

Compartment syndrome

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Learning outcomes



At the end of this lecture you will be able to:

- Diagnose a compartment syndrome
 - Outline anatomy
 - Outline pathophysiology
 - Recognize as a surgical emergency
 - Interpret critical signs
- List causes
- Support correct management

What is a muscle compartment syndrome?

- Critical increase of pressure
 - In a closed muscle compartment
 - The capillary perfusion of the muscle is compromised by pressure
 - Leads to critical loss of oxygen in the muscle (hypoxia)

A compartment syndrome is an increase of the pressure in a muscular compartment that exceeds the pressure within the capillaries.

This syndrome occurs when the pressure within a closed osteo-fascial muscle compartment rises above the Muscle Perfusion Pressure (MPP) and so deprives the muscle of oxygen.

What's the normal Muscle Perfusion Pressure (MPP)?	
 MPP is the diastolic Blood Pressure (dBP) minus the IntraMuscular Pressure (IMP) 	MPP dBP
 If MPP is below 30 mm mercury (Hg), muscle hypoxia will occur 	
	AO

The muscle perfusion pressure (MPP) is the diastolic blood pressure (dBP) minus the pressure in the muscle compartment itself (IMP)

If **MPP** is below 30mm mercury, muscle hypoxia will occur (acute compartment syndrome (ACS)).



Serious decrease in the MPP, over several hours, can result in irreversible damage to the muscle tissue, as well as the nerves and blood vessels traversing the affected muscle compartment.

What is a muscle compartment syndrome?

- Critical increase of pressure
 - In a closed muscle compartment
- Potential to cause irreversible damage to:
 - Muscle tissue
 - Nerves
 - Blood vessels
- True orthopedic emergency
 - Immediate recognition and treatment by fasciotomy saves limbs
 - Late diagnosis or inadequate treatment leads to irreversible damage





A compartment syndrome is a real orthopedic emergency.

Early recognition and treatment will save the affected limb.

Late diagnosis, or poor treatment, can end in disaster. Late diagnosis, or poor management of compartment syndrome, is a frequent cause for claims by lawyers for clinical negligence, in some societies.



The limbs have muscles that are regarded in groups that perform similar actions.

Each of these groups has its distinct fascial, or osteofascial, compartment.

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Osteofascial compartments, or 'compartments', exist in all parts of the body.

Each compartment contains muscles, nerves and blood vessels.

As you can see from this picture, for example, there are 4 separate osteofascial compartments in the lower leg. Often, all 4 are affected by compartment syndrome of the leg.



Similar to the leg, such muscle compartments exist in the forearm...



Courtesy Insa Bamba, Ivory Coast



... the thigh ...



...and the foot.

We shall concentrate on the lower leg for the rest of this presentation, as it is the most common site of ACS.

But, each anatomical area has different and specific compartments, and a good knowledge of the anatomy is important.

Pathophysiology—causes

- Injury to muscles
- Reperfusion of injury
 - Return of blood flow after period of limb ischemia
- Bleeding into muscles
 - Edema
 - Swelling
- Increased pressure compartment
 - Pressure on nerves and veins



Pathophysiology

- Muscle necrosis leading to fibrosis and...
- Volkmann's ischemic contracture
 - Late consequence of delayed treatment



Muscle death leads to fibrosis and ischemic contracture, as seen here in a neglected forearm flexor compartment syndrome—Volkmann's contracture. This is a late consequence of delayed treatment.

Courtesy Insa Bamba, Ivory Coast

Consequences—of increased pressure in a muscle compartment

Compressed veir

and nerve

Arteries

• Never occluded as compartment pressure never reaches systolic blood pressure

Veins

- Poor return of blood
- Causes further swelling Nerves
- Temporary dysfunction
- Can lead to paraesthesia and later paralysis Muscles
- Pain on passive stretching
- Can lead to contractures

This is what happens when the muscle compartment pressure increases.

As muscle perfusion deteriorates, the muscle is deprived of oxygen. As this evolves, there is severe and increasing pain and, ultimately, the muscle fibres may die, leading to scarring and contracture. The early sign that must always be sought is pain in the muscle on passive stretching.

As veins become compressed, the blood cannot return which causes further muscle swelling.

When nerves are compressed, the patient often complains of pins and needles, and then, with prolonged compression, paralysis may occur.

What can cause a compartment syndrome?

- Fractures
 - Closed and open
- Cast / dressings
 - Too tightly applied
 - Disproportionate pain ignored
- Reperfusion injury
 - After successful repair of arterial injuries
- Burns
- Snake bites
- Surgical repair of fascial defect

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There can be many causes of muscle compartment syndrome: these include both open and closed fractures.

- Tight dressings or casts, especially if pain, which is more than expected for the known pathology, increases.the risk.
- Reperfusion injury; If there has been an arterial disruption and a period of warm ischemia of the distal limb, the reestablishment of the circulation can cause muscle eddemasswellinggaaddacoompartmeentssyddoomeeFboththis reason, after vascular repair, prophylactic fasciotomy may be considered.
- Burns will cause swelling, and in the presence of atistifubned extristion and in the presence of atistifubned extristion and the factor of the system of t
- Envenomation, particularly by snake bite, can result in deep swelling.
- Injudicious repair of a fascial defect has been known to cause a rise in pressure in the affected compartment.



Orthopedic surgeons can also cause acute compartment syndrome by prolonged surgery in certain positions. Acute compartment syndrome of the uninjured leg can occur after prolonged surgery on a fracture table if there has been local muscle pressure as a result of muscle compression due to improper positioning.

You can see how, on the picture on the left, prolonged surgery on the right leg can cause swelling to the normal left leg by direct pressure on the calf.

Similarly, on the picture on the right, you can get ACS of the normal left leg after prolonged surgery in this position.



ACS in the lower extremities is a well-known complication of prolonged spinal surgery in the knee-chest position , or of prolonged surgery in the lithotomy position.

Picture created by C Colton.

What are the symptoms of a compartment syndrome and how to diagnose it?

1. Pain out of proportion to the known injury, and increasing

2. Local pain on passively stretching the affected muscle(s)

.....then later

- 3. Paraesthesia
- 4. Paralysis



ACS is usually a clinical diagnosis, at least initially.

The first is pain out of proportion to the known injury, and especially pain on stretching the affected muscle group.

A later symptom is tingling along the nerve distribution, because of nerve compression due to swelling within the compartment that the nerve traverses.

And if the nerve compromise is prolonged, it can lead to paralysis as a late feature.

And delay, of course, is a disaster.

If you have the two pain signs, you will be correct in 60% of cases. If you have three signs you will be correct 95% of the time. But, that may be too late.

How to get an objective diagnosis?

- Record diastolic blood pressure (dBP)
- Measure intramuscular pressure (IMP)
- Calculate difference between the two (MPP)
 - If difference less than 30 mmHg
 - Compartment syndrome



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Measure the diastolic blood pressure, then the intramuscular pressure, to calculate the muscle perfusion pressure.

To measure the IMP, you can use a standard syringe, a three-way tap and a blood pressure manometer, or you can use the arterial pressure transducer in the anesthetic room to set up a device like this.

There are also available ready-made pressure measuring devices.

So, here is a check to see how many of you are awake.

The pressure is 46 – does this patient, after tibial nailing, in some pain, but doubtful diagnosis, have an ACS?

The diastolic blood pressure is 60

OK, good.

What if the diastolic blood pressure is 90?

Right, you all know how to diagnose it clinically and how to diagnose it on monitoring.

What is the treatment?

Courtesy Badri Narayan, UK



The surgical release of the affected muscle compartments, by incising the skin and fascia over the whole length of the compartment is known as dermatofasciotomy (or fasciotomy, for short).

This is the **only** treatment for a confirmed, or strongly suspected, muscle compartment syndrome.

It is essential to perform this as an emergency procedure, and certainly no later than 6 hours from the onset of the condition.

Basically, as soon as possible-it is a true surgical emergency.

What to do while waiting to start emergency surgery?

Immediately

- Split any plaster cast completely
- Release any tight dressings
- Elevate limb to level of heart
- Correct any hypoxia
 - Correct any hypotension
 - Administer supplementary oxygen

We all know that setting up an emergency surgical procedure takes time, so simple things help while we await surgery.

A tight plaster must be split right down to skin and spread.

Tight dressings must be removed.

Elevation of the limb, but not too much, will help to reduce swelling. Too much elevation can reduce blood flow!!!

Dealing with any hypotension will improve muscle perfusion by normalising the diastolic BP.

Oxygen always helps.



This patient suffered a high-energy segmental injury to the tibia in a motorcycle accident. He also had a talus fracture.

He has an ACS.

You need to decompress all 4 compartments.

Tourniquet applied "just in case", but not inflated.

You get to the front two compartments by using a standard anterior approach.

It is important that the planned line be marked, especially in a swollen limb a few seconds palpating the edges of the bone, helps to prevent wrong incisions.

Courtesy Badri Narayan, UK

Two-incision fasciotomy of leg

- 1. Anterolateral incision
 - To release anterior and lateral compartments



This shows the picture after an anterolateral incision and decompression of the lateral and anterior compartments.

You can see how the muscles are swollen and bulge out of the release incison, but they are ALIVE. The surgery was in time.

Courtesy Badri Narayan, UK

Two-incision fasciotomy of leg

- 1. Anterolateral incision
- 2. Posteromedial incision



The surgeon then moves to the posteromedial side and decompresses both the superficial and deep posterior compartments, via a posteromedial incision.

Again, note how the swollen muscle bulges.

Courtesy Badri Narayan, UK

Temporary fixation of the fracture

- 1. Anterolateral incision
- 2. Posteromedial incision
- 3. External fixator



What do you do with the bone?

The safest option is to apply an external fixator. This avoids further trauma to the bone and keeps the leg stable.

It is useful to go across the ankle joint to the foot, because you want to hold the ankle in a neutral position in order to avoid contractures.

This case also had a complex tibial plateau fracture as well as a shaft fracture, and you can see the fixator spanning across the knee.

Courtesy Badri Narayan, UK

Negative pressure wound therapy



The use of negative pressure water-tight dressing system (commercial name VAC therapy) is the standard nowadays.

Here is another patient with a complex injury and with a VAC across a fasciotomy wound.

What else do you see in this picture?

You can see that the external fixator has been extended on to the foot by using a pin in the first metatarsal, and also has been extended UNDER the leg to elevate the limb to prevent heel sores.

Courtesy Badri Narayan, UK

Alternative wound management



Not everyone has access to the VAC, or it may not be available in emergency. A simple alternative is to apply a moist, non-adhesive dressing.

Here is a patient where another method of closure has been employed, using staples and elastic vessel loops. You have to be very careful about overtightening and causing skin problems.

What else do you also see? Fasciotomy was also performed on the foot.

Courtesy Badri Narayan, UK

Wound closure step by step





- Use elastic closure
 - Never close primarily
- Close wound progressively
 - Postoperative second look (2-3 days)
 - Watch decrease of swelling
 - Finally close wound fully

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Courtesy Hédi Annabi, Tunesia

Aftercare

- Negative pressure wound therapy
- Splint to prevent contracture
- Return in 48–72 hours for closure or skin graft



What is the aftercare?

- Elevation
- Return to theatre in 48 to 72 hours for a "second look". This offers the opportunity to do a limited further debridement of any remaining dead muscle, and you can usually partially close the extremes of the wound and apply a split-skin graft, possibly meshed, to granulating areas.

Here is a patient after partial closure of the fasciotomy and skin grafting the rest of the defect.

Courtesy Badri Narayan, UK



A meshed split-skin graft has been used here to cover a posteromedial defect after fasciotomy of a lower leg.

Courtesy Nicholas Lubega, Malawi



A palmar Henry approach has been used here to release superficial and deep flexors, followed by the pronators and supinator. A dorsal approach is centered over the proximal forearm and can be used to release the "mobile wad" (brachioradialis, extensors radialis and brevis). It is important to remember when treating an electrical injury with a compartment syndrome, the most damage is deep along the bone (ie, the pronator and supinator muscles) and may require debridement at the initial surgery. Do not miss this!

Courtesy Isa Bamba, Ivory Coast











Success story from Malawi

- 28 year old man
- Crush injury in printing press
- Forearm fractures
 - Came to hospital immediately
- Swelling of forearm
 - High index of suspicion
 - Pain on passive stretching of muscles



Courtesy Nicholas Lubega, Malawi

Success story from Malawi

- Fasciotomy of all 3 compartments
- Plating of both fractures



Courtesy Nicholas Lubega, Malawi

Success story from Malawi

Wounds not closed primarily

- Application of nonadherent wound dressings Wound closure at later stage
- Mesh graft



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Courtesy Nicholas Lubega, Malawi

Sad story from Ethiopia

- Delayed admission
- Inadequate so-called fasciotomy performed
- Amputation of forearm



Summary

- Diagnose a compartment syndrome
 - Outline anatomy
 - Outline pathophysiology
 - Recognize as a surgical emergency
 - Interpret critical signs
- List causes
- Support correct management



