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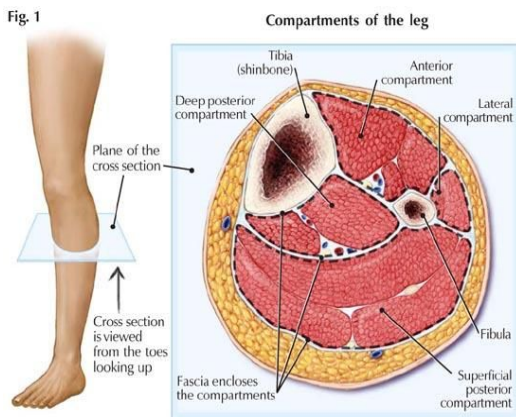
Acute compartment syndrome¹

Occurs when the tissue pressure within a closed muscle compartment exceeds the perfusion pressure and results in **muscle** and **nerve** ischemia². It typically occurs following a traumatic event, most commonly a fracture. Also could happen due to burns or a plaster.

A surgical emergency!

Interstitial pressure exceeds capillary perfusion pressure leading to muscle necrosis (Muscles are (in 4-6h) and eventually nerve necrosis.

Leg compartments



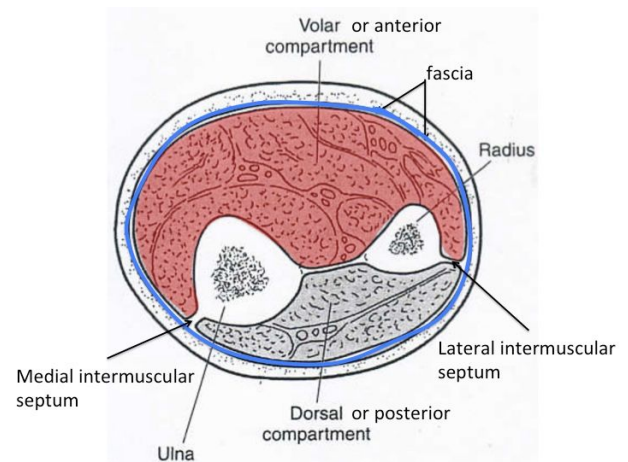
- **Anterior compartment:**

- Muscles:
 - Tibialis anterior
 - Extensor hallucis longus
 - Extensor digitorum longus
 - Peroneus tertius
- Neurovascular:
 - Deep peroneal nerve
 - Anterior tibial vessels

- **Lateral compartment:**

- Muscles:
 - Peroneus longus
 - Peroneus brevis
- Neurovascular:
 - Superficial peroneal nerve

Forearm compartments



- **Volar (anterior) compartment**

- **Dorsal Compartment**

¹Bleeding, 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.

² Nerve is capable of regeneration but muscle, once infarcted, can never recover and is replaced by inelastic fibrous tissue.

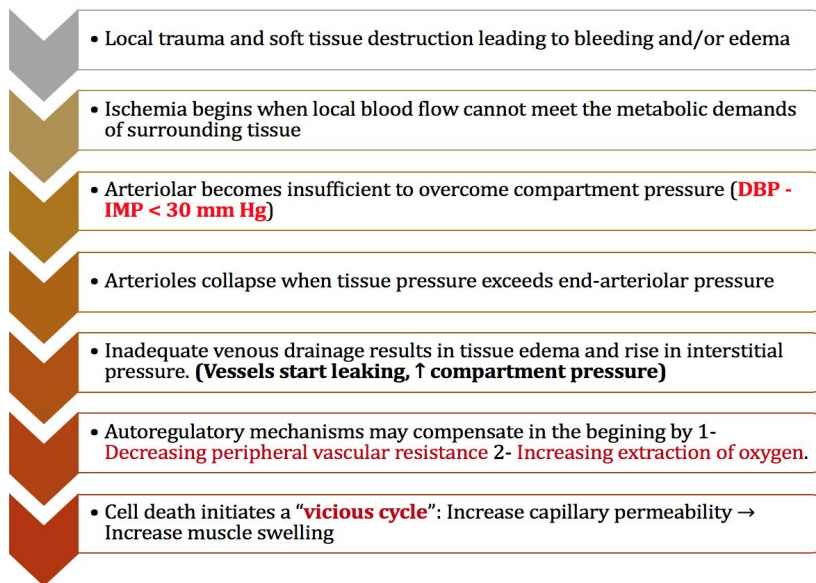
- **Superficial posterior compartment:**

- Muscles:
 - Gastrocnemius
 - Plantaris
 - Soleus
- Neurovascular:
 - Sural nerve

- **Deep posterior compartment:**

- Muscles:
 - Tibialis posterior
 - Flexor hallucis longus
 - Flexor digitorum longus
 - Popliteus
- Neurovascular:
 - Tibial nerve
 - Posterior tibial vessels

Pathophysiology:



Etiology

Increased Volume-internal	Decreased volume-external
<ul style="list-style-type: none"> ● Hemorrhage into a compartment <ul style="list-style-type: none"> ○ Fractures (most common cause) <ul style="list-style-type: none"> ■ Tibia shaft ■ Supracondylar ○ Bleeding disorders ● Swelling from traumatized tissue <ul style="list-style-type: none"> ○ Crush syndrome ○ Soft tissue injury ● Increased fluid <ul style="list-style-type: none"> ○ Burns\injections ● Post-ischemic swelling ● Reperfusion injury: <ul style="list-style-type: none"> ○ Ischemia causes damage to cellular basement membrane that results in edema ○ With reestablishment of flow, fluid leaks into the compartment increasing the pressure 	<ul style="list-style-type: none"> ● Tight casts / dressings
	Fracture Treatment Increases IMP ³
	<ul style="list-style-type: none"> → Splinting/casting → Manipulation → Traction → Spanning Ex Fixation → Nailing

Incidence of ACS:

1. Medial knee fx/dislocations 53%
2. Segmental tibia fractures 48%
3. Foot crush injuries 41%
4. Schatzker VI plateau fractures 18%
5. Calcaneal fractures 10%
6. Tibial fractures 2-10%

Diagnosis:

- ❖ The earliest (sensitive) and most reliable indicators of ACS:
 - **Pain out of proportion to the injury**
 - **Pain with passive stretching of the muscles in the compartment:**
dorsiflexion to check the posterior compartment of the leg.
- ❖ Pain May be worse with elevation
- ❖ Patient will not initiate motion on their own



³ Intramuscular pressure.

❖ **Late signs:**

- **4Ps:** Paralysis, Paresthesia, Pallor and Pulselessness.
 - **Pulselessness usually not common;** very high compartment pressure to cause it .
- Tight (**Woody compartment**)
- Tender compartment.
- Reduced two-point discrimination

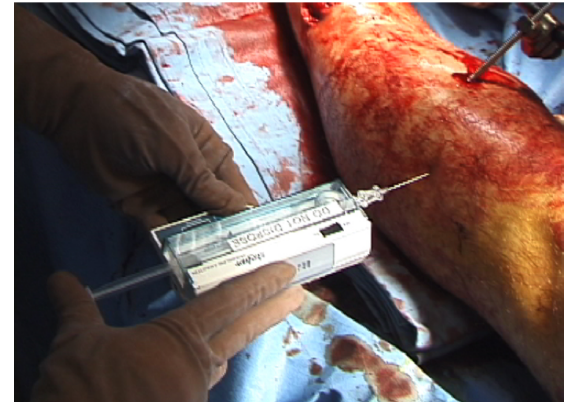
In Pediatrics:

❖ **3 As**

- Increasing **Analgesic** requirement
- **Anxiety**
- **Agitation**

Intramuscular Pressure (IMP) Measurement:

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



Perfusion Pressure (ΔP) Vs IMP :

- ❖ Currently, the “**differential pressure**” is considered the **most reliable** indicator of when fasciotomy is **necessary**:
 - ${}^4\text{DBP} - \text{IMP} < 30 \text{ mm Hg}$
- ❖ Relying on IMP alone may lead to:
 - **Unnecessary fasciotomies**
 - **Failure to perform needed fasciotomies**

⁴ Diastolic blood pressure

Ischemia	
Muscle Ischemia	Nerve Ischemia
<ul style="list-style-type: none"> ❖ 4 hours - reversible damage ❖ 8 hours - irreversible changes ❖ 4-8 hours - variable ❖ Myoglobinuria after 4 hours <ul style="list-style-type: none"> ➢ Renal failure ➢ Check CK levels ➢ Maintain a high urinary output – Alkalinize the urine 	<ul style="list-style-type: none"> ❖ 1 hour - normal conduction ❖ 1- 4 hours - neuropraxic damage⁵ (reversible) ❖ 8 hours - axonotmesis⁶ (irreversible)

Who's at risk?

- ❖ **Inability to accurately obtain history and physical exam**
 - Head trauma
 - Impaired sensorium
 - Drug/ETOH intake
 - Pediatric
- ❖ **Polytrauma and hypotensive patients**
- ❖ **High energy fractures**
- ❖ **Post operative patients on analgesia that may mask the development of pain**

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.
 - a. **Bi-valving the cast and loosening circumferential dressings**
 - b. **Leg compartment: keep the ankle in neutral to 30 degree plantar flexion**
 - c. **Forearm compartment: avoid deep elbow flexion**
3. The limb should **not be elevated above the head** 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 myoglobinuria is mandatory to avoid potential renal failure.



⁵ Temporary loss of motor and sensory function due to blockage of nerve conduction

⁶ An injury to the peripheral nerve of one of the extremities of the body

Emergent Fasciotomy (Time window for ACS is 6 Hours)

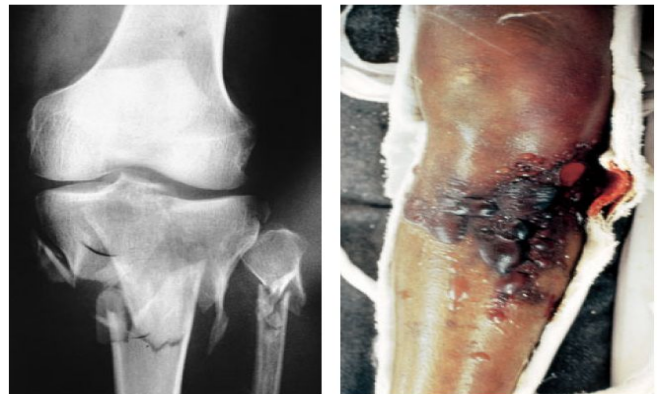
Indications	Technique of Fasciotomy
<ul style="list-style-type: none"> → Clinical presentation consistent with compartment syndrome → Compartment pressures within 30 mm Hg of diastolic blood pressure ($DBP - IMP < 30$ mm Hg) → 6-8 hours of total ischemia time 	<ul style="list-style-type: none"> → Longitudinal skin incision that extends the entire length of the compartment. → Release of fascia of involved muscle. → Skin left open <ul style="list-style-type: none"> ◆ Closure of skin is usually achieved after swelling has subsided ◆ Skin grafting is often required → Second and third look surgeries are often required
Contraindications	
Missed compartment syndrome (High risk of complications)	

Complications of Fasciotomy:

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

Complications 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



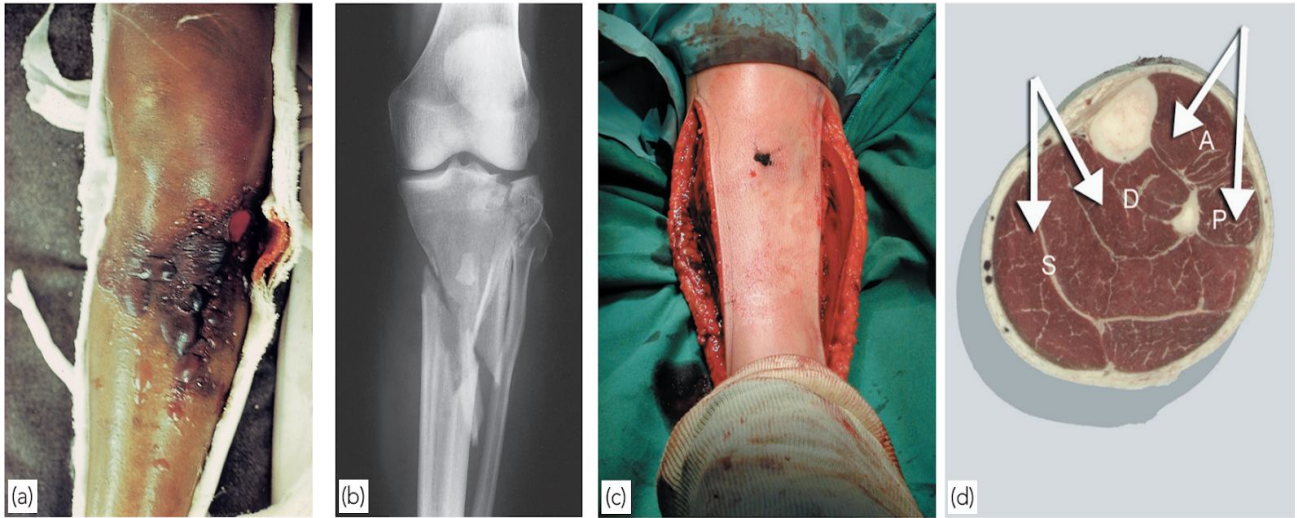
(a)

(b)



(c)

30.30 Compartment syndrome (a) With a fracture at this level the surgeon should be constantly on the alert for symptoms and signs of a compartment syndrome. This patient was treated in plaster. Pain became intense and when the plaster was split (which should have been done immediately after its application), the leg was swollen and blistered (b). Tibial compartment decompression (c) requires fasciotomies of all the compartments in the leg.



25.3 Compartment syndrome (a,b) A fracture at this level is always dangerous. This man was treated in plaster; pain became intense and when the plaster was split (which should have been done immediately after its application), the leg was swollen and blistered. (c) Tibial compartment decompression is best done through two separate incisions and requires fasciotomies of all compartments (d). (A: anterior, P: peroneal, S: superficial posterior, D: deep posterior.)

Acute Joint Dislocation

- ❖ **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.



Joint stability: Complex synergy leading to a FUNCTIONAL and STABLE joint	
Bony stability	Soft Tissue
<ul style="list-style-type: none"> ● Shape of the joint (ball and socket vs round on flat) 	<ul style="list-style-type: none"> ● Dynamic stabilizer: Tendons/Muscles ● Static stabilizer: Ligaments ± meniscus/labrum

Risk groups are:

- **Major trauma victims** especially unconscious patient
 - Athletes and sport enthusiasts
 - Connective tissue disorder patient; due to increased joint instability in result of abnormal soft tissue stabilizers.
- ❖ **Dislocation of a major joint should lead to considering other injuries.** Major joints: Spine, shoulder, elbow, wrist, hip, knee and ankle.
 - ❖ Different joints have different force vectors that may lead to a dislocation. It depends on the direction of the force and the position of the joint while receiving this force.
 - ❖ 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.

- ❖ When a joint is strained:
 - It may be sprain
 - It may be fracture
 - It may be dislocated
 - It may be fracture and dislocated

- **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.**
- **X-ray** is the milestone in diagnosing dislocation:
 - 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. ☒
- Should check for **other injuries** (distracting injury) ☒
- Should always check the **distal neurovascular status**. ☒
- Should check for **compartment syndrome**.

- **Management:**

- Must rule out other injuries.
- Pain relief.
- 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.
- Check neurovascular status after reduction.
- X-rays after reduction.
- Protect the joint for 2 to 3 week to heal and after that send them to physical ☒therapy department.
- Rehabilitation.
- Follow for late complications.

- **Reduction:**

- Monitor **vitals**.
- IV **analgesia** (opioid).
- IV **sedation** (to relax the muscles).
- **Gradual traction** to distract the joint.
- **Realignment and rotation** to reduce the joint based on direction of dislocation.
- A **palpable clunk** will be felt.
- **Check ROM** and stability of the joint.
- Once joint is felt to be reduced, **check distal NV 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.
- **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 reduction if closed reduction fails, Usually due to insufficient muscle relaxation or Entrapment of soft tissue.

- **Complications:**

- **Early Complications:**

- Heterotopic ossification. (bone formation at an abnormal anatomical site, usually in soft tissue, see picture).
- Neurological injury (reversible or irreversible).
- Vascular injury (more commonly with neurological injuries).
- Compartment syndrome.
- Osteochondral fracture/injury.



- **Late complications:**

- Stiffness.
- Heterotopic ossification.
- Chronic instability more common in shoulder joint.
- Avascular necrosis it may appear after 4 to 6 months and more common in the head of femur.
- Osteoarthritis.

- **Special consideration:**

- **Hip joint Dislocation:**

- **Posterior** dislocation is commonest
- **An orthopedic emergency!**
- Major trauma with hip flexed (dashboard injury in RTAs)
- **Sciatic nerve injury** is common; check extension and flexion of the big toe.
- High incidence of late avascular necrosis



- **Shoulder dislocation:**

- Common.
- **Anterior** dislocation is more common
- 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 and numbness over its area.



- **Knee dislocation:**

- **Very serious emergency.**
- It 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 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.

