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Compartment Syndrome

Compartment syndrome is caused by an increased pressure within a closed anatomical space, which compromises the circulation and function of the tissues within that space. This may result in temporary or permanent damage to muscles and nerves. Compartment syndrome may be acute or chronic:

- Acute compartment syndrome is most often caused by trauma, which may be relatively minor. Intense exercise can also cause acute compartment syndrome. Acute compartment syndrome requires prompt diagnosis and urgent treatment.
- Chronic compartment syndrome is usually caused by exercise and presents with recurrent pain and disability, which subside when the cause (usually running) is stopped but return when the activity is resumed.

Sites affected

Compartment syndrome can occur wherever a compartment is present. Therefore, although the upper and lower limbs are most commonly affected, other sites may be affected, particularly the abdomen and gluteal regions:

- Forearm compartments and structures at risk:
 - Ventral compartment: median and ulnar nerves; radial and ulnar arteries.
 - Dorsal compartment: posterior interosseous nerve; no major vessels.
- Lower limb and structures at risk:
 - Anterior tibial compartment: deep peroneal nerve, anterior tibial artery.
 - Superficial posterior compartment: no major nerves or vessels.
 - Deep posterior compartment: posterior tibial nerves and vessels, peroneal artery.
 - Peroneal compartment: deep and superficial peroneal nerves.
- Gluteal compartment syndrome:
 - Uncommon and is often diagnosed late, resulting in muscle necrosis and sciatic nerve palsy.
- Abdominal compartment syndrome:^[1]
 - May occur in any multiple trauma patient who has undergone a period of profound shock.
 - It may cause acute kidney injury, cardiac dysfunction and an elevated central venous pressure.
 - The diagnosis can be confirmed by the measurement of intra-abdominal pressure, either by a Foley's catheter in the bladder or a nasogastric tube in the stomach.
 - Sudden release of the abdominal compartment syndrome may lead to an ischaemia-reperfusion injury causing acidosis, cardiac dysfunction and cardiac arrest.

Acute compartment syndrome

With increasing duration and magnitude of interstitial pressure, there is increasing impairment of muscle and nerve function and necrosis of soft tissues. Initial venous compromise may progress to reduced capillary flow, which increases ischaemia and may further increase the interstitial pressure, leading to a vicious cycle of increasing pressures. Arterial blood inflow is reduced when the pressure exceeds systolic blood pressure.

Causes

- Fractures, especially fractures of the forearm and lower leg that have been internally fixed or infected.
- Crush injury.
- Burns.

- Infection.
- Prolonged limb compression - eg, immobilisation in a tight plaster cast.
- Vascular; ischaemia-reperfusion injury, haemorrhage, phlegmasia caerulea dolens.
- Iatrogenic; intramuscular injections, vascular puncture in anticoagulated patients.
- Muscle hypertrophy in athletes. [2]

Presentation

Acute compartment syndromes usually present within 48 hours of injury. A high index of suspicion is required, especially with an unconscious patient following major trauma. Clinical features include:

- Increasing pain despite immobilisation of the fracture.
- Sensory deficit in the distribution of nerves passing through the compartment.
- Muscle tenderness and swelling.
- Excessive pain on passive movement, increasing pain despite immobilisation.
- Peripheral pulses may still be present.
- Later features are of tissue ischaemia with pallor, pulselessness, paralysis, coolness and loss of capillary return.

Differential diagnosis

Any other cause of limb swelling - eg, **peripheral oedema**, infection, **deep vein thrombosis**.

Investigations

- Diagnosis is essentially clinical with recognition of patients at risk and recognition of early signs.
- Intracompartmental pressure can be measured by several methods, including wick catheter, needle manometry, infusion techniques, pressure transducers or side-ported needles.
- The critical pressure for diagnosing compartment syndrome is unclear.
- MRI scans help make the diagnosis of compartment syndrome in clinically ambiguous cases. [3]

Management

The mainstay of treatment is prompt diagnosis and early surgery. Patients with a swollen limb and no clear underlying cause should be considered for urgent orthopaedic opinion. [4]

- Urgent decompression is required to prevent severe ischaemia. Early orthopaedic referral and continuous compartment pressure monitoring are required.
- All potentially constricting dressings, casts and splints must be removed. Splitting a plaster is not sufficient. The compartment pressure should be measured.
- Open fasciotomy:
 - Indications for fasciotomy vary between different authorities - eg, an absolute compartment pressure greater than 30-40 mm Hg with a clinical picture consistent with compartment syndrome; difference between diastolic pressure and compartment pressure less than 30 mm Hg or difference between mean arterial pressure and compartment pressure less than 40 mm Hg.
 - The skin and deep fascia must be divided along the whole length of the compartment.
 - Otherwise, the limb should be closely observed until improvement is apparent clinically. If no improvement occurs then a fasciotomy is required. All four compartments may need to be opened in cases involving the leg.
 - After fasciotomy, the wound should be left open. Healing may be encouraged by suturing, skin grafting or the wound left to heal by itself.
 - Debridement may be indicated for any muscle necrosis.

Complications

- Tissue necrosis develops within about 12 hours.
- Muscle necrosis leads to fibrosis and shortening, resulting in an ischaemic contracture (Volkmann's ischaemic contracture).

Prognosis

- Nerve dysfunction may be reversible with time but infarcted muscle is damaged permanently.
- Early surgery enables a good functional outcome but delay results in muscle ischaemia and necrosis.

Chronic (exertional) compartment syndrome^[5]

Chronic exertional compartment syndrome most often occurs in the lower legs, but occasionally occurs in the thighs, upper arms, forearms and hands. Most people have symptoms in both legs.^[6]

Risk factors

- Chronic compartment syndrome most often occurs in athletes aged under 40 years but can occur at any age.
- Most at risk are those who exercise with repetitive motions or activity.
- Sporting activities with particular risk include running, football, cycling, tennis and gymnastics.
- Excessive training increases the risk.

Presentation

- Increased tissue pressure causes severe pain and tightness, with hardness of the compartment on examination.
- Pain is triggered by exercise and becomes worse as exercise continues, until it is severe enough to force the person to stop exercising. The pain resolves with rest.
- Compromised circulation causes pain on passive stretching of the involved compartment.
- Nerve and muscle dysfunction within the affected compartment causes muscle weakness, numbness or tingling, and an abnormal gait.

Investigations

- Intracompartment pressure testing before and after exercise is considered the gold standard for confirmation of chronic compartment syndrome.^[7]
- The pressure difference from rest and activity is normally small, but patients with exercise-induced compartment syndrome have a large increase in pressure readings when the symptoms are present after exercise.
- MRI scanning can detect changes that are characteristic of compartment syndrome.
- Other investigations to assess the cause of limb pain may include CT, ultrasound and Doppler scanning.

Differential diagnosis

Chronic compartment syndrome must be differentiated from other causes of leg pain, including:

- **Medial tibial stress syndrome (shin splints).**
- Stress fractures.
- Vascular abnormalities - eg, popliteal artery aneurysm, peripheral artery dissections.

Management

- Conservative management includes eliminating or limiting the offending activity, altering training regimens, and deep massage treatments.
- Surgical treatment involving decompressive fasciotomy, which is effective in relieving pain and increasing exercise tolerance in most patients.
- Fasciotomy is the treatment of choice for athletes who are unwilling to modify their exercise or sport.^[8]

Complications

Patients with chronic compartment syndrome have an increased risk of developing acute compartment syndrome; patients should therefore be educated on the features of acute compartment syndrome and the importance of urgent intervention.

Further reading & references

- **Compartment Syndrome**; Wheeless' Textbook of Orthopaedics

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