CHAPTER 21

Exercise-Induced Compartment Syndrome

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INTRODUCTION

There are many causes of lower extremity pain in the athlete. Whether dealing with a recreational runner or elite soccer player, it is important to remember the mentality of an athlete. Returning to the sport is commonly one of the patient's concerns, which makes accurate and timely diagnosis and treatment of the utmost importance. On average, there is a 22-month delay in proper diagnosis (1). Using clinical symptoms and diagnostic testing, a correct diagnosis of chronic compartment syndrome, also known as exercise-induced compartment syndrome (EICS), can be successfully achieved.

ETIOLOGY

Pain in the lower leg and foot can be caused by several conditions, such as stress fractures, medial tibial stress syndrome, nerve entrapment syndromes, and EICS (2,3). Recurrent muscle tightening, fullness, and aching in defined anatomic compartments are pathognomonic for EICS. Reports of pain that is worse with exercise and relieved by rest often occur over the course of months or even years (2). This clinical course is in contrast with the sudden presentation of symptoms seen in acute compartment syndrome. Multiple theories on the etiology of EICS exist, such as compromise of the microcirculation via venous return and decreased oxygen supply for muscle demand while exercising (1,3,4). External pressure from taping or bracing can play a role. Pain can also be caused from the buildup of metabolic waste products due to the decreased amount of oxygen, and exercise itself can be at fault as microtrauma to the muscle causes swelling and inflammation (2,5). It has been shown there can be an increase in muscle volume up to 20% with exercise (1).

Risk factors for EICS include anabolic steroid and creatine use, eccentric stretching, and abnormal biomechanics such as limb-length discrepancy, varus or valgus position of the lower extremity, and decreased endurance strength or flexibility (1,2,6). Diebal et al showed that forefoot running can actually alleviate the symptoms of EICS (7).

A total of 95% of EICS occurs in the anterior and lateral compartments of the leg (1). Unfortunately, 39-46% of those with EICS will have fascial herniations or defects (3). Brennan and Kane describe eccentric contraction as leading to herniation by decreasing fascial compliance in post-pubertal athletes (8). Overall, the mean age at diagnosis of EICS is 20 years with a relatively equal ratio of men and women affected (9).

DIAGNOSIS

While the vast majority of EICS occur in the anterior and lateral compartments of the leg, the other leg compartments as well as the compartments of the foot can certainly be affected. There are 5 compartments of the leg to potentially be affected: the anterior, lateral, superficial posterior, and deep compartments; and a fifth compartment that includes only the tibialis posterior muscle has also been described (3). Patients typically describe a specific time, distance, or intensity of exercise that elicits the pain (1). First, an aching sensation is present, which then progresses to muscle fullness and eventually numbness and weakness (6). Muscle tenderness is typically seen in the middle of the muscle in comparison to on the bone (10).

Different forms of exercise may produce slightly different symptoms. Moeyersoons et al described gnawing pain and weakness in runners with a history of symptoms for 1 year or more. Cyclists were described as having symptoms days after an intense ride or during bursts of speed. Soccer players commonly complain of intermittent pain during games or intense activity, which necessitates periods of rest before returning to the game (9).

Nerve damage with EICS begins at 4 hours of increased pressure (5). The location of numbness follows a distribution that allows the physician to easily determine which compartment is affected. After exercise, the athlete should be examined for tenderness on palpation, pain with passive ankle dorsiflexion, and firmness of the involved lower extremity compartments (1). In comparison to acute compartment syndrome where there are clinical signs such as pain, pallor, paresthesias, pulselessness, and paralysis, EICS patients may not have the same experience. Diagnosis by either a wick or slit catheter is the gold standard (5,11) (Figure 1).

Following the criteria from Pedowitz et al, there are 3 measurements and associated pressures to diagnose chronic

Table 1. Compartment pressures as diagnostic criteria for CECS

Pre-exercise	≥15 mm Hg
1 min post-exercise	≥30 mm Hg
5 min post-exercise	≥20 mm Hg

Classically, 1 or more of the pressure criteria must be met to make the diagnosis; ideally, all the criteria should be present. (adapted from Ref. 11)

compartment syndrome: compartment pressure ≥15 mm Hg prior to exercise, compartment pressure ≥30 mm Hg 1 minute post-exercise, and compartment pressure ≥20 mm Hg 5 minutes post-exercise (11). Shubert describes borderline CECS if the pressure fails to return to a resting level after 15 minutes of exercise (6). Certain considerations for accurate catheter measurement, such as anatomic placement and depth of the catheter, should be kept in mind. The lower extremity should also be as relaxed as possible when measuring compartment pressure (3). Other testing may be useful to determine whether the condition is truly EICS. Infrared spectroscopy determines the oxygen content in the blood and could be used as an additional test. A bone scan may be helpful in differentiating EICS from a stress fracture or shin splints. Electromyography would be useful as well to rule out a nerve entrapment syndrome (1).

TREATMENT

Like many other conditions, conservative treatment is always tried initially. For EICS, relief with modalities such as alternative exercises, orthotics, and nonsteroidal anti-inflammatory drugs is attempted (2,3). It has been recommended to attempt an initial 6-8 weeks of conservative treatment (6). Discontinuing the inciting exercise entirely may be indicated in severe cases (1). In competitive and elite athletes, surgical intervention by fasciotomy is often initially sought out. Fasciotomy is certainly the most definitive treatment and can be performed in multiple ways. In an open fasciotomy, visualization of the affected compartment is readily available. Complications vary from 11-13% and include infection, nerve damage, hematoma formation, and vascular injury. Subcutaneous endoscopic fasciotomies work through smaller incisions, however, they carry the disadvantages of increased complications and possibility for reoccurrence of compartment syndrome (1,14). Minimally invasive fasciotomies and partial fasciectomies, where a portion of fascia is removed, can also be used (6).

It has been shown that EICS can become acute compartment syndrome if there was inadequate release of the compartment pressure during the fasciotomy (10,12). Speaking anatomically, fasciotomy for the anterior and lateral leg compartments should be performed over the anterolateral aspect of the middle of the leg. Posterior leg compartment fasciotomy should be performed as an extension of the dissection with a lateral approach or via a separate posterior incision (3). Postoperatively, compressive dressings should be applied for the first few days with both range of motion and weight-bearing exercises to be initiated. Return to activity ranges from 6-8 weeks (1). Fronek et al found a reduction in pain in 92% of the patients following fasciotomy (12). Fraipoint et al showed improvement in 81-100% of patients and low reoccurrence of symptoms (3). Shubert separates the improvement of symptomatic relief by compartments with the anterior and lateral compartments showing 80-100% relief and posterior compartments showing 50-65% relief (6).

CASE STUDIES

Cetinus et al described a 20-year-old male football player with an 18-month history of lower leg tightness that was elicited with running. Initially the pain was produced at the 30-minute mark, however, with time the pain started to be produced 10 minutes into the run. No pain was elicited with rest. Following exercise, the posterior medial aspect of the leg was noted to be tense and pain was noted with passive ankle dorsiflexion. Conservative modalities of massage and anti-inflammatory medications were tried initially. The standard technique for measuring compartment pressure was performed 15 minutes before and after running on a treadmill. After failed conservative treatment and persistent pain, superficial and deep leg compartment fasciotomies were performed. Six weeks after the procedure, the patient was able to run. At 3 months, he resumed playing football (2).

Parise et al discussed EICS in a 21-year-old female soccer and lacrosse player. She described numbness, tingling, cramping, and weakness in the arches of her feet bilaterally for the past 6 years. Six to 8 weeks of physical therapy with her athletic trainer was prescribed without relief. Following the above-mentioned criteria for compartment pressure testing, she was diagnosed with EICS and underwent surgery with a plantar medial approach. One year later, she again developed compartment syndrome where surgical release of all plantar compartments was performed. Two years later, compartment syndrome of bilateral legs occurred, and surgical intervention was once again performed. Roberts et al found in their study that those with compartment syndrome were more likely to be of shorter height and have longer strides, which places a greater demand on the anterior leg muscles. In all 3 instances, bilateral involvement was seen, which is a common presentation of EICS (9,13). Botox injections into the anterior and lateral compartments were done in a study by Horobeti et al. Their results showed reduced compartment pressure and pain over an average of 9 months (15).

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