Compartment syndrome: the importance of early diagnosis

Compartment syndrome is a serious condition that, if unrecognised, can have devastating consequences for a patient, affecting future quality of life. There are numerous causes but the most common follow trauma to the upper and/or lower limbs (Fig 1). Nurses must be ever vigilant when caring for patients with such injuries and be aware of the signs and symptoms indicating the development of the condition.

Definition
Mubarak and Hargens (1981) have described compartment syndrome as ‘An elevation of the interstitial pressure in a closed osseofascial compartment that results in microvascular compromise’. Compartment syndrome may be acute or chronic, depending on the cause of the increased pressure and how long the symptoms last.

Anatomy
The muscles of the limbs are grouped into compartments that are formed by thick layers of fairly inelastic tissue called fascia. Within the compartments are the nerves and blood vessels that supply the limbs. The forearm has four interconnected compartments:
- The superficial volar compartment;
- The deep volar compartment;
- The dorsal compartment;
- The compartment containing the mobile wad of Henry.

The leg also consists of four compartments (Fig 2):
- The anterior compartment;
- The deep posterior compartment;
- The lateral compartment;
- The superficial posterior compartment.

Pathophysiology
If the pressure in a compartment rises, capillary blood perfusion is reduced, which compromises tissue perfusion and oxygenation. Eventually this reaches a level where tissue viability can no longer be maintained (Phillips, 1992). The increased interstitial pressure overcomes the intravascular pressure of the microcirculation causing the walls of the vessels to collapse and thus impeding blood flow. This results in local tissue ischaemia, leading to oedema which, in turn, increases the intra-compartmental pressure (Jobe, 1992).

This destructive sequence of events occurs as a vicious cycle (often referred to as Volkmann’s ischaemia) which, in less than 12 hours, can result in necrosis of the nerve and muscle tissue within the compartment.

Necrotic muscle will never recover, hence the seriousness of the condition and the importance of recognising the warning signs and being aware of the types of injury that may put patients at risk.

Causes
Compartment syndrome can be caused by any condition that either increases the pressure in a compartment, for example, trauma, or which reduces the size of the compartment, for example, prolonged external pressure. Common injuries that result in compartment syndrome are fractures, crush injuries and gunshot wounds.

McQueen et al (2000) reported that 69 per cent of all cases diagnosed at a Scottish trauma unit were following a fracture. Of those, 36 per cent were due to tibial fracture and 9.8 per cent to a fracture of the radius.

The syndrome is also fairly common following a soft tissue injury, although there appears to be less awareness among health professionals that this can occur. Young men are at particular risk of compartment syndrome, especially those with a clotting disorder and those taking anticoagulant therapy, where the risk of intracompartmental haemorrhage following trauma is increased (McQueen et al, 2000).

Prolonged external compression is another common cause. Patients with a plaster cast or tight bandaging, or those who are rendered unconscious following trauma and spend a prolonged period compressing a limb, are at increased risk. Other causes include:
- Allergy;
- Burns;
- Tumour;
- Infection;
- Snake bites;
- Coagulopathies (genetic, iatrogenic or acquired).

Incidence
Compartment syndrome can occur anywhere where skeletal muscle is surrounded by substantial fascia; that is, any myofascial compartment. The compartments that are most commonly affected are the volar compartments of the forearm and the anterior and deep posterior compartments of the leg (Frederick et al, 1998; Jobe, 1992).

McQueen et al (2000) have cited the average annual incidence as being 7.3 per 100,000 for men and 0.7 per 100,000 for women. It is more common in younger
people, possibly because they have relatively large muscles. Because the compartment size does not change after growth is complete, children have less space for swelling following muscle injury compared with older people, who tend to have more hypotrophic muscles (McQueen et al, 2000).

**Signs and symptoms**
The signs and symptoms of compartment syndrome have been described by Solomon et al (2001), using five Ps as a mnemonic:

- Pain – This is the most common and consistent sign, and is reported as seeming extreme and out of proportion to the injury. The pain is persistent, progressive and unremitting, and is exacerbated by touch, pressure, limb elevation and stretching;
- Passive stretch – Ischaemic muscles are highly sensitive to stretching, therefore hyperextension results in extreme pain;
- Paraesthesia – As the nerves become ischaemic, paraesthesia may occur within the affected compartments;
- Pallor – The limbs may be a pale, dusky colour;
- Pulse absent or diminished. Because compartment syndrome is a disorder of the microvasculature, the major vessels are frequently not affected and a pedal pulse may be present in lower limb compartment syndrome or a radial pulse in upper limb compartment syndrome.

Further signs that may indicate compartment syndrome are shown in Fig 3.

**Pain management: precautions**
Controversy surrounds the pain management of orthopaedic patients potentially at risk of compartment syndrome (Whitesides, 2001) because alleviating the pain, which is the major symptom, may mask symptoms of the development of the condition. However, for humanitarian reasons and because pain is detrimental to other physiological mechanisms, health care professionals have a responsibility to treat pain appropriately, but they must be vigilant so they can identify unusual pain patterns.

In cases where a patient has a need for analgesia out of proportion to the procedure being undertaken or to the injury, reassessment is essential in order to identify potential complications such as compartment syndrome (Macintyre and Ready, 2001).

Epidural analgesia may not be appropriate for patients at high risk of developing compartment syndrome because complete eradication of pain may mask warning signs. In fact Rimmer (2002) suggests that the vaso-dilating effects of the local anaesthetic may actually increase the risk of compartment syndrome.

Patient-controlled analgesia (PCA) is a useful mode of delivery of good quality pain relief. Modern equipment has a history facility, which allows analgesic demands to be reviewed. Provided close monitoring of the limb, general observations and pump recordings are regularly recorded and appraised (1–2 hourly), any pattern of increasing symptoms can be identified.

The most effective way of managing postoperative or trauma pain is to adopt a multimodal approach; this has been described by Pasero and McCaffery (2001) as the cornerstone of acute pain management. It involves the concurrent use of paracetamol and a non-steroidal anti-inflammatory drug (NSAID) alongside an opioid (often delivered via PCA). Although NSAIDs have been considered one of the most efficient ways of controlling pain, they have also been associated with unwanted side-effects, such as gastric ulceration, renal toxicity and inhibition of platelet aggregation – potentially causing haemorrhagic complications. Caution should, therefore, be exercised when using this class of drug in older patients or those at increased risk of the complications described above (Middleton, 2003).

There is evidence to suggest that a combination of analgesic drugs with differing pharmacological actions on the pain pathway produces an opioid-sparing effect (Pasero and McCaffery, 2001). Increased requirements for opioids when using a balanced analgesic regimen may, therefore, be a crucial indicator of potential complications. Following high-risk trauma injuries, increasing pain and/or opioid requirements should alert the practitioner to the possibility of compartment syndrome. Where the syndrome is suspected, examination should be undertaken and, where possible, pressure levels monitored (Phillips, 1992).
Complications of compartment syndrome

One of the main causes of complications from compartment syndrome is delay in diagnosis. The complications are usually disabling, particularly if compartment syndrome is not diagnosed initially.

They include infection, contractures (following prolonged ischaemia) or amputation (sometimes the tissue is beyond repair and amputation is the only way to prevent gangrene). In extreme circumstances death can occur. This is usually due to hyperkalaemia secondary to tissue necrosis causing cardiac arrhythmias, or to myoglobinuria (the excretion of myoglobin in the urine leading to renal failure).

Patient education

The most significant determinant of a good outcome following compartment syndrome is a prompt diagnosis. It is important, therefore, to give patients with injuries that predispose them to compartment syndrome the following discharge instructions:

- Immediately call or return to the hospital if you notice the following in the affected limb:
  - Severe pain;
  - Numbness;
  - A burning sensation;
  - Weakness.

- It is important to ensure that patients have a follow-up examination date and are encouraged to attend after any injury, especially those where compartment syndrome could result.

Chronic compartment syndrome

Excessive exercise may cause chronic compartment syndrome. The patient presents with a history of pain and tightness that begins approximately 20–30 minutes after exercise. Running has been shown to increase muscle volume by up to 20 per cent (Frederick, 1998). Recurrence of increased pressure can lead to the need for fasciotomy to reduce compartmental pressure (Phillips, 1992). Athletes should be advised to see their doctor at the first sign of the following (Edwards, 1996):

- Pain and/or swelling and tingling/numbness of the leg and foot;
- Pain when flexing or pointing the big toe.

Conclusion

Early diagnosis of compartment syndrome is vital to avoid long-term disability. This will be achieved only by raising awareness of the condition in all members of the multidisciplinary trauma and orthopaedic team.

Staff must be able to identify those patients who are at greatest risk, and provide appropriate analgesia while monitoring them. They must also be aware of the signs and symptoms of the condition and initiate immediate appropriate action once compartment syndrome is suspected.

For related articles on this subject and links to relevant websites see www.nursingtimes.net

REFERENCE


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FIG 3. SIGNS THAT MAY INDICATE COMPARTMENT SYNDROME (PAULA, 2003)

- Significant pain following an injury to an extremity
- Severe pain out of proportion to the patient’s injury
- A burning sensation or tightness in the limb following an injury
- One or more of the five P signs associated with compartment syndrome

Health professionals should observe the following patients carefully:

- Those with a limb injury taking anticoagulants;
- Those who have sustained one of the following:
  - Long bone fracture;
  - High-energy trauma;
  - Penetrating injuries (for example gunshot wounds, stabblings);
  - Venous injury;
  - Crush injury.

Always be highly suspicious of any injury that causes limb pain. High-velocity injuries are particularly worrisome.

Monitoring compartment pressure

Pressure monitoring is an invasive procedure, and is not available in some units. However, many orthopaedic consultants advocate its use for all high-risk injuries. Normal intercompartment pressure should be less than 15mmHg. Various devices are used; some make single pressure readings, while others monitor pressure continuously. The recently developed fibreoptic transducer (camino-catheter) has also proven to be reliable and simple to use (Phillips, 1992).

Reducing compartmental pressure

The following are measures that will help reduce compartmental pressure:

- Split plaster casts and release constrictive bandages. It has been shown that either of these actions will reduce compartmental pressure by 50–85 per cent (Phillips, 1992);
- Position the limb so that it is not elevated above the level of the heart, because this can significantly increase ischaemia;
- Administer colloid or crystalloid fluids; replace blood, and maintain coagulability by replacing platelets and plasma;
- Use non-reamed nails rather than reamed ones for the surgical stabilisation of a fracture. Animal studies have shown that this reduces the incidence of compartment syndrome (Phillips, 1992).

When the pressure in a compartment reaches 30mmHg, prompt decompression of the threatened compartment by open fasciotomy is indicated (Apley and Solomon, 1999; Frederick, 1998). This involves dividing the fascia along the length of the compartment to release the pressure.