



5-Compartment Syndrome And Acute Joint Dislocation

Objectives:

1. To explain the pathophysiology of CS
2. To Identify patients at risk of developing CS
3. To be able to diagnose and initially manage patients with CS
4. To be able to describe the possible complications of CS To describe mechanisms of joint stability
5. To be able diagnose patients with a possible acute joint dislocation
6. To be able to describe general principles of managing a patient with a dislocated joint
7. 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, toronto note, slide, note

Acute compartment syndrome¹

[osmosis high yield notes](#)

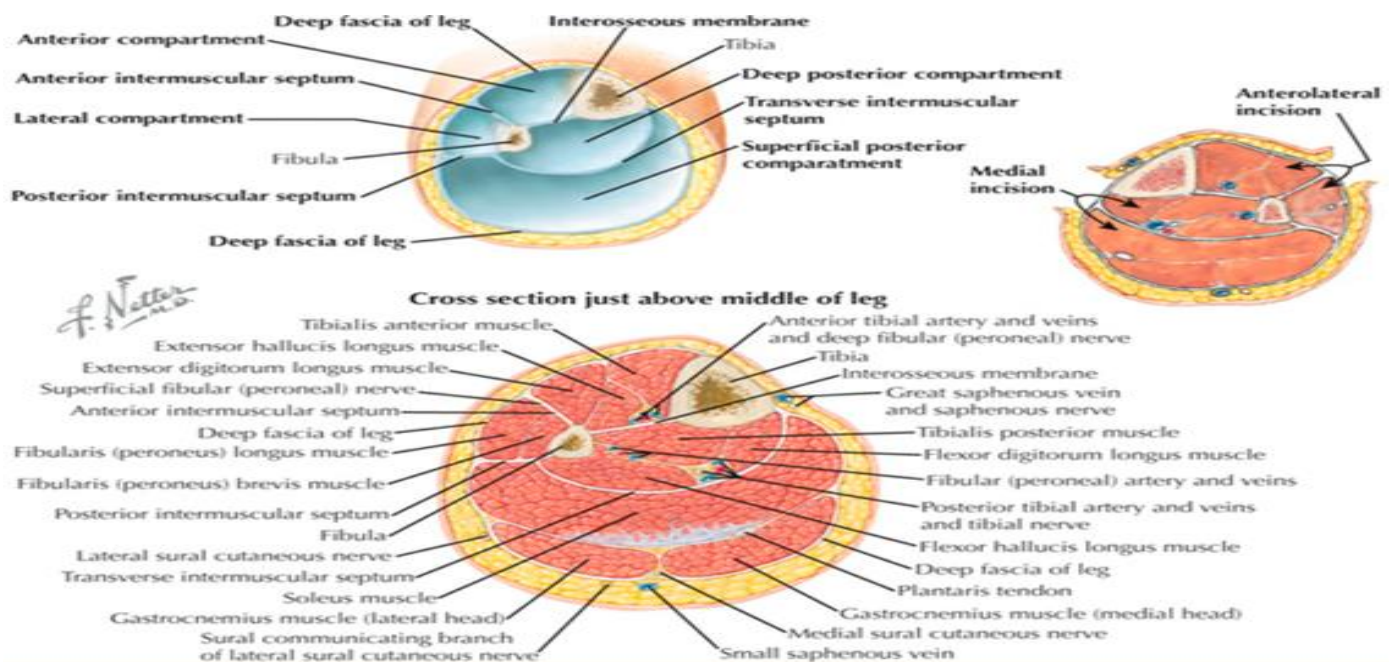
[Toronto notes](#)

[DIT STEP 2 VIDEO WATCH FROM \(4:48-7:26\)](#)

[kaplan notes](#)

- **Definition:** “Acute compartment syndrome is a potentially devastating condition in which the pressure within an osseofascial compartment rises to a level that decreases the perfusion gradient across tissue capillary beds, leading to cellular anoxia, muscle ischemia, and death”
- Occurs when the tissue pressure within a closed muscle compartment exceeds the perfusion pressure and results in muscle and nerve ischemia¹², which lead to muscle necrosis (Muscles are (in 4-6h) and eventually nerve necrosis. It typically occurs following a traumatic event, most commonly a fracture. [Also, could happen due to burns or a plaster.](#)
- A surgical emergency!
- It can develop wherever a compartment is present
- (Artery> arteriole> capillary bed (diffusion/exchange)> venule> vein)

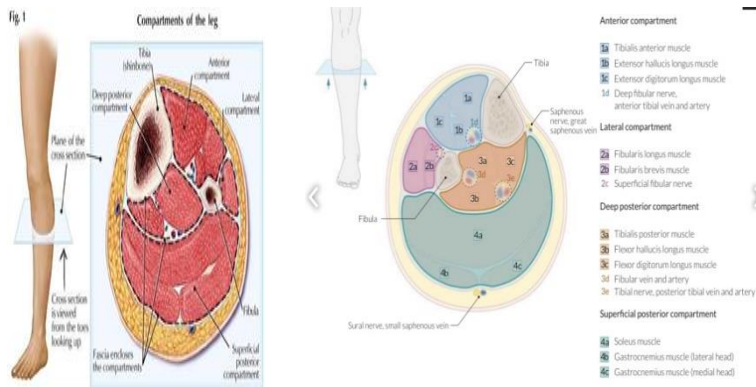
Anatomy:



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.

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

Leg compartments



Anterior compartment:

Muscles:

- Tibialis anterior
- Extensor hallucis longus
- Extensor digitorum longus
- Peroneus tertius

Neurovascular:

- Deep peroneal nerve (will lead to numbness in first webspace)
- Anterior tibial vessels

Lateral compartment:

Muscles:

- Peroneus longus
- Peroneus brevis

Neurovascular:

- Superficial peroneal nerve (will lead to numbness in dorsum of the foot)

Superficial posterior compartment:

Muscles:

- Gastrocnemius
- Plantaris
- Soleus

Neurovascular:

- Sural nerve (will lead to numbness in lateral side of foot)

Deep posterior compartment:

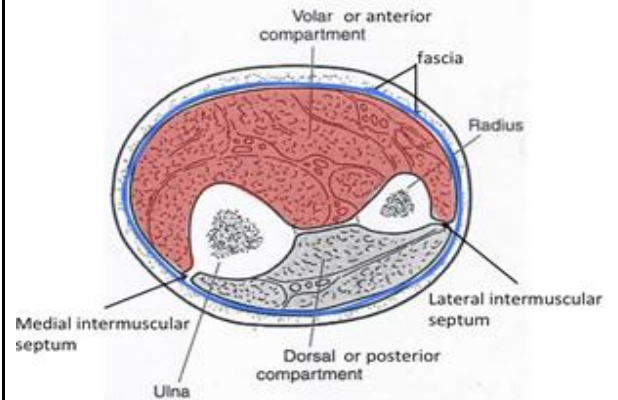
Muscles:

- Tibialis posterior
- Flexor hallucis longus
- Flexor digitorum longus
- Popliteus

Neurovascular:

- Tibial nerve (will lead to numbness in plantar aspect of foot)
- Posterior tibial vessels

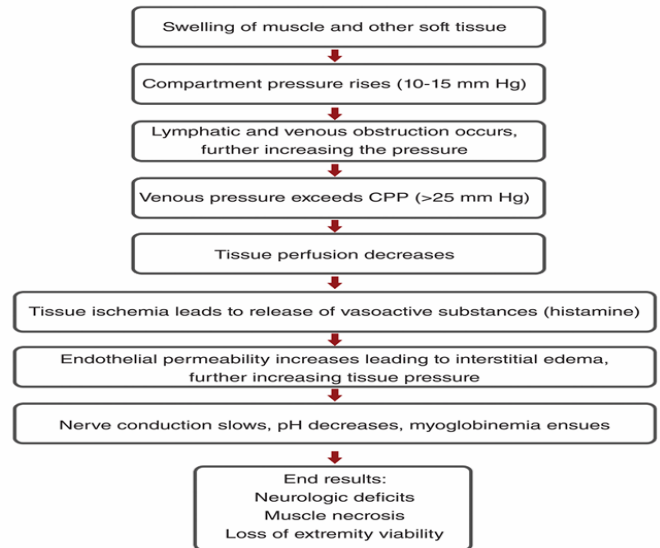
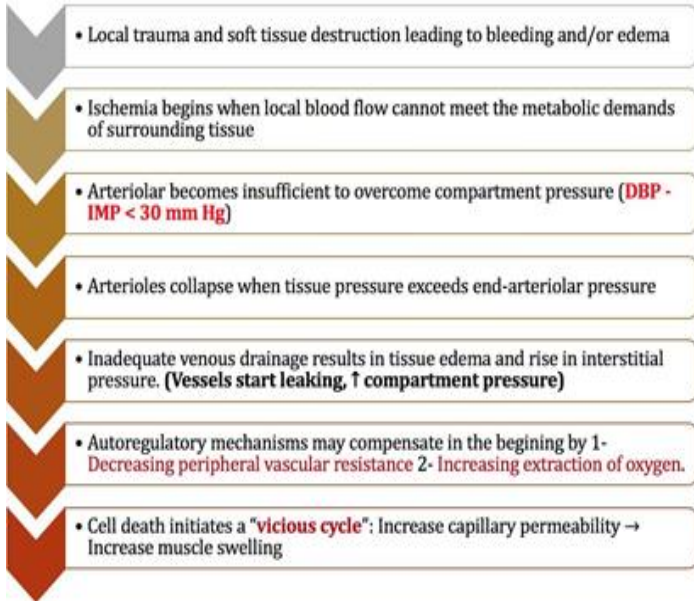
Forearm compartments



Volar (anterior) compartment

Dorsal Compartment

Pathophysiology:



NYSORA®

Threshold pressure:

- 30 mm Hg (rigid)
- Less than 30 mm Hg difference between compartment pressure and diastolic pressure (clinically relevant)

Etiology:

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 fracture • Hemorrhage: • Vascular injury • Coagulopathy (anticoagulation therapy) • Increased capillary permeability after burns (especially circumferential) • Infusions or high-pressure injections (eg, regional blocks, paint guns) <p>Reperfusion after prolonged periods of ischemia the basement membrane it's already damaged.</p>	<ul style="list-style-type: none"> • Tight circumferential dressings (eg, can occur with cotton cast padding alone) • Cast or splint • Prolonged limb compression, as in Trendelenburg and lateral decubitus or from alcohol or drug abuse • Risk factors (general): • Head injury • Decreased conciseness (Late diagnosis) <p>Hypotension</p>

Extra

The etiology of compartment syndrome		
	External compressing forces	Internal expanding forces
Trauma-related	<ul style="list-style-type: none"> • Burn eschars • Constrictive bandage/cast 	<ul style="list-style-type: none"> • Fracture hematoma • Blood vessel injury with hemorrhage • Repetitive muscle use (esp. excessive running, seizures) • Crush injury • Penetrating injuries (e.g., gunshot and stab wounds) • Burn edema • Reperfusion syndrome with ischemia-reperfusion edema
Non-traumatic	<ul style="list-style-type: none"> • Incorrect positioning limbs (e.g., immobile patient) 	<ul style="list-style-type: none"> • Increased capillary permeability, e.g., shock • Coagulopathies

! Peripheral circulation is reduced in polytrauma patients with shock. Therefore, increased compartment pressure in polytrauma patients is associated with an early, high risk of muscle ischemia!

Fracture Treatment Increases IMP³:

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

Incidence of Acute compartment syndrome:

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%

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



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 and plantarflexion for the **anterior compartment**
- Pain May be worse with elevation
- Patient will not initiate motion on their own
- Presence of risk factor
- High index of suspicion

Late signs:

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



³ Intramuscular pressure.

In Pediatrics:

- **3 As**

1. Increasing Analgesic requirement
2. Anxiety
3. Agitation

Intramuscular Pressure (IMP) Measurement:

- Rarely necessary
- Must be done at area of highest expected pressure
- May give false low result
- Adjunct to clinical examination.
- Needed for comatose or otherwise non-evaluable patient:
 - Anesthesia and Sedated
 - Head Injury
 - Intoxicated
 - Pediatric patients



Perfusion Pressure (ΔP) Vs IMP:

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

Ischemia

Muscle Ischemia	Nerve Ischemia
<ul style="list-style-type: none"> ● 4 hours - reversible damage ● 8 hours - irreversible changes ● 4-8 hours - variable <input type="checkbox"/> Myoglobinuria after 4 hours <input type="checkbox"/> Renal failure <input type="checkbox"/> Check CK levels <input type="checkbox"/> 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)

⁴ Diastolic blood pressure

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

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. Regular close monitoring

6. Avoid nerve blocks, sedation and strong analgesia to obtain patients feed back

7. Maintain normal BP as hypotension may decrease perfusion further and compound any existing tissue injury

8. Early assessment of metabolic acidosis and myoglobinuria is mandatory to avoid potential renal failure.

Emergent Fasciotomy (Time window for ACS is 6 Hours)

Indications	Technique of Fasciotomy
<ul style="list-style-type: none"> ● Absolute Compartment pressure >30 mmHg or <30 mm Hg difference from diastolic pressure. ● 6 hours of total ischemia time (ex: arterial embolism) ● Significant tissue injury. ● Worsening initial clinical picture. ● Delayed presentation with a picture of developed compartment syndrome. 	<ul style="list-style-type: none"> ● 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. ● Results in decreased compartment pressure ● Skin left open ● Debridement of all necrotic tissue is necessary we should leave skin open for second and third look BC we want to debride all necrotic tissue . ● Second and third look surgeries are often required ● Closure of skin is usually achieved after swelling has subsided ● Skin grafting is often required ● It is a prophylactic procedure ● Should be done as long as there is still viable tissue ● Should not be done if there is no expected viable tissue, otherwise infection is likely ● Does not reverse injury to permanently damaged tissue so better to have a low threshold <div data-bbox="740 1361 1326 1576" style="text-align: center;"> </div>

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

- Flexion contracture
- Paralysis
- Loss of sensation

➤ Leg:

Anterior compartment:

- Drop foot

Deep posterior compartment:

- Claw toes
- Loss of sensation in the sole

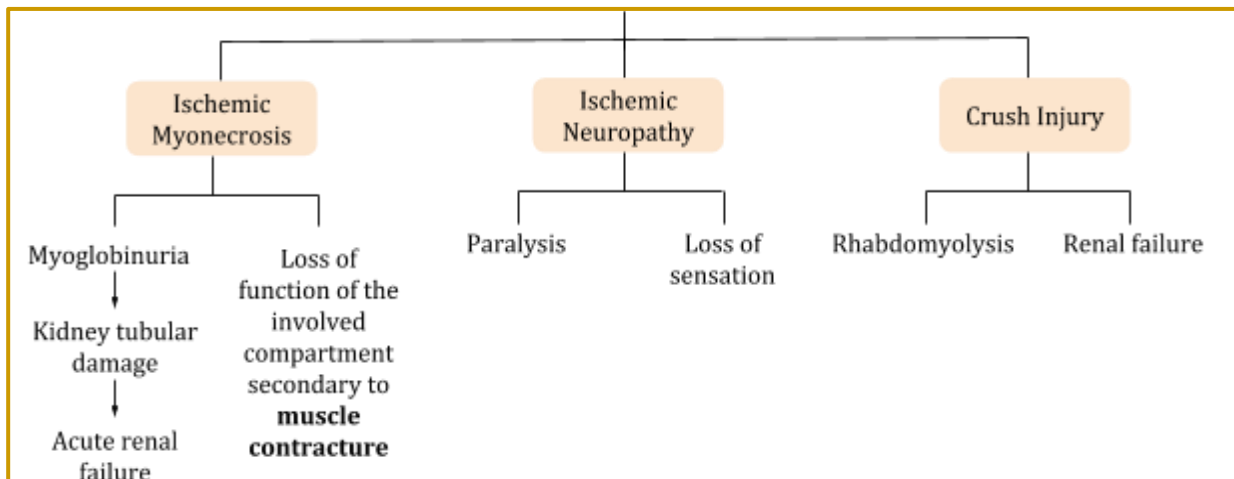
➤ Forearm:

Volar compartment:

- Volkmann's contracture **Volkmann contracture** (or **Volkmann ischemic 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



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.



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



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.



Definition

A joint dislocation is described by stating the location of the distal segment **to proximal 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: 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)

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

Pathophysiology:

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. **You should look for other associated injury (neurovascular injury/peri-articular fracture).**
- 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
- Acute joint dislocation means very high energy trauma , or sometimes happens with low energy trauma like in the shoulder dislocation. Be aware also of the people who have ligament laxity or connective tissue disorders (ehlers danlos syndrome) they might have spontaneous voluntary dislocation. Shoulder dislocation and joint laxity are more common in female.

Risk groups:

- 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 or fracture or dislocated or fracture and dislocated

Diagnosis:

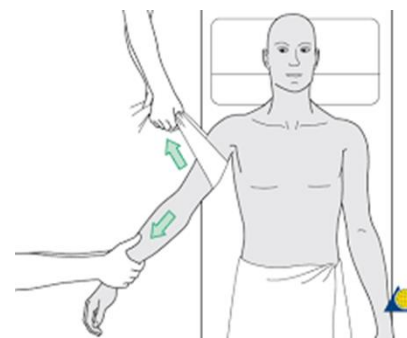
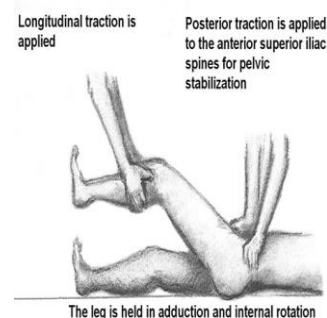
- History of a traumatic event (major trauma or any trauma with the limb in high risk position)
- Pain and inability to use the limb.
- Deformity.
- Shortening.
- Malalignment.
- Malrotation.
- X-ray is the milestone in diagnosing dislocation:
 - Should be done urgently without delay if dislocation is 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: OSCE

- Must rule out other injuries.
- consent also
- 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 weeks to heal and after that send them to physical therapy department.
- Rehabilitation.
- Follow for late complication

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



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 month and more common in the head of femur.
- Osteoarthritis.



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

● Hip joint Dislocation:

[dr .nabil video](#)

- 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.
- High incidence of late avascular necrosis
- An orthopedic emergency!



● Shoulder dislocation:

[dr .nabil video](#)

- 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:**

[dr .nabil video](#)

- 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(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.



MCQs

1-A 55-year-old man comes to the emergency department because of blunt trauma to his left forearm from heavy equipment. He developed mild pain and swelling but did not seek any medical attention. Today, the patient developed severe pain, swelling, and numbness in his left forearm. His temperature is 37.1°C (98.8°F), pulse is 80/min, respirations are 16/min, and blood pressure is 130/76 mm Hg. Physical examination of the left upper limb shows tense swelling in the left forearm and tenderness that was exaggerated by extension of the fingers. His radial pulse is intact. Which of the following is the most likely diagnosis?

- A-acute compartment syndrome.
- B-fracture of radial bone
- C-volkman contracture
- D-brachial artery injury .

Ans: A

2-A 12-year-old boy comes to the emergency department because of elbow pain. He was treated a day ago for the fracture described in the radiograph below and is currently dealing with increased elbow and forearm pain and swelling. His temperature is 37.1°C (98.8°F), pulse is 90/min, respirations are 22/min, and blood pressure is 128/86 mm Hg. Physical examination shows the skin is intact, tight, and pale. There are no lacerations and the radial pulse is diminished. If the patient avoids treatment, which of the following is the most likely complication?



- A- ulnar nerve damage
- B- volkmann ischemic contracture
- C- avascular necrosis
- D- venous thrombosis

Ans: B

3-Patient with epilepsy developed status epilepticus and during the attack he fell and had bilateral posterior shoulder dislocation in ED they managed his fracture and had splint, 4 hours later nurse noticed decrease urine output and urine turned to dark brown, he had high creatinine level, which level support the diagnosis?

- A- Creatinine kinase.
- B- Hemoglobin.
- C- Haptoglobin.
- D- Urea.

Ans: A

4- Young male presented to the ER after falling on his outstretched hand. What is the most likely diagnosis:

- A- Shoulder dislocation.
- B- Clavicle fracture.
- C- Glenoid fracture.
- D- Sternoclavicular joint dislocation

Ans: A



5-A 38-year-old man comes to the emergency department because of an electrocution while working on the residential power lines. He underwent electric cardioversion for ventricular fibrillation in the ambulance on the way to the hospital. The patient arrives unconscious, but stable. Physical examination shows a 3 cm full thickness burn on the right wrist and a 2 cm full thickness burn on the dorsum of the right foot. His airway is controlled, and he is being monitored for cardiac rhythm abnormalities. Fluid resuscitation is started with lactated ringers. Two hours after arrival at the emergency department, the right lower extremity begins to develop marked pallor, tight skin, which is cold to the touch, and peripheral pulses are absent on the right. Which of the following is the most appropriate next step in management?

- A-Administer IV alteplase.
- B-Administer IV antibiotics.
- C-consult for emergent thrombectomy.
- D-emergent fasciotomy of the leg.

Ans: D

6-A 25-year-old man comes to the emergency department because of pain following a car accident. The patient says he has left lower extremity pain and swelling. A lower extremity radiograph shows a comminuted fracture of the proximal left tibia. A long leg cast was applied and several hours later the patient complains of worsening pain despite analgesic therapy and paresthesia of the left lower extremity. Intraoperative compartment pressures are obtained. Which of the following compartment delta pressures is considered the threshold that would indicate an emergent fasciotomy?

- A- <30 mm hg
- B- <40 mm hg
- C- <50 mm hg
- D- <60 mm hg

Ans: A

7- Which nerve is the most likely to be injured in anterior shoulder dislocation?

- A-Axillary.
- B- Ulnar.
- C- Median.
- D-Anterior interosseous.

Ans: A

8-Which of the following is the most important sign of impending compartment syndrome?

- A. Increasing need of analgesics
- B. Loss of movement
- C. Loss of sensation

Ans: A

9- 35-year-old patient had a car accident. 8 hours after that, the nurse noted decreased in urine output and change in color. Upon examination swollen all compartments and bp 110/60. Creatinine has risen from 90 micromol to 250 micromol (normal up to 115) What is the next step in management?

- A. Alkalization of urine
- B. Four compartment fasciotomies
- C. Below knee amputation
- D. Above knee amputation

Ans: A myoglobinurea which will cause acute tubular necrosis leading to acute renal injury

10- a 17-year football player and had an injury to the shoulder. X ray shows dislocation of the humerus. What concomitant sign can you see clinically?

- A. Deltoid atrophy
- B. Wrist drop

Ans: A anterior dislocation most common than another types of shoulder dislocation so the axillary nerve would be damaged another answer could be loss of sensation above deltoid area

11- Which of the following is most likely to be found in compartment syndrome?

- A. IMP 29 DBP 50
- B. IMP 30 DBP 65
- C. IMP 29 DBP 70
- D. IMP 30 DBP 75

Ans: A

12- A 38 year old women had an accident where a car or a heavy object was on her leg . After knowing that its an isolated injury and everything else is fine what is the Most indicative factor that she has compartment syndrome?

Ans: Pain with passive stretch of affected compartment

13- 19 year old male Post-operative patient following debridement presented with pain. Which of the following is a suggestive sign for compartment syndrome?

- A. Pain is worsening
- B. Pain is intermittent
- C. Pain is decreasing
- D. loss of sensation

Ans: A