Acute Compartment Syndrome

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KEYWORDS

• Acute compartment syndrome • Fasciotomy • Intramuscular pressure • Perfusion pressure
• Pressure monitoring • Complication

KEY POINTS

- Frequent clinical assessment of patients considered to be at risk for developing compartment syndrome, ideally using a structured checklist, remains the cornerstone of diagnosis. In alert patients, monitoring of limb swelling, pain (both at rest and with passive muscle stretching), and neurologic status provides clues to the onset of acute compartment syndrome (ACS). The clinical findings are of greatest utility when several findings are present together.
- When a patient is unconscious or otherwise not able to be clinically assessed at frequent intervals, then continuous measurement of intramuscular pressure within the anterior compartment is of benefit. Continuous pressure monitoring, using a threshold for fasciotomy of a perfusion pressure (diastolic pressure minus muscle pressure) sustained at less than 30 mm Hg for 2 hours, has a 93% positive predictive value for the diagnosis of ACS.
- Although based primarily on retrospective studies, the literature is convincing that, when compartment syndrome is going to occur, early fasciotomy can avoid myonecrosis or ischemic neuropathy. However, the challenges in diagnosis, and the fact that compartment syndrome does not begin at a well-defined point in time, make it impossible to draw specific conclusions about the optimum timing of fasciotomy.

INTRODUCTION

Nature of the Problem

Acute compartment syndrome (ACS) is a complication of trauma or tissue ischemia, and can potentially involve any myofascial compartment in the body, whether in the extremities or trunk. Compartment syndrome most often occurs following a fracture or a crush injury to the limb.[1] When muscle swelling occurs following such injury, or with muscle reperfusion following a period of ischemia, the mass within the myofascial compartment increases because of accumulation of blood and other tissue fluids. Because of the inelastic nature of muscle fascia and other connective tissues, this accumulation of mass leads to increased pressure within the compartment, which is transmitted to the thin-walled venous system, causing venous hypertension and further transudation of fluid.[2] Progressive tissue ischemia and necrosis ensues, with eventual irreversible ischemic injury to all of the myoneural tissues within the involved compartment.

Despite ACS being well known and most clinicians being aware of its potential limb-threatening nature, it is a progressive phenomenon, and there is no standard definition of when compartment begins. The standard clinical signs and symptoms of ACS are pain and swelling, which are just as common in patients without ACS.[3] It is possible to quantify intramuscular pressure by direct measurement,[4,5] but both the clinical findings of ACS and measurement of intramuscular pressure have significant pitfalls as a means of diagnosis.[3,6–13] As a result, there is

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significant variation in the diagnosis of ACS and the frequency with which fasciotomy is performed.[14,15] Compartment syndrome is one of the most common causes of litigation against orthopedic surgeons.[16]

The only effective treatment of ACS is immediate decompressive surgical fasciotomy, wherein the skin and muscle fascia of the involved compartment are incised the length of the compartment in order to release the constricting soft tissues and increase the volume of the muscle compartment, thereby causing immediate reduction of compartment pressure and restoring perfusion. It has been estimated that muscle necrosis may occur within 2 hours of injury in as many as 35% of patients with ACS.[17] It is widely considered that performing early fasciotomy is critical to achieving the best possible outcomes when compartment syndrome occurs,[18–23] and it is generally accepted that performing unnecessary fasciotomy is better than missing a true case of compartment syndrome.

INDICATIONS/CONTRAINDICATIONS FOR EMERGENCY FASCIOTOMY

The only effective treatment of ACS is immediate fasciotomy, but if fasciotomy is performed the patient is committed to further surgery, a prolonged hospital stay, increased cost of care,[24,25] and increased morbidity.[21] Thus, clinicians facing patients at risk of ACS must choose a treatment plan from among several bad choices: perform fasciotomy and expose the patient to the risks and costs associated with that procedure, or not do fasciotomy and expose the patient to the potential adverse effects of delayed fasciotomy or missed ACS. Because of the latter, the primary indication for fasciotomy is a reasonable clinical assessment that the patient's examination is deteriorating, or that the patient is at risk of ACS and cannot be reliable followed from a clinical perspective.

Given that the diagnostic stakes are high and that there is some uncertainty in the diagnosis of ACS, understanding the risk factors for compartment syndrome allows surgeons to raise or lower the threshold for fasciotomy in a given clinical scenario. Young men sustaining high-energy trauma, especially of the lower leg and forearm, are considered to be the most at risk for compartment syndrome,[1] and a recent analysis suggests that young age is the strongest predictor.[26] ACS can occur without fracture, and such patients are older and have more medical comorbidities than those with a fracture.[19] Fracture pattern and location are also important. Park and colleagues[27] evaluated 414 acute tibial fractures and compared rate of ACS requiring fasciotomy according to fracture location. ACS was most common in mid-diaphyseal tibia fractures (8% of cases), compared with proximal and distal metaphyseal fractures (<2% each).[27] Several series report an appreciable incidence of compartment syndrome in patients with tibial plateau fractures,[28] and these fractures must also be considered in the high-risk category. In addition, ACS occurs in slightly more than half (53%) of patients with medial knee fracture-dislocations and 18% of patients with bicondylar tibial plateau fractures treated with knee-spanning external fixation.[29]

The indication for fasciotomy is the diagnosis of early or impending ACS, but ACS is an entity without a definitive diagnostic test. The clinical diagnosis of ACS is best made using specific clinical findings (**Box 1**). However, the published literature makes it clear that these clinical signs and symptoms are unreliable, whether they are present[3,30] or absent.[31,32]

Given the lack of diagnostic certainty assigned to clinical signs and symptoms,[3] it makes sense to use objective evidence to diagnose ACS and decide when fasciotomy is needed. Compartment pressure monitoring has been advocated since the 1970s,[4,33] but the literature has not been able to provide consensus recommendations on what pressure thresholds were best used for fasciotomy.[10] The use of a pressure threshold for fasciotomy that is based on muscle perfusion pressure rather than on an absolute value of muscle pressure is more relevant physiologically and more specific.[34] The perfusion pressure (also referred to as the delta P) is defined as the difference between the patient's diastolic blood pressure and the intracompartment pressure.

Box 1
Specific clinical signs and symptoms used to diagnose ACS

- Tenseness or firmness of the involved compartment.
- Motor weakness.
- Pain with passive stretch of the involved muscle.
- Increasing pain and pain that is out-of-proportion to that expected.
- Loss of sensation in a specific neuronal distribution for a given compartment (eg, the deep peroneal nerve for the anterior compartment of the leg).