

Acute Compartment Syndrome of the Lower Leg: A Review

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ABSTRACT

Acute compartment syndrome (ACS) of the lower leg is a time-sensitive orthopedic emergency that relies heavily on precise clinical findings. Late findings of ACS can lead to limb amputation, contractures, paralysis, multiorgan failure, and death. Hallmark symptoms of ACS include the 6 P's: pain, poikilothermia, pallor, paresthesia, pulselessness, and paralysis. Suspicion of ACS is confirmed by measurement of intracompartmental pressure of the affected compartment. The definitive treatment of ACS is timely fasciotomy. We review the pathophysiology, common causes, diagnosis, and treatment of this potentially devastating condition.

Keywords: acute compartment syndrome, delta pressure, intracompartmental pressure, orthopedic, Stryker

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Acute compartment syndrome (ACS) of the lower leg is a limb-threatening condition and a surgical emergency. Lower leg ACS is a condition in which increased pressure within a muscle compartment surrounded by a closed fascial space leads to a decline in tissue perfusion and compromises motor and sensory function.¹⁻³ In addition to muscle, key structures within the fascial compartment that are affected by increased compartment pressures include nerves and vasculature.¹ Importantly, a delay in diagnosis or treatment can result in irreversible damage to these components with devastating and permanent complications such as contractures, paralysis, amputation, sepsis with multiorgan failure, and even death.^{1,4,5}

The average annual overall incidence of ACS is 3.1 per 100,000 people, and it is higher in males than females.^{1,3,6} Fracture caused by trauma accounts for approximately 75% of ACS cases.³ Early recognition of ACS is critical and requires a high index of clinical suspicion based on a thorough knowledge of risk factors, pathophysiology, and clinical manifestations.^{1,7,8} In addition, accurate intracompartmental pressure (ICP) measurement and serial monitoring of changes in ICP levels within the muscle compartment are necessary to confirm ACS.⁹⁻¹¹ Lastly, prompt intervention and treatment with fasciotomy will ultimately prevent permanent

damage to the extremity. Despite this, ACS is one of the most highly litigated conditions in orthopedic surgery with awards as high as 14 million dollars for failure to diagnose and adequately manage ACS.^{2,8}

COMMON CAUSES OF ACS

The most common types of injury contributing to the development of ACS are trauma-related tibial shaft fracture (36%) followed by soft tissue injury (23%) and forearm fractures (> 9%).^{2,3,9} However, a variety of other etiologies, including non-traumatic causes, can contribute to ACS and are listed in [Table 1](#). There are atypical causes of ACS that non-orthopedic providers need to be cognizant of. Male patients are 10 times more impacted by ACS than females, and this may be explained by males having larger muscle mass within a fixed compartment.^{3,8,12} Younger patients (≤ 35 years of age) are also at a greater risk for ACS because they have a tighter fascia with larger muscle mass and they are prone to injuries or accidents.^{3,8,12}

PATHOPHYSIOLOGY

Although the pathophysiology of ACS remains unclear, a primary hypothesis behind the development of compartment syndrome is the arteriovenous pressure gradient theory.^{3,6} The arteriovenous pressure gradient principal proposes that ACS occurs

Table 1. Common Factors Contributing to Lower Leg Acute Compartment Syndrome^{1-3,6,8,9,14,15}

Orthopedic
Tibial fracture
Blunt or penetrating trauma
Total knee arthroplasty
Vascular
Reperfusion therapy
Arterial puncture or injury
Hemorrhage
Deep vein thrombosis
Soft tissue
Crush injury
Contusion
Burn
Envenomation (snake bite)
Iatrogenic
Drugs (anticoagulants)
Bleeding disorders (sickle cell)
Casts or splints
Constrictive dressings
Extravasation of drugs and fluids
Prolonged lithotomy positioning
Viral myositis
Diabetic muscle infarction

when blood flow does not meet the metabolic demands of affected tissues subsequently resulting in tissue ischemia. This leads to a series of events to ensue, including increased inflammation, arterial spasm, disrupted capillary flow, increased osmotic pressure, proteinaceous exudate, muscle fiber swelling, and edema.^{1,3,6,11} If not intervened upon, this cycle self-propagates and contributes to further increased ICP. Bleeding that may be present from an injury further contributes to the buildup of pressure within the compartment. Consequently, there is a continual rise in edema within the compartment enclosed in an inexpendable fascia, leading to tighter compartments and higher ICP. Eventually, when tissue and venous pressure compromises capillary perfusion, muscle and nerve ischemia ensues. If the

compartment is not surgically decompressed, the pressure-induced ischemia results in tissue and cellular necrosis and irreversible damage.^{1,3,6,11}

Anatomy of the Lower Leg

There are 4 compartments in the lower leg, and these include the anterior, lateral, superficial posterior, and deep posterior compartments (Figure 1 and Table 2).^{2,11,13} Each compartment contains specific nerves, arteries and veins, muscles, and bony structures that with injury contribute to the unique clinical presentations in ACS. Knowledge of the most important structures within these compartments is critical to efficiently assess and diagnose physiologic changes in ACS that contribute to pathologic development.^{2,3,8,9}

DIAGNOSIS

Diagnosis of ACS is based largely on physical examination and 6 cardinal clinical manifestations described as the 6 P's.^{1-3,6,8} The 6 P's include: 1) pain, 2) poikilothermia, 3) paresthesia, 4) paralysis, 5) pulselessness, and 6) pallor.^{1-3,8} The earliest indicator of developing ACS is severe pain. Pulselessness, paresthesia, and complete paralysis are found in the late stages of ACS. Additionally, serial measurement of ICP is critical in confirming and determining the progression of ACS.^{1-3,9} Accurate ICP measurement is especially important when assessing for ACS in patients who are incapacitated or unable to provide reliable answers. Vigilant monitoring of ICP is also critical in patients in whom epidural anesthesia is in use because motor and sensory symptoms of ACS can be easily masked.^{10,14,15}

Other diagnostic considerations including the use of ancillary testing such as laboratory testing or imaging are briefly discussed. Lastly, it is important to consider differential diagnoses while assessing for ACS including the possibilities of cellulitis, deep vein thrombosis, neuropraxia, or peripheral arterial injuries.¹⁶

The 6 P's

All characteristics of the 6 P's may not be present in individuals. Furthermore, presentation of these symptoms will vary depending on time that has lapsed since the initial pressure began to rise, the rate of ICP increase, blood pressure, and damage within the compartment.²

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