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**Clinical  
Reviews**

## COMPARTMENT PRESSURE MEASUREMENTS HAVE POOR SPECIFICITY FOR COMPARTMENT SYNDROME IN THE TRAUMATIZED LIMB

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□ **Abstract—Background:** Osseofascial compartment syndrome is defined by ischemic necrosis of muscle caused by elevated pressure within fascial compartments. The diagnosis can be made either clinically or through compartment pressure measurements. Compartment pressure above 30 mm Hg was traditionally used as the threshold for diagnosis of compartment syndrome, but was challenged due to a high number of false-positive results. Perfusion pressure (diastolic blood pressure – compartment pressure) <30 mm Hg came to be promoted as a confirmatory diagnostic test. **Objective:** The objective of this article is to review the specificity of perfusion pressure for compartment syndrome in the acutely traumatized limb. **Discussion:** Perfusion pressure has been shown to generate false-positive results in 18–84% of patients with tibial fractures. Two studies showed that not a single patient with measurements qualifying for fasciotomy actually needed the procedure. **Conclusion:** Both absolute compartment pressure and tissue perfusion pressure generate a high rate of false-positive results in the acutely traumatized limb. An alternative diagnostic test or process is needed to prevent overtreatment. In the meantime, emergency medicine and orthopedic surgery textbooks and guidelines should promote awareness of the limitations of the test. © 2013 Elsevier Inc.

□ **Keywords—**compartment syndrome; physical examination; manometry; fasciotomy; diagnosis; unnecessary surgery

### INTRODUCTION

The osseofascial compartment, designed for strength, is inelastic and does not deform to accommodate severe swelling. The two most common conditions that cause such swelling are fractures (69%) and soft-tissue injury (23%) (1). Beyond a certain pressure, microvascular blood flow is compromised, defining the onset of acute limb compartment syndrome, or osseofascial compartment syndrome. The process is consummated in ischemic necrosis of the enclosed muscles. Necrotic muscle heals with scar tissue, forming myotendinous adhesions and contractures (2). The process can be averted before full infarction occurs by cutting through the fascia and releasing the swollen and ischemic muscles, allowing blood flow to resume.

This procedure, called fasciotomy, is not benign. Complications of fasciotomy include 77% altered sensation at the wound margins, 25% swollen limbs, 26% tethered scars, 13% recurrent ulceration, 13% muscle herniation, and 7% tethered tendons. It causes 23% of patients to keep their limb covered, 28% to change hobbies, and 12% to change jobs (3).

Both underdiagnosis and overdiagnosis will cause significant patient harm. Therefore, the diagnostic process needs to have excellent sensitivity and specificity. Although the ischemic contractures of compartment

syndrome were described as early as the 1880s, and its prevention with fasciotomy was shown to be effective in 1926, it wasn't until the mid-1970s that an objective confirmatory test for compartment syndrome came to be proposed and widely adopted (4–7). Compartment pressure measurement quickly became the accepted confirmatory test for this disease. Early studies that led to its widespread use were uncontrolled (8). Therefore, its specificity was unknown.

In the late 1980s and early 1990s, absolute compartment pressure measurements were challenged as leading to an unacceptably high rate of false positives (9,10). In the mid-1990s, the decades-old Whiteside technique of measuring compartment perfusion pressure (diastolic blood pressure – compartment pressure) started to be more widely advocated as a more accurate technique (7,11). Thought to reflect the ability of diastolic blood flow to overcome tissue resistance and supply perfusion to the limb, it is referred to as delta P, differential pressure, or critical pressure (7,12–14). In a 1996 study on a post-operative population, it was shown that the use of absolute pressure elevations would qualify 43% of patients with tibial fractures for fasciotomy, but that using mean perfusion pressure for the first and second 12 h after surgery brought the actual fasciotomy rate down to 2.6% (13). Despite excellent outcomes, this study was criticized for having a 12-h mean time of observation in a condition where traditional teaching calls this a time-dependent diagnosis (15).

Current emergency medicine practices are largely extrapolated from the orthopedic literature (largely on post-operative patients with tibial fractures) and applied to the larger heterogeneous pool of Emergency Department (ED) patients with suspected compartment syndrome. Although emergency medicine textbooks acknowledge controversy over thresholds for surgery, they promote traditional thresholds: [the] “mainstay of treatment is fasciotomy, particularly for compartment pressures >30–40 mm Hg” (16). A similar rule is stated in another text: “Pressures exceeding 30 mm Hg or within 30 mm Hg of the patient’s mean arterial pressure are an indication for fasciotomy” (17). Neither of these texts comment on the potential for false positives and non-therapeutic fasciotomy. One text states “equivocal measurements still require clinical judgment,” but fails to state that all measurements require such judgment (18). Practitioners are urged to “have a very low threshold for measuring pressures within a muscle compartment,” and that “the key to early detection of compartment syndrome is a high index of clinical suspicion” (19,20). The reader comes away with a sense of the need to check pressures in low- to moderate-risk patients and to have the orthopedic surgeon perform fasciotomy for absolute pressure readings above 30 mm Hg and perfusion pressure measurements below 30 mm Hg.

The body of this article presents the accumulating evidence that not only absolute compartment pressure, but now even the use of perfusion pressure in the acutely traumatized limb is known to have poor specificity. It generates an unacceptably high rate of false-positive results in low- to moderate-risk patients. The article urges emergency medicine textbooks to reveal the critical limitations of this diagnostic test, and calls for practicing Emergency Physicians to exercise restraint in the use of this test.

## DISCUSSION

### *Compartment Pressure Measurement*

As alluded to earlier, using an absolute compartment pressure of >30 mm Hg as the indication for fasciotomy was challenged in the 1980s and 1990s for poor specificity, and using perfusion pressure of <30 was advised (9,10,13). In the past decade, several studies have emerged challenging perfusion pressure as well. A 2001 article, a portion of whose title was “Beware of overtreatment!”, reported on 95 patients with tibial fractures and warned “if we had decompressed all legs with a [perfusion pressure] under 30 mm Hg ... 45.4% of them would have been fasciotomized” (15). Instead, they used surgical judgment as the confirmatory test. Switching the gold standard from perfusion pressure to the surgeon’s clinical judgment avoided 28 fasciotomies in 97 limbs (95 patients). All patients had 1-year follow-up and none developed sequelae of compartment syndrome. The authors estimated the specificity of perfusion pressure <30 as 65% for compartment syndrome. This poor specificity occurred despite the unblinded use of perfusion pressure to help decide surgery, which biases toward defining the test as accurate and inflates the apparent specificity. The actual specificity may have been even lower.

The only randomized controlled trial of compartment pressure monitoring compared to clinical examination found that pressure monitoring would have qualified 18% of patients for a fasciotomy (using perfusion pressure <30) (21). The study population was post-operative patients with tibial fracture. Because none of the 18% of patients with low perfusion pressure had clinical signs of compartment syndrome, none received fasciotomy, and none of these patients experienced sequelae of compartment syndrome. Not a single patient whose perfusion pressure indicated fasciotomy actually needed the procedure.

A study of surgeon behavior showed that although some surgeons have low fasciotomy rates of 2%, others have rates of 24%, with the difference correlating with how frequently they checked compartment pressure

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