage)
- Loss of sensation and chronic pain
- Loss of limb "Amputation"

Leg complications

Anterior compartment:

- Drop foot

Deep posterior compartment:

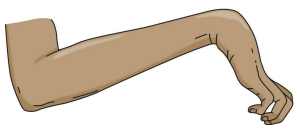
- Clawed toes, Ischemia of the calf muscles
- Loss of sensation in the sole

Forearm complications

Volar "palmar side" **compartment**:

- Volkmann contracture[1]

- Muscles are dead and start to be contracted → fibrosed → holds in a position → not allowed to move. The most commonly affected sites are the forearm and hand, leg and foot. In a severe case affecting the forearm, there will be wasting of the forearm and hand, and clawing of the fingers.



The possible complication upon opening the fascia is such as when the patient already developed rhabdomyolysis, the patient could develop **hyperkalemia** and cardiac arrest eventually, so you have to be in certain with anesthesia, first with opening of compartment there will be gush of lysed cells that contains lactic acid and potassium into the blood and to the body causing something called (**reperfusion injury**), so after cutting, you should tell anesthesia to inject calcium gluconate.

Extra

- **Chronic Compartment Syndrome** "Chronic exertional compartment syndrome (CECS)":
  - Young athletes especially long-distance runners sometimes develop pain along the anterolateral aspect of the calf, brought on by muscular exertion. Swelling of the anterior calf muscles contained within the nonexpansile deep fascia causes ischaemia of the deep peroneal nerve as it traverses the compartment. The condition is diagnosed from the history and can be confirmed by measuring the compartment pressure before and after exercise. Release of the fascia is curative. The same syndrome is very rarely seen in the forearm muscles (known as 'arm pump' in motorcyclists).
- **Interesting information:** The ischemic calcification and even ossification that occur in traumatic compartment syndromes in the lower extremity can often mimic a tumor. The initial injury is usually a crushing type that causes increased compartment pressure from muscle swelling. This pressure eventually leads to ischemic necrosis of the compartment muscle, which several years later becomes calcific or even ossified. Because the muscle appears firm and calcified on radiographic examination, the clinician may not relate the finding to an old injury and may suspect a calcifying sarcoma such as synovial sarcoma. The most common place for this pseudotumor is in one of the muscle compartments of the leg, and it causes stiffness and muscle weakness at the ankle and foot area.

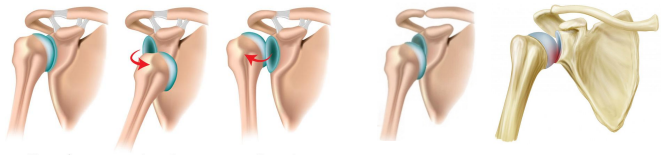
Radiograph (A) and CT scan (B) of an old compartment syndrome of the anterior compartment of the leg of an 81-year-old woman who had a history of fracture treated with internal fixation 60 years prior.

1- Permanent flexion contracture due to shortening of forearm muscles ("claw-like deformity" of the hand, fingers, and wrist) usually caused by ischemia due to compartment syndrome, muscle once infarcted is replaced by inelastic fibrous tissue (Volkmann's ischaemic contracture).

Acute Joint Dislocation

Definition

- A joint dislocation is described by stating the location of the distal segment in relation to proximal.
  - 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
- **Dislocation**: is the total loss of contact between the articular surfaces of the joint.
- **Subluxation**: is the partial loss of contact between the articular surfaces of the joint.
- **Joint stability**:
  - Bony stability:
  - ➜ Shape of the joint (ball and socket vs round on flat)
  - Soft tissue:
  - ➜ Dynamic stabilizer (tendons/muscles)[1]
  - ➜ Static stabilizer (ligaments ± meniscus/labrum)[2]

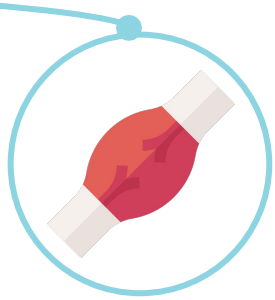


- Complex synergy leading to a functional and stable joint.
- It takes higher energy to dislocate a joint with bony stability (e.g. Hip) than a joint with mainly soft tissue stability (e.g. Shoulder) like weak ligaments.
- Connective tissue disorders may lead to **increased joint instability** due to abnormal soft tissue stabilizers[3].
- Dislocation of a major joint should lead to considering other joints[4].
- When a joint is subjected to sufficient force in certain directions it might sustain a fracture (in stable joint usually like hip joint), a dislocation (with torn ligament) or a fracture dislocation.
- Different joints have different force vectors that may lead to a dislocation.
- A joint might dislocate in different directions; in acute dislocation mainly is in one direction.
- Chronic joint dislocation, more in small joints, chronic doesn't mean recurrent.

Groups at Risk

Major trauma victims especially unconscious patient.
(e.g. Dashboard injury)

Athletes and sport enthusiasts.
(e.g. Anterior shoulder dislocation)



Connective tissue disorder patient;
due to increased joint instability in result of abnormal soft tissue stabilizers and increased soft tissue laxity.

1- The body move the joint by contracting the muscles and these muscle cause compressive force to hold the joint in place, such as in shoulder deltoid muscle.
2- One which is holding the joint in the place regardless of the movement status of joint (mainly ligaments) e.g. acute knee dislocation happens because there is injury in the ligament of knee that stabilize the knee joint, shoulder dislocation rely mainly on soft tissue called labrum which is a kind of cartilage that surrounds the periphery of the glenoid, if torn the join is no further stable.
3- Ehlers-Danlos Syndrome has high tendency to have dislocation at lower threshold of energy.
4-If an energy is sufficient to dislocate a joint you should suspect other injuries including muscle/neurovascular.

Diagnosis

- History of a traumatic event (major trauma or any trauma with the limb in high risk position).
- Very severe pain and inability to use the limb.
- Deformities:
  - Squaring of shoulder in shoulder dislocation (may have axillary nerve injury, deltoid atrophy and loss of sensation)
  - Shortening
  - Malalignment
  - Malrotation
- Should check for other injuries (distracting injury), pain can hide things.
- Should always check the distal neurovascular status, before & after to protect the patient from further damage and yourself from medicolegal issues.
- Should check for compartment syndrome.

loss of the usual rounded contour of the shoulder

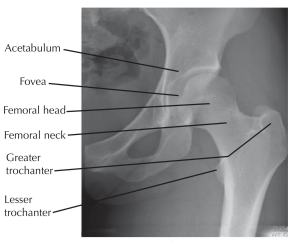
Squaring of shoulder (right shoulder dislocation)

Internal rotation, shortening of the leg & posterior hip dislocation

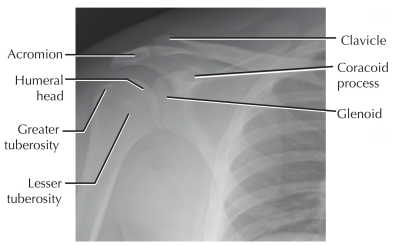
Summary:
1-Severe pain
2-Seen deformity
3-Loss of function

X-ray

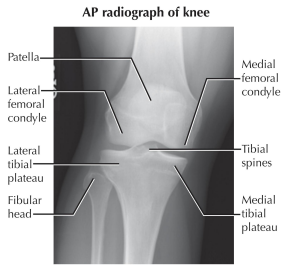
- Should be done urgently without delay if dislocation is suspected, the dislocation must reduced after obtaining X-rays, because maybe there's a fracture and you make it worse.
- Two perpendicular views of the involved joint, it's 2D image, one view is misleading.
- Occasionally, special views are required such as the **axillary view** (to isolate the joint) for shoulder dislocation.
- X-rays to the joint above and below.
- Normal X-rays:



Hip, AP xray



X-ray, AP



Management Principles

Don't forget to take consent from the patient

1. Must rule out other injuries
2. Pain relief (consent for reduction/conscious sedation "no intubation")
3. Urgent reduction (By traction and countertraction until we heard clunk "pop" sound)
4. Check stability and safety zone
5. Check neurovascular status after reduction (even before)
6. X-ray after reduction to confirm the reduction[1,2]
7. Protect the joint (by immobilization and stabilizing for 2-3 weeks)
8. Rehabilitation (physiotherapy)
9. Follow for late complications

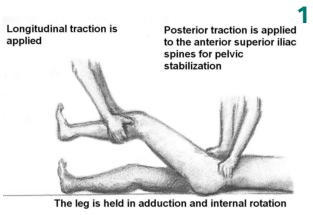
1- If the patient is in hospital setting already, then it's better to do X-ray before reduction for documentation if available.
2- Meanwhile, if patient is in the scene of injury then came to hospital, then it's better to reduce right away because the muscle are softer at that time and it's easier to reduce.

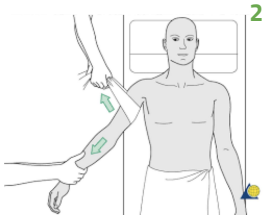
Reduction Technique

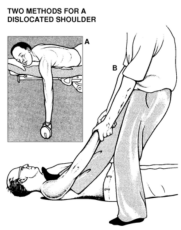
- The best treatment of pain is reduction of joint not medications.
- During reduction, follow the following steps:

1	Monitor vitals.
2	IV analgesia (opioid).
3	IV sedation (to relax the muscles).
4	Gradual traction to distract the joint.
5	Realignment and rotation to reduce the joint based on direction of dislocation.
6	A palpable clunk will be felt.
7	Check ROM "range of motion" and stability of the joint.
8	Once joint is felt to be reduced, check distal NV "neurovascular" status: • If it was intact before but not after → further urgent management is needed. • If it was not present before but intact after → check again later to confirm.
9	Observe patient vitals until medications wear out.
10	Stabilize joint and get X-rays.

- If irreducible or partial reduction only:
  - Urgent closed reduction under general anesthesia and possible open reduction if closed reduction fails.
- Usually due to:
  - Insufficient muscle relaxation.
  - Entrapment of soft tissue.







Summary

1. Start with (closed reduction with sedation) if that didn't work
2. Do (closed reduction under general anesthesia) if that didn't work as well
3. Do (open reduction)

Fracture and dislocation, you must rush the patient to the OR in 6 hours to prevent AVN

Special Consideration

- A fracture dislocation is usually reduced in an open fashion in the operating room.
- Must confirm **concentric reduction** on the X-rays, otherwise an open reduction should be performed.
- Make sure that the neurovascular status is documented before & after.

1- Posterior hip dislocation technique: Stabilize the pelvis with sheet → hip flexion → axial traction → wait for a 'Clunk' (if needed you could do internal rotation) → joint is reduced.
2- Shoulder dislocation technique: Has many techniques one of them is dislodging by using body weight of patient and pull the arm along the joint then use a folded sheet by a helper to pull shoulder.

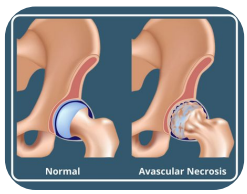
Complications

Early (Acute)

- **Heterotopic ossification**, formation of extraskeletal bone in muscle and soft tissues
- Neurological injury (reversible or irreversible)
- Vascular injury (common in neurological injuries)
- **Compartment syndrome**
- Osteochondral fracture/injury

Late (Chronic)

- Heterotopic ossification
- Stiffness
- Chronic instability, recurrent dislocation (common in shoulder)
- Avascular necrosis, It's a local bone ischemia due to destruction of blood supply (common in femur head)
- Osteoarthritis

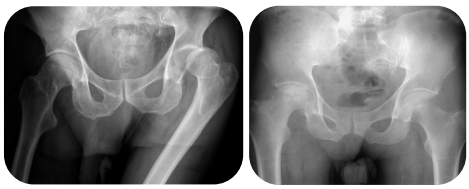


Examples of Joint Dislocation

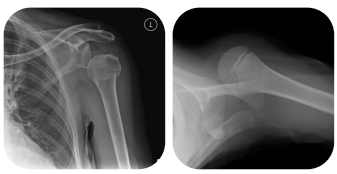
IMPORTANT

Hip Dislocation

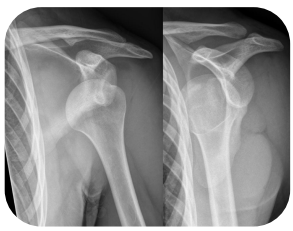
- **Posterior** dislocation is commonest among hip dislocations (high energy mechanism injury).
- Major trauma with hip flexed (dashboard injury in RTAs).
- Sciatic nerve injury is common; Most likely temporarily and take 9 months to resolve. check extension/flexion of big toe
- Loss of ankle dorsiflexion (foot drop), due to injury to peroneal nerve.
- High incidence of late avascular necrosis (10% in the beginning, reaching 80% after 6 hours), you have to follow up for 1 year.
- An orthopedic emergency!. Low recurrence rate.
- Immobilized by knee immobilization (brace), hip immobilization is hard.
- Traction by pulling flexed hip + counter-traction by holding pelvis on table.



Shoulder Dislocation



- Common. Low energy mechanism injury (sports)
- **Anterior** dislocation is more common.
- Patients presents with pain and limited range of motion after shoulder injury.
- May cause chronic instability (damaged labrum). Most common complication is recurrent dislocation.
- Patients with **seizures** (epilepsy) prone to **posterior** dislocation.
- Can result in axillary nerve injury (wasting in deltoid muscle and numbness over its area).
- Young patient with dislocation = Higher rate of recurrence.
- Immobilized by a normal sling.
- Image is showing anterior shoulder dislocation (humerus is anterior).
- Traction by pulling arm + counter-traction by a sheet around arm and pulling it.



Knee Dislocation

- Very serious emergency (could be either anterior or posterior).
- Usually with severe (high energy) trauma.
- Three or more ligaments are teared[1].
- May be associated with **popliteal artery injury** (50%) "limb threatening", peroneal nerve injury (foot drop) or with fracture/compartment syndrome.
- Needs accurate vascular assessment (popliteal artery).
- Most require surgery either early or late or both, prognosis is not great.
- Image is showing anterior knee dislocation (tibia is anterior).
- The pathognomonic sign of a posterolateral knee dislocation is the anteromedial distal thigh transverse "pucker" or "dimple sign".

1- Have medial & lateral collateral ligaments and, anterior & posterior cruciate ligaments, these main ligaments hold the knee + meniscus.

EXTRA

Compartment Syndrome

- increased interstitial pressure in an anatomical compartment (forearm, calf) where muscle and tissue are bounded by fascia and bone (fibro-osseous compartment), with little room for expansion
- interstitial pressure exceeds capillary perfusion pressure, leading to irreversible muscle necrosis (in 4-6 h) and eventually nerve necrosis

Etiology

- intracompartmental
  - fracture (particularly tibial shaft or paediatric supracondylar and forearm fractures)
  - reperfusion injury, crush injury, or ischemia
- extracompartmental: constrictive dressing (circumferential cast), poor position during surgery, circumferential burn

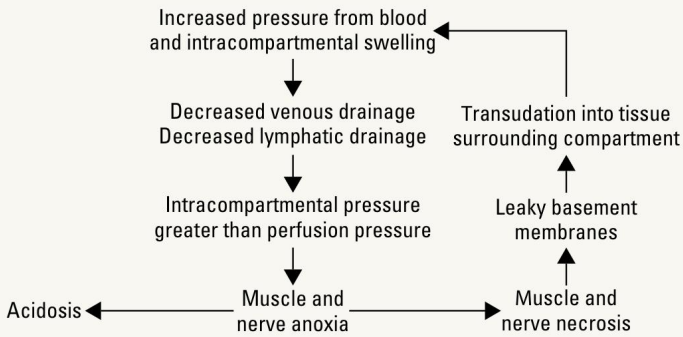


Figure 8. Pathogenesis of compartment syndrome

Most important sign is increased pain with passive stretch. Most important symptom is pain out of proportion to injury

5 Ps of Compartment Syndrome
Pain: out of proportion for injury and not relieved by analgesics
- Increased pain with passive stretch of compartment muscles

Pallor: late finding
Paresthesia
Paralysis: late finding
Pulselessness: late finding

Clinical Features

- pain out of proportion to injury (typically first and most significant symptom)
- pain with active contraction of compartment
- pain with passive stretch (most sensitive sign)
- swollen, tense compartment
- suspicious history

- **5 Ps**: late sign – do not wait for these to develop to make the diagnosis!

Investigations

- compartment syndrome is a clinical diagnosis; investigations usually not necessary
- in children or unconscious patients where clinical exam is unreliable, compartment pressure monitoring with catheter (normal = 0 mmHg; elevated ≥30 mmHg or [dBP – measured pressure] ≤30 mmHg)

Treatment

- non-operative
  - remove constrictive dressings (casts, splints), elevate limb to the level of the heart
- operative
  - urgent fasciotomy
  - 48-72 h postoperative: necrotic tissue debridement + wound closure
  - may require delayed closure and/or skin grafting

Complications

- Volkmann's ischemic contracture: ischemic necrosis of muscle; followed by secondary fibrosis; and finally calcification - especially following supracondylar fracture of humerus
- rhabdomyolysis, renal failure secondary to myoglobinuria

EXTRA

Shoulder Dislocation

- complete loss of continuity between the two articular surfaces of the glenohumeral joint; may be anterior or posterior

Investigations

- anterior disloction x-rays: AP, trans-scapular, and axillary views of the shoulder
- posterior dislocation x-rays: AP, trans-scapular, and axillary views of the shoulder; or CT scan

Prognosis

- recurrence rate depends on age of first dislocation
- <20 yr = 65-95%; 20-40 yr = 60-70%; >40 yr = 2-4%

Specific Complications

- recurrent dislocation (most common complication)
- unreduced dislocation
- shoulder stiffness
- rotator cuff or capsular or labral tear (Bankart/SLAP lesion)
- injury to axillary nerve/artery, brachial plexus

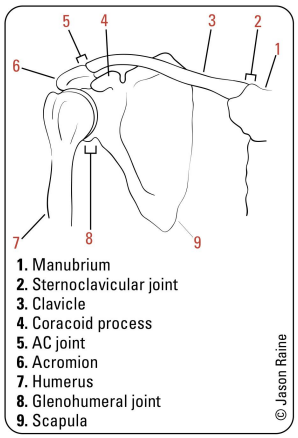


Figure 9. Shoulder joints

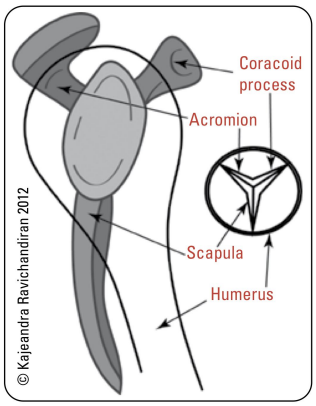


Figure 10. Mercedes-Benz

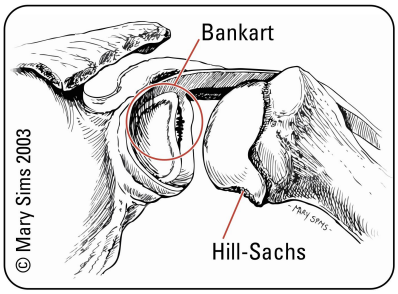


Figure 11. Posterior view of anterior dislocation causing Hill-Sachs and Bankart lesions

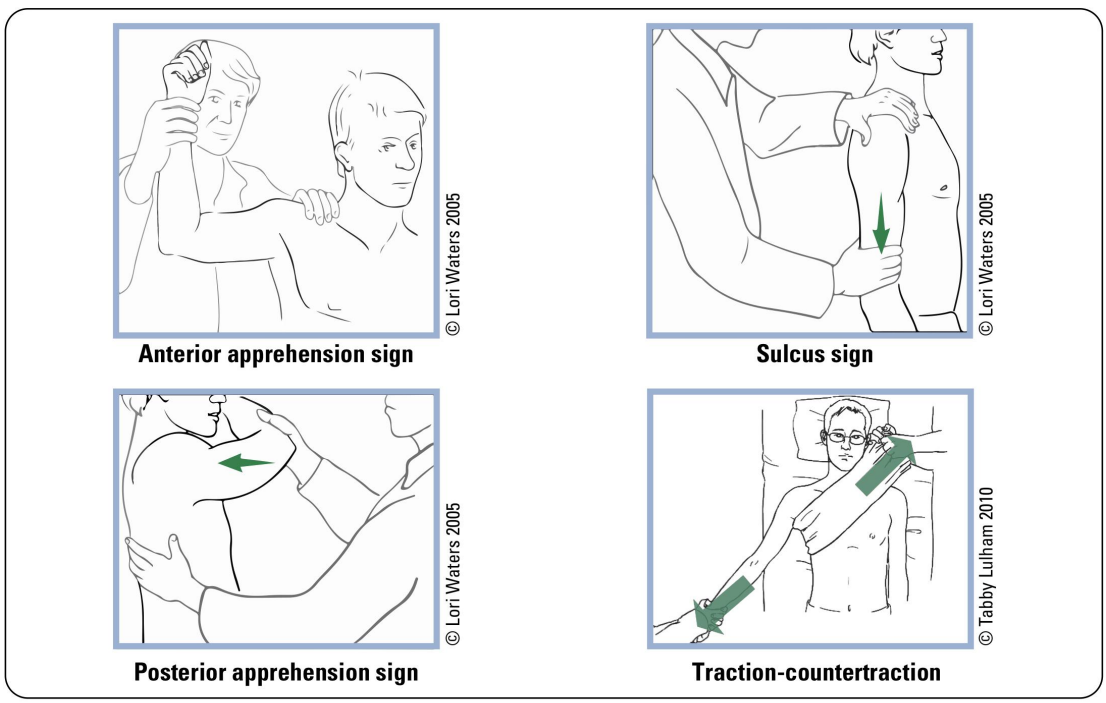


Figure 12. Shoulder maneuvers

Posterior Shoulder Dislocation
Up to 60-80% are missed on initial presentation due to poor physical exam and radiographs

There are 4 Joints in the Shoulder
Glenohumeral, AC, sternoclavicular (SC), scapulothoracic

Shoulder passive ROM: abduction – 180°, adduction – 45°, flexion – 180°, extension – 45°, int. rotation – level of T4, ext. rotation – 40-45°

Factors Causing Shoulder Instability

- Shallow glenoid
- Loose capsule
- Ligamentous laxity
- Frequency of Dislocations
- Anterior shoulder > Posterior shoulder
- Posterior hip > Anterior hip

The glenohumeral joint is the most commonly dislocated joint in the body since stability is sacrificed for motion

Table 8. Anterior and Posterior Shoulder Dislocation

	Anterior Shoulder Dislocation (>90%)	Posterior Shoulder Dislocation (5%)
MECHANISM		
	Abducted externally rotated/hyperextended arm Blow to posterior shoulder Involuntary, usually traumatic; voluntary, atraumatic	Adducted, internally rotated, flexed arm FOOSH 3 Es (epileptic seizure, EtOH, electrocution) Blow to anterior shoulder
CLINICAL FEATURES		
Symptoms	Pain, arm slightly abducted and externally rotated with inability to internally rotate	Pain, arm is held in adduction and internal rotation; external rotation is blocked
Shoulder Exam	**"Squared off" shoulder** **Positive apprehension test**: patient looks apprehensive with gentle shoulder abduction and external rotation to 90° as humeral head is pushed anteriorly and recreates feeling of anterior dislocation **Positive relocation test**: a posteriorly directed force applied during the apprehension test relieves apprehension since anterior subluxation is prevented **Positive sulcus sign**: presence of subacromial indentation with distal traction on humerus indicates inferior shoulder instability	**Anterior shoulder flattening**, prominent coracoid, palpable mass posterior to shoulder **Positive posterior apprehension ("jerk") test**: with patient supine, flex elbow 90° and adduct, internally rotate the arm while applying a posterior force to the shoulder; patient will "jerk" back with the sensation of subluxation Note: the posterior apprehension test is used to test for recurrent posterior instability, NOT for acute injury
Neurovascular Exam Including	**Axillary nerve**: sensory patch over deltoid and deltoid contraction **Musculocutaneous nerve**: sensory patch on lateral forearm and biceps contraction	Full neurovascular exam as per anterior shoulder dislocation
RADIOGRAPHIC FINDINGS		
Axillary View	Humeral head is anterior	Humeral head is posterior
Trans-scapular 'Y' View	Humeral head is anterior to the center of the "Mercedes-Benz"sign	Humeral head is posterior to center of "Mercedes-Benz" sign
AP View	Sub-coracoid lie of the humeral head is most common	Partial vacancy of glenoid fossa (vacant glenoid sign) and >6 mm space between anterior glenoid rim and humeral head (positive rim sign), humeral head may resemble a lightbulb due to internal rotation (lightbulb sign)
Hill-Sachs and Bony Bankart Lesions	± **Hill-Sachs lesion**: compression fracture of posterior humeral head due to forceful impaction of an anteriorly dislocated humeral head against the glenoid rim ± **Bony Bankart lesion**: avulsion of the anterior glenoid labrum (with attached bone fragments) from the glenoid rim	± **Reverse Hill-Sachs lesion** (75% of cases): divot in anterior humeral head ± **Reverse bony Bankart lesion**: avulsion of the posterior glenoid labrum from the bony glenoid rim
TREATMENT		
	Closed reduction with IV sedation and muscle relaxation **Traction-countertraction**: assistant stabilizes torso with a folded sheet wrapped across the chest while the surgeon applies gentle steady traction **Stimson**: while patient lies prone with arm hanging over table edge, hang a 5 lb weight on wrist for 15-20 min **Hippocratic method**: place heel into patient's axilla and apply traction to arm **Cunningham's method**: gentle longitudinal support and traction of the arm at the patient's side, massage/relaxation of deltoid, trapezius, and biceps to allow atraumatic shoulder reduction. Low-risk, low pain; if not successful try above methods Obtain post-reduction x-rays Check post-reduction NVS Sling x 3 wk (avoid abduction and external rotation), followed by shoulder rehabilitation (dynamic stabilizer strengthening)	Closed reduction with sedation and muscle relaxation Inferior traction on a flexed elbow with pressure on the back of the humeral head Obtain post-reduction x-rays Check post-reduction NVS Sling in abduction and external rotation x 3 wk, followed by shoulder rehabilitation (dynamic stabilizer strengthening)

EXTRA

Hip Dislocation

- full trauma survey (see Emergency Medicine, *Patient Assessment/Management*, ER2)
- examine for neurovascular injury prior to open or closed reduction
- high index of suspicion for associated injuries
- reduce hip dislocations within 6 h to decrease risk of AVN of the femoral head
- hip precautions (no extreme hip flexion, adduction, internal or external rotation) for 6 wk post-reduction
- see *Hip Dislocation Post-Total Hip Arthroplasty*, OR32

Up to 50% of patients with hip dislocations suffer fractures elsewhere at the time of injury

ANTERIOR HIP DISLOCATION

- mechanism: posteriorly directed axial loading of the femur with hip widely abducted and externally rotated
- classified into inferior (flexion, abduction, external rotation) and superior (extension and external rotation)
- clinical features: shortened, abducted, externally rotated limb
- treatment
  - closed reduction under conscious sedation/GA
  - post-reduction CT to assess joint congruity

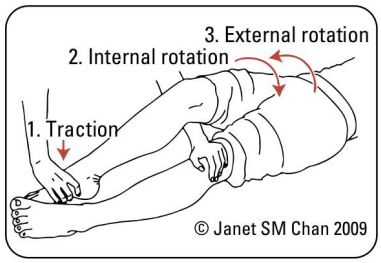


Figure 34. Rochester method

POSTERIOR HIP DISLOCATION

- most frequent type of hip dislocation (90%)
- mechanism: severe axial load to knee with hip flexed and adducted
  - e.g. knee into dashboard in MVC
- clinical features: shortened, adducted, internally rotated limb
- x-ray: affected femoral head will appear smaller than unaffected femoral head
- Thompson and Epstein classification – posterior dislocation:
  - I – with no or minor posterior acetabular wall fracture
  - II – with large posterior acetabular wall fracture
  - III – with comminuted acetabular fracture
  - IV – with acetabular floor fracture
  - V – with fracture of femoral head
- treatment
  - closed reduction under conscious sedation/GA only if no associated femoral neck fracture or ipsilateral displacement
  - ORIF if unstable, intra-articular fragments, or significant displacement
  - post-reduction CT to assess joint congruity and fractures

COMPLICATIONS FOR ALL HIP DISLOCATIONS

- post-traumatic OA
- AVN of femoral head
- associated fractures (e.g. femoral head, neck, or shaft)
- sciatic nerve palsy in 25% (10% permanent)
- HO
- thromboembolism – DVT/PE

EXTRA

Dislocated Knee

Mechanism
- high energy trauma more common (i.e. MVC) or low energy (sport related, obesity)
- by definition, caused by tears of multiple ligaments

Clinical Features
- knee instability
- effusion
- pain
- ischemic limb

Classification
- Kennedy classification (based on direction of tibial displacement) classified by relation of tibia with respect to femur
  - anterior, posterior, lateral, medial, rotary
- Schenck classification (based on pattern of ligamentous injury)

Schenck Classification
Type 1
Single ligament injury (ACL or PCL)
Type 2
Injury to ACL and PCL
Type 3
Injury to ACL, PCL, and either MCL or LCL
Type 4
Injury to ACL, PCL, MCL, LCL
Type 5
Multiligamentous injury with periarticular fracture

Investigations
- x-ray: AP and lateral
  - associated radiographic findings may include extensor mechanism injury, tibial plateau fracture dislocations, proximal fibular fractures, and/or avulsion of fibular head
- assessment of NVS:
  - ABI (abnormal if <0.9)
  - arteriogram or CT angiogram if abnormal vascular exam (such as abnormal pedal pulses)
  - detailed neurologic assessment, paying close attention to the peroneal nerve (foot drop is common)

Treatment
- urgent closed reduction
  - can be complicated by interposed soft tissue (posterolateral variant)
- assessment and management of neurovascular injuries
- emergent operative repair if vascular injury, open fracture or dislocation, irreducible dislocation, or compartment syndrome
- ligament reconstruction to restore knee stability is typically performed in a staged fashion
- comprehensive physiotherapy

Specific Complications
- high incidence of associated injuries (tibia/fibula fracture, extensor mechanism injury)
- popliteal artery injury
- peroneal nerve injury
- capsular tear
- chronic: instability, stiffness, post-traumatic arthritis

Quiz

Q1: A 35-year-old male sustains a closed tibial shaft fracture after falling from 12 feet. Which of the following measurements would be concerning for an evolving compartment syndrome?

A. Preoperative anterior compartment measurement of 25, with preoperative DP of 60

B. Intraoperative anterior compartment measurement of 25, with intraoperative DP of 54

C. Intraoperative anterior compartment measurement of 29, with preoperative DP 58

D. Intraoperative anterior compartment measurement of 28, with intraoperative DP of 72

Q2: During a dual incision fasciotomy of the leg, the soleus is elevated from the tibia to allow access to which of the following compartments?

A. Superficial posterior

B. Deep posterior

C. Lateral

D. Anterior

Q3: An 80-year-old woman presents to the emergency room with right shoulder pain and immobility. She fell down the steps outside her house and landed on her right side two hours prior to presentation. On exam, her right arm is abducted and externally rotated. She has decreased sensation to touch over the lateral aspect of her right shoulder. What is your diagnosis?

A. Anterior shoulder dislocation

B. Posterior shoulder dislocation

C. Impingement syndrome

D. Adhesive capsulitis

1:C 2:B 3:A

Quiz

Q4: 50 year old patient admitted to the ICU and intubated, a day later the nurse calls you and says he has compartment stiffness with an intramuscular pressure of 30 mmhg and a DBP of 70 mmHg, which of the following is the most appropriate management?

A. Fasciotomy
B. Observation
C. Ice
D. Angiogram

Q5: 23 year old male after MVA, came with limited shoulder abduction and loss of sensation over the lateral shoulder, what nerve is affected?

A. Radial
B. Ulnar
C. Axillary
D. Median

Q6: 17 year old male was presented to the ER with blunt trauma to his left leg, upon evaluation it appears that he developed compartment syndrome. According to the picture which compartment is mostly affected?

A. Anterior compartment
B. Lateral compartment
C. Superficial posterior compartment
D. Deep posterior compartment

4:B 5:C 6:A

Quiz

SAQs

441:

20-year-old man is post-surgical fixation of Rt tibia fracture earlier today. He has below knee back slab. He has increasing leg pain that cannot be controlled with pain meds.

1. What's your initial management in the floor?
   - Remove the back slab

2. Mention 3 possible complications if left untreated?
   1- Muscle necrosis
   2- Acute kidney injury
   3- Limb loss

22-year-old man sustained posterior hip dislocation.

3. Please describe reduction technique in Emergency department:
   1- Use analgesic and tell the patient to relax
   2- Stabilize the pelvis with sheet
   2- Do hip flexion
   3- Do axial traction
   4- If needed do internal rotation

439:

A 23-year-old patient presents to the emergency department after a motor vehicle accident. The patient was an unrestrained driver involved in a head-on collision. The patient is heavily intoxicated on what he claims is only alcohol. An initial trauma assessment is performed, and is notable for significant bruising of the right forearm. The patient is in the trauma bay, and complains of severe pain in his right forearm. A physical exam is performed and is notable for pallor, decreased sensation, and cool temperature of the skin of the right forearm. Pain is elicited upon passive movement of the right forearm and digits. A thready radial pulse is palpable. A FAST exam is performed, and is negative for signs of internal bleeding. The patient's temperature is 99.5°F (37.5°C), pulse is 100/min, blood pressure is 110/70 mmHg, respirations are 12/min, and oxygen saturation is 98% on room air. Radiography of the right forearm is ordered. The patient is still heavily intoxicated.

1. What is your diagnosis?
   - Compartment syndrome

2. How would you manage such patient?
   - Page 6

Done by

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