



4- Compartment syndrome & Acute joint dislocation

Objectives:

ACS:

- ◆ 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.

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References: 435 team, Doctors' notes, 436 slides, Toronto notes

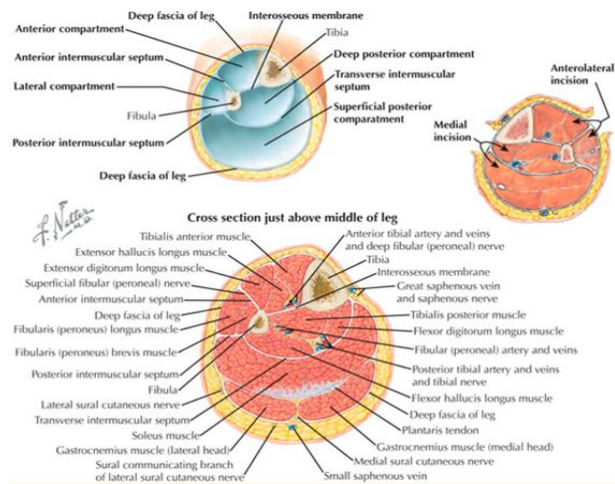
Acute compartment syndrome¹

★ Definition:

“Is 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 anoxia², muscle ischemia, and death”

Either: 1- The content of one of the compartments increased. Or
2- The space between them decreased.

- An orthopedic **emergency!**
- It can develop wherever a compartment is present.



Occurs when the tissue pressure within a closed muscle compartment (**Intercompartmental pressure**) exceeds the perfusion pressure → results in muscle and nerve ischemia³ → which lead to muscle necrosis.

It typically occurs following a traumatic event, most commonly a fracture. Also, could happen due to burns or a plaster.

- (**Arterial pressure is greater than** > arteriole > capillary bed (diffusion/exchange) > venule > vein)



★ Pathophysiology: **IMPORTANT**

Threshold pressure:

- It's enough to say CS if the **Intercompartmental pressure exceeds 30 mm Hg (rigid)**.
- **Less than 30 mm Hg difference between compartment pressure and diastolic pressure (clinically relevant) imp to know how to calculate** it means that the Intercompartmental pressure is high and almost exceeding the diastolic pressure.

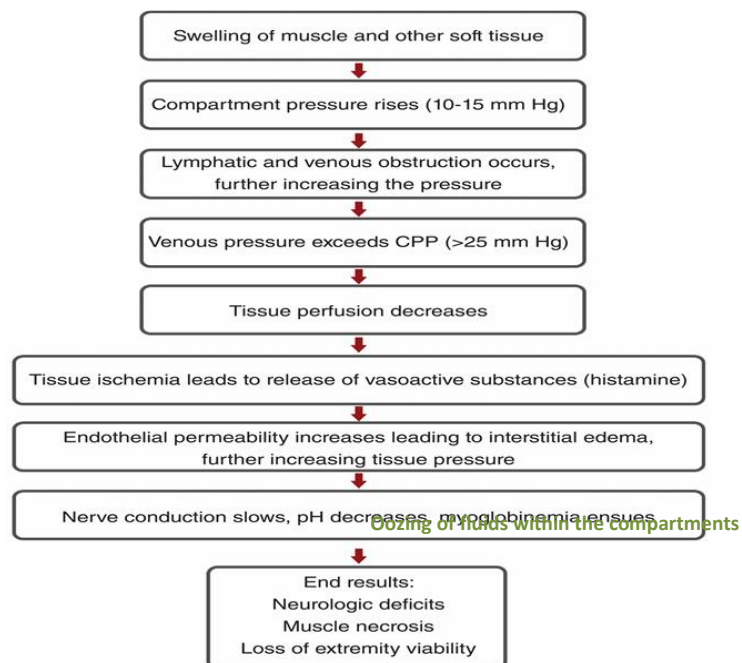
Ex1: a patient had a diastolic pressure (DBP) of 60 and Intercompartmental pressure (IMP) of 20 is this CS?

No, because $60 - 20 = 40$ which is **not < 30 mm hg** “Didn't exceed the perfusion pressure”

Ex2: a patient had a diastolic pressure of 40 and Intercompartmental pressure of 20 is this CS?

Yes, because $40 - 20 = 20$ which is **< 30 mm hg**

Ex: patient had fracture or direct contusion to the leg:



¹ Bleeding, oedema or inflammation (infection) may increase the pressure within one of the osteofascial compartments; there is reduced capillary flow which results in muscle ischaemia, further oedema, still greater pressure and yet more profound ischaemia – a vicious circle that ends, after 12 hours or less, in necrosis of nerve and muscle within the compartment. [osmosis high yield notes](#) [Toronto notes](#) [DIT STEP 2 VIDEO WATCH FROM \(4:48-7:26\)](#) [kaplan notes](#)

² An absence of oxygen.

³ Is capable of regeneration but muscle, once infarcted, can never recover and is replaced by **inelastic fibrous tissue**.

★ Etiology: Huge list

Increase the Compartment Volume	Reduction in Volume of Tissue Compartments
<ul style="list-style-type: none"> • Close soft tissue injury/ crush injury. • Close fracture. • Open fracture⁴. Common mistake: people think that because of the an open fracture, the pressure will resolve, but in fact the opening الموجودة بالكومبارتمنت is less than 1 cm which doesn't relieve the pressure. • Hemorrhage. • Vascular injury. Like laceration • Coagulopathy (anticoagulation therapy). • Increased capillary permeability after burns (especially circumferential). • Infusions or high-pressure injections (eg, regional blocks, paint guns). • Reperfusion after prolonged periods of ischemia. The basement membrane it's already damaged. 	<ul style="list-style-type: none"> • Tight circumferential dressings (eg, can occur with cotton cast padding alone) • Cast or splint • Prolonged limb compression it happens more in western countries BC people get drunk and lay down on legs for >24H, as in Trendelenburg and lateral decubitus or from alcohol or drug abuse • Risk factors (general): <ul style="list-style-type: none"> ○ Head injury. ○ Decreased conciseness (Late diagnosis) ICU pt, Due to prolonged compression and no communication between the doctor and the pt so CS could be missed, not bc it's a direct cause. ○ Hypotension Due to decreased perfusion pressure

Orthopedics 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 shaft fracture is number 1? In a scientific way and what's proven, people reached that by evidence.

But logically thinking (not proven), tibia is a big bone in a small tight area

⁴ The fracture site is communicating with the external environment.

★ **Diagnosis:** it's a clinical diagnosis! No X-ray, US, MRI or CT!

Signs and symptoms

The earliest:

The late signs:

- ✓ **Pain!!!!** out of proportion to the injury **Patient is crying and no medication works** (↑ need of analgesics). This is **the most sensitive** and after it we look for the presence of risks (the list above) and with a high index suspicion.
- ✓ Pain with **passive stretching of the muscles in the compartment**: dorsiflexion to check the **posterior compartment** of the leg and plantarflexion for the **anterior compartment**.
- ✓ Pain May be worse with elevation.
- ✓ Patient will not initiate motion on their own.
- ✓ Presence of risk factor.
- ✓ **Tense swelling**
- ✓ High index of suspicion to save the limbs.

Scenario: A 22 Y/O male patient C/O pain. The nurse called you and told you that this patient had surgery to fix his tibia this early morning and she is suspecting CS, you rushed to the patient and found him chatting on whatsapp, is this CS? **NOO** :\

- ✓ **4Ps:** Paralysis, Paresthesia, Pallor and Pulselessness.
 - Pulselessness is RARE (it happens because the pressure gets very high to the point where it starts to compress the arteries), and only severely high compartment pressure causes it. **So it's a late sign and you shouldn't mention it.**
- ✓ **Tight (Woody compartment)** most reliable sign
لما أمسك الكاف مسك بتكون صلبه. الانتفاخ سيجتف يختاف من دكتور اللثاني لذلك نعتمد على هذي السايين
- ✓ Tender compartment.
- ✓ Reduced two-point discrimination.



In Pediatrics:

3 As: (Increasing Analgesic requirement, Anxiety, Agitation)

Intramuscular Pressure (IMP) Measurement: not used, only mention it

- ✓ Rarely necessary.
- ✓ Must be done at area of highest expected pressure.
- ✓ May give false low result.

The only relative indication for using it is: if the patient is **unconscious** (ICU). BUT, if you see a patient with a risk factor and felt the compartment to be tight, there is no reason to waste your time and measure, just take the patient and do surgery to him!!! If you involved yourself with taking measurements, you will put yourself in a medicolegal corner and people can sue you! :/



★ Management

First is Prevention

- Maintain normal blood pressure.
- Remove any constricting bandage.
- Keep limb elevated.
- Regular close monitoring.
- Avoid nerve blocks, sedation and strong analgesia to obtain patients feedback.

Fully Developed CS

- Remove any constricting bandage (the first and immediate thing)
- Maintain normal blood pressure.
- Keep limb at heart level.
- Diuresis to avoid kidney tubular injury if late.
- Urgent surgical decompression (**Fasciotomy**).
 1. Split the cast and dressing down to the skin.
 2. Elevate the leg.
 3. ICE.
 4. Feel the compartments, if not tight you observe the patient every 2 H.
 5. If compartments are tight, take patient to OR for emergency Fasciotomy.

★ Fasciotomy: it's a surgical decompression

Indications

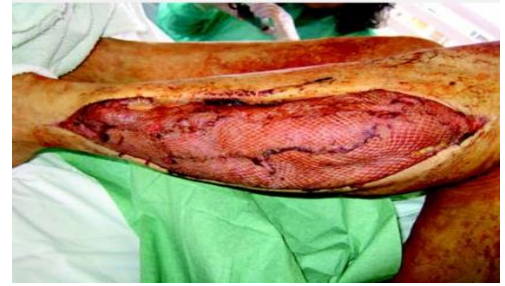
- Within 6 hours of total ischemia time (ex: arterial embolism), should not be done if there is no expected viable tissue, otherwise welcome to the infection. The problem with the 6 H is that it only applies for those with acute vascular ischemia who comes early, not chronic.
- Significant tissue injury.
- Worsening initial clinical picture.
- Delayed presentation with a picture of developed compartment syndrome.
- Absolute Compartment pressure >30 mmHg or <30 mm Hg difference from diastolic pressure.

Technique of Fasciotomy⁵

- It is **a prophylactic procedure, doesn't reverse injury to permanently damaged tissue, So better to have lower threshold.**
- Should be done as long as there is still viable tissue.
- Longitudinal skin incision that extends the entire length of the compartment.
- Release of fascia of involved muscle which Allows swollen muscles to expand in volume.

⁵ [Watch](#)

- Results in decreased compartment pressure.
- Skin left open.
- Debridement of all necrotic tissue is necessary.
- Second and third look surgeries are often required.
- Closure of skin is usually achieved after swelling has subsided.
- Skin grafting is often required.



You cut the skin -> deep fascia -> muscles burst out like if it's breathing-> keep it open -> evaluate after 48 H -> close the wound if possible -> if not possible do skin grafting. (you should close within 7 days)

★ Complications of ACS:

1. **Ischemic myonecrosis** Muscle death: > Myoglobinuria > kidney tubular damage > acute renal failure 1st thing. ↑ Creatine kinase (CK). = Rhabdomyolysis.
2. **Loss of function** of the involved compartment secondary to muscle contracture:
 - Flexion contracture
 - Paralysis
 - Loss of sensation
3. **Leg:**
 - Anterior compartment: **Drop foot** it's miserable (Pic A).
 - Deep posterior compartment: Claw toes (Pic B) + Loss of sensation in the sole.
4. **Forearm:**
 - Deep Volar compartment: Volkmann's contracture is a permanent shortening (contracture) of forearm muscles, usually resulting from injury, that gives rise to a claw like deformity of the hand, fingers, and wrist. It is more common in children. Muscles are dead and start to be contracted -> fibrosed -> holds in a position -> not allowed to move.



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

Acute Joint Dislocation Not recurrent

★ Definitions:

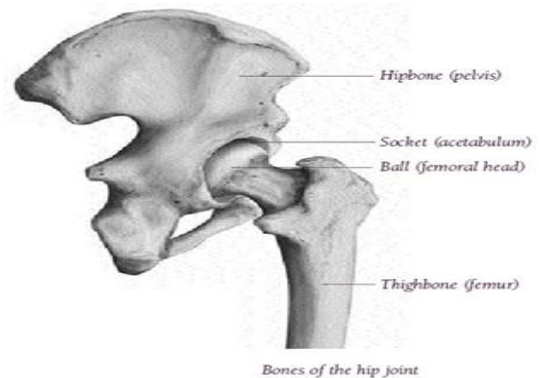
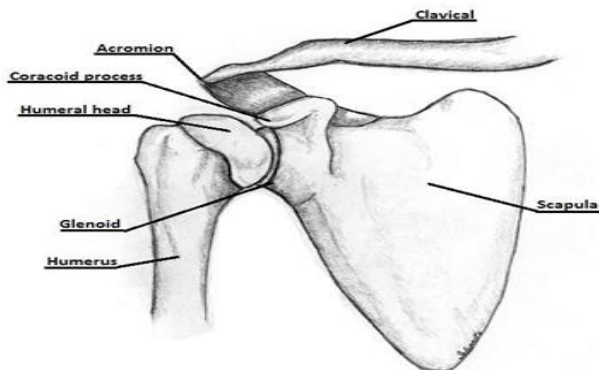
- **Dislocation** is a total loss of contact between the articular surfaces of the joint.
- **Subluxation** is a partial loss of contact between the articular surfaces of the joint. Pic shows anterior subluxation
- **A joint dislocation** is described by stating the location of the distal segment.
 - **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.



★ Joint stability:

Bony stability⁶

Shape of the joint (ball and socket Hip vs round on flat shoulder). The more movement needed by joint the less bony stability and the more dependence on soft tissue.



Soft Tissue

- Dynamic stabilizer: Tendons/Muscles. Means change with contraction
- Static stabilizer: Ligaments ± meniscus/labrum). يعني الركبة ما يصير لها دسلوكيشن إلا لو قطعت كل اللقمنتس اللي حولها بعكس الكتف

★ Pathophysiology:

- It takes **higher energy** to dislocate a joint **with bony stability** than a joint with mainly soft tissue stability like weak ligaments; in this case, we see recurrent joint dislocation with no history of trauma, only because their ligaments are weak.
- 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. لأن الميجر جوينتس ما تتأثر إلا لو كان فيه إنيرجي قوية أثرت عليها بالتالي كافية إنها تأثر على اللي حولها
- 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 commonly in one direction
- A joint might dislocate in different directions.

★ Risk groups:

1. Major trauma victims especially unconscious patient.
2. Athletes and sport enthusiasts.
3. Connective tissue disorder patient; due to increased joint instability in result of abnormal soft tissue stabilizers.

It depends on the direction of the force and the position of the limb at the time of dislocation. Ex: you're driving a car and had a dashboard injury, it will push your flexed knee backward.

⁶ Hip joint depends more on the bony stability (deep socket). The joint is shoulder joint (very shallow joint not deep), depends mainly on ligaments.

★ **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.** Like squaring of shoulder in shoulder dislocation (pic1).
May have **Axillary** nerve injury → **deltoid** atrophy + loss of sensation.
- **Shortening.** رجل أقصر من رجل في posterior hip dislocation (pic 2)
- Malalignment.
- Malrotation.



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

X-ray: If you're sure that the joint is dislocated, you reduce it first, but if you're not, you do an X-ray first.

- 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.



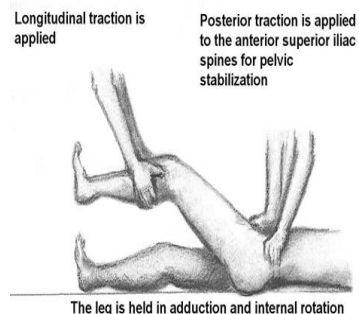
★ **Management principles:**

A 22 y/o male with hip dislocation, describe your reduction steps.

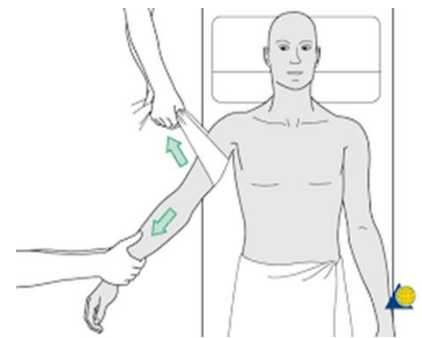
Must rule out other injuries.	
1	Consent/conscious sedation → pain relief.
2	Neurovascular assessment before reduction.
3	Urgent reduction. Check stability and safety zone. After reduction you move the limb in all directions till you feel that at a certain level, he might dislocate his joint again. Then after that you tell him not to move his limb above this level.
4	Check neurovascular status after reduction.
5	Immobilization, stabilizing.
6	X-rays after reduction.
7	Protect the joint for 2 to 3 weeks to heal and after that send them to physical therapy department.
8	Rehabilitation. Follow for late complication.

★ **Reduction Technique:** Best treatment of pain is reduction of joint not medications.

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 status:
 - If it was intact before but not after, farther urgent management is needed.
 - If it was not present before but intact after, check again later to confirm.



- Observe patients' vitals until medications wear out.
- Stabilize joint and get X-rays.
- **If irreducible or partial reduction only:** Urgent closed reduction under general anesthesia and possible open reduction⁷ if closed reduction fails, **Usually due to** insufficient muscle relaxation or Entrapment of soft tissue.

Posterior hip dislocation technique: 1. Hip flexion 2. Traction of leg 3. Countertraction of pelvis 4. Wait for a طقة 'Clunk'.

★ **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. pic shows: **fracture and dislocation**, you must rush the patient to the OR.





★ **Complications:**

Early	Late
Heterotopic ossification. (bone formation at an abnormal anatomical site). تسوي رستر كشن اوف موفمنت احيانا Neurological injury (reversible or irreversible). Vascular injury (more commonly with neurological injuries). Compartment syndrome. Osteochondral fracture/injury.	Stiffness. Heterotopic ossification. Chronic instability more common in shoulder joint. Recurrent dislocation Avascular necrosis it may appear after 4 to 6 month and more common in the head of femur. It's a local bone ischemia due to destruction of blood supply Osteoarthritis.

⁷ open reduction: you open the joint and see what inside.

★ Examples of joint dislocation:

<p>Hip joint Dislocation: <u>dr.nabil video</u></p>	<ul style="list-style-type: none"> - Posterior dislocation is commonest. - Major trauma with hip flexed (dashboard injury in RTAs). - Sciatic nerve injury is common; check extension and flexion of the big toe. - loss of foot dorsiflexion - High incidence of late avascular necrosis 10% <p>An orthopedic emergency!</p>	
<p>Shoulder dislocation <u>dr.nabil video</u></p>	<ul style="list-style-type: none"> - Common. - Anterior dislocation is more common. Patients presents with pain and limited range of motion after shoulder injury. - Patients with seizures prone to posterior dislocation. (Because they can't protect themselves when they fall while having a seizure) - May cause chronic instability. - Can result in axillary nerve injury and wasting in deltoid muscle (deltoid atrophy) and numbness over its area. 	
<p>Knee dislocation <u>dr.nabil video</u></p>	<ul style="list-style-type: none"> - Very serious emergency. Very BAD! - It is could be anterior dislocation or posterior dislocation. - Three or more ligaments are teared. - Usually with severe (high energy) trauma. - May be associated with popliteal artery injury (50%) or peroneal nerve injury. - Limb threatening and needs accurate vascular assessment. - May be associated with fracture/ compartment syndrome. - Most require surgery either early or late or both. 	