Ministry of Defence

Synopsis of Causation

Compartment Syndrome

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September 2008

Disclaimer

This synopsis has been completed by medical practitioners. It is based on a literature search at the standard of a textbook of medicine and generalist review articles. It is not intended to be a meta-analysis of the literature on the condition specified.

Every effort has been taken to ensure that the information contained in the synopsis is accurate and consistent with current knowledge and practice and to do this the synopsis has been subject to an external validation process by consultants in a relevant specialty nominated by the Royal Society of Medicine.

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1. Definition

1.1 **Acute compartment syndrome (ACS)** is a condition which occurs when increased tissue pressure within a myofascial compartment compromises the vascular supply and the function of structures within that space.

1.2 The increase of hydrostatic and osmotic pressure in the anatomical compartment leads to a decrease in arterial inflow and impairment of perfusion. A cascade of injury follows, with disruption of the metabolic processes of the muscle, cytolysis and the release of osmotically active cell contents. This results in further perfusion of fluid from capillaries and added pressure within the compartment, compromising the function of structures such as blood vessels and nerves and the muscle units they supply. ACS is potentially limb- and life-threatening and requires urgent intervention.

1.3 Normal compartment pressure at rest is 10-15mmHg. Pressures above 40mmHg are indicative of compartment syndrome. Serial values are often the most revealing. Pressures within 10-30 mm Hg of the diastolic blood pressure can also be suggestive of the condition.

1.4 **Exertional compartment syndrome (ECS)** is also known as chronic or recurrent compartment syndrome and is characterised by exertional limb pain during and immediately after exercise, paraesthesia and swelling, usually of the lower limb. Ischaemic changes within the muscle compartment are probably responsible, although the mechanism of the condition is poorly understood.

1.5 Definitions for elevated pressures are: pre-exercise, >14-15mmHg; 1 minute post-exercise, >30mmHg, and 5 minutes post-exercise >19-20mmHg.

2. Clinical Features

2.1 **Acute compartment syndrome:** Virtually any muscle mass surrounded by fascia is at risk, but the compartments of the limbs are the most vulnerable. Other areas which may be affected include the shoulder, back, and buttocks, and rarely the abdomen may be affected. The hand and foot, being subject to crush injury, are notably vulnerable sites. The diagnosis may be overlooked, with disastrous consequences, and a high index of suspicion is needed to ensure that the condition is not missed.

2.2 The main clinical features of ACS in the conscious patient may be divided into early and late signs and symptoms. Early features include pain, markedly disproportionate to any apparent underlying trauma, and aggravated by passive muscle stretching along with palpable tightness and tenderness of the compartment. Later, hyperaesthesia of the nerves traversing the compartment may be a feature, and weakness of the muscles. Pulselessness may be noted, but it is a misconception that the presence of pulses excludes compartment syndrome. The process may ultimately result in tissue necrosis, irreversible muscle injury, contractures and even loss of the limb. In some cases rhabdomyolysis may ensue, followed by renal failure which may be fatal.

2.3 ACS is a surgical emergency, and is treated by urgent and extensive fasciotomy. If this is carried out within 6-12 hours of the appearance of symptoms it can prevent most ischaemic myoneural deficits. Early diagnosis and treatment are therefore essential, and sophisticated means of measuring intracompartmental pressure have been developed, although these are not without their limitations.[1,2,3] Fasciotomy often results in the need for skin-grafting to close the incisions at a later date.

2.4 **Exertional (chronic) compartment syndrome:** Although this condition usually involves the lower limb, rare cases do occur in which the upper limb is primarily affected e.g. in weight lifters. ECS characteristically occurs in competitive athletes, particularly long-distance runners, who may perform long periods of intensive training involving prolonged running. Lower limb symptoms of pain, cramps and paraesthesia often occur in the individual during and after a consistent running distance, are frequently bilateral and escalate with continued activity. Upper limb symptoms too may be reproducable at a specific workload or time interval. Symptoms generally subside within an hour or so of stopping the activity but recur when exercise is resumed. This feature helps to differentiate the condition from stress fracture (with associated local tenderness) and shinsplints.

2.5 Muscle weakness of the affected limb may be a feature of these episodes and gradually increasing fullness is a frequent complaint. Pain is increased both on passive stretching and active contraction.

2.6 The clinical features of ECS are only evident in the immediate aftermath of exercise, and the nature and location of signs and symptoms will depend on the compartment affected. Measured compartment pressures at rest and while symptomatic with exertion are valuable in reaching the diagnosis.

3. Aetiology

2.7 **Acute compartment syndrome:** The many causes of ACS share the same origin; namely, increased pressure within a closed tissue space. This may result from increase of volume within the compartment; for example due to oedema, haemorrhage or haematoma formation, or decreased compartment size from external compression of a limb.

2.8 Increased volume and pressure may be caused by:

- Fractures
- A direct blow to the compartment
- Vascular injury
- Crush injury
- Intensive muscle use (e.g. tetany, seizures or very rarely, vigorous exercise)
- Burns
- Intra-arterial injection (may be iatrogenic)
- Vascular puncture in an anticoagulated or haemophiliac patient
- Envenomation
- Decreased serum osmolarity (e.g. nephrotic syndrome)
- Extravasation of intravenous infusion
- Venous obstruction

2.9 Decreased compartment size may be caused by:

- Burns (eschar)
- Tight dressings or casts
- Lying on a limb e.g. after drug overdose, intoxication or during surgery
- Military anti-shock trousers (MAST)

2.10 Fractures are the cause in some 75% of cases, and of these, fractures of the tibia are most commonly responsible. Other fractures which are more likely to cause the condition include those involving the humeral shaft and bones of the forearm. Despite a common misconception ACS may be associated with open fractures. Crush injuries of the foot and hand also require particular vigilance.

2.11 Comminuted fractures are more likely to give rise to ACS[4], and this probably reflects the greater degree of force required to cause this type of injury. Indeed any high energy trauma is more liable to cause ACS, and penetrating injuries such as gunshot wounds often cause severe muscle laceration and arterial tears, which in turn lead to increased intracompartmental pressure.

2.12 Acute compartment syndrome has been recorded in patients with no history of trauma, although such cases appear to be extremely uncommon.[5]

2.13 Complications of ACS include infection, permanent nerve damage, loss of limb or death. Cosmetic disfigurement may occur from surgical procedures involved in treatment.

2.14 **Exertional compartment syndrome**: The pathogenesis of this condition is uncertain, although it probably resembles that of ACS in that structures within a closed myofascial compartment are compressed. During exercise, muscle bulk increases some 20% and allied with repetitive muscle contraction may increase intracompartmental pressure to a level which

causes transient ischaemia and deoxygenation[6]. Symptoms of ECS probably occur when the pressure between successive muscle contractions remains high within a small unyielding fascial compartment[7].

2.15 An alternative explanation is that muscle tissue, damaged by repetitive hard surface exercise, releases protein-bound ions which increase osmotic pressure, provoke oedema and so decrease blood flow within the compartment.

2.16 The predisposing factors and pathophysiology of ECS are imperfectly understood and although cases have been reported in which the condition appears to have originated at the time of some minor trauma[8], such instances appear to be rare.

4. Prognosis

4.1 **ACS:** The prognosis of ACS depends upon a number of factors. These include most importantly the rapidity with which it is diagnosed and treated, whether or not complications occur and the underlying diagnosis.

4.2 Infection is a serious complication of ACS, and is more likely in cases where decompression is delayed. When it occurs, it increases the likelihood that amputation will ultimately be required. Systemic complications include renal failure, acute respiratory distress syndrome and disseminated intravascular coagulation.

4.3 It is said that between 1% and 10% of patients go on to develop Volkmann's ischaemic contracture. Hypoaesthesia and painful dysaesthesia may also result.

4.4 **ECS:** Although there have been reports of successful treatment of ECS by conservative means, massage and physiotherapy alone are rarely satisfactory and fasciotomy is the treatment of choice.[9,10] Surgical intervention has a generally satisfactory outcome[11], with some 70% to 85% of patients able to return to pre-treatment levels of activity without symptoms. The success rate depends largely on the compartment concerned, and patients with lower limb ECS in whom the deep posterior compartment is affected respond less well than those whose anterior or lateral compartment is involved. Cases of recurrent ECS have been reported, almost certainly attributable to scarring and closure of the initial compartment release.

4.5 Most athletes who have undergone fasciotomy for ECS affecting the lower limb will experience some muscle weakness, particularly involving gastrocnemius and soleus muscles, due to loss of the supporting compartment fascia.

5. Summary

5.1 **Acute compartment syndrome** is a serious limb- and life-threatening condition usually associated with trauma, particularly fractures of the lower limb. It is due to increased tissue pressure within a myofascial compartment resulting in ischaemia of the structures within that compartment.

5.2 **Exertional compartment syndrome** is a condition most commonly affecting the lower extremities in competitive athletes, probably caused by raised pressure within a non-compliant myofascial compartment due to repetitive muscle activity, causing symptoms during and immediately after exercise.

6. Related Synopses

Shin Splints

7. Glossary

comminuted fracture	Of a bone: a break resulting in a number of fragments.
cytolysis	Destruction of a cell due to damage to the cell wall and leakage of the cellular contents.
dysaesthesia	Unpleasant abnormal sensation.
envenomation	The injection of a poisonous material (venom) by sting, bite, or other apparatus; e.g. snakebite.
eschar	A dry, inelastic, often constricting scab which is produced by e.g. a burn.
extravasation	Leakage of blood from a blood vessel.
fasciotomy	Surgical division of fascia (sheet of connective tissue).
hyperaesthesia	Increased sensitivity to normal stimulation of skin.
hypoaesthesia	Reduced sensitivity to normal stimulation of skin.
iatrogenic	Induced inadvertently by medical treatment or procedures.
ischaemic	Suffering from a deficiency in the arterial blood supply
myofascial space, myofascial compartment	An anatomical compartment, containing muscle and associated blood- and nerve-supplies and bounded by fascia (sheets of connective tissue).
myoneural	Relating to muscle and nerve; specifically, the junction between the a nerve and the muscle which it supplies.
necrosis	Cell death.
oedema	The presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body.
osmolarity	The concentration of particles or substances in a solution.
paraesthesia	Abnormal sensation.
rhabdomyolysis	Destruction of muscle cells. This may be the result of prolonged physical pressure, or the side- effect of certain drugs or toxins.
vascular	Pertaining to the blood vessels.

Volkmann’s ischaemic contracture	Destruction and contraction of muscle due to irreversible damage following prolonged interruption of blood supply.

8. References

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