

Compartment Syndrome of the Hand



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KEYWORDS

• Compartment syndrome • Hand • Upper extremity • Hand surgery

KEY POINTS

- Many etiologies can create increased compartmental pressure, which causes capillary bed collapse, decreased tissue perfusion, and cell death.
- Examination findings of disproportionate pain, hand swelling, intrinsic minus posturing, and intracompartmental pressure monitoring aid in the diagnosis.
- Early recognition and compartment release can minimize functional loss.
- Emergency fasciotomy is the definitive treatment for hand compartment syndrome.

INTRODUCTION

Hand compartment syndrome is a relatively uncommon condition, with many etiologies, and if not diagnosed and managed expeditiously, results in significant functional morbidity. Early recognition is crucial to initiating timely treatment and minimizing functional loss. There are numerous etiologies of compartment syndrome including trauma, insect bites, high-pressure injection, infection, contrast infusion, and crush injuries^{1–12} (**Box 1**).

Pathophysiology

Although underlying causes vary, the final common pathophysiologic pathway of compartment syndrome is increased compartmental content resulting in increased interstitial fluid pressure, which causes capillary bed collapse, decreased tissue perfusion, and cell death.¹³ A vicious cycle occurs where increased intracompartmental pressure leads to decreased tissue perfusion, increased capillary permeability, and, in turn, interstitial fluid leaks into the compartment, amplifying intracompartmental pressure, and so on. The magnitude and duration of the compartmental pressure influences tissue viability (**Fig. 1**).

Nerve axonal transport slows with a pressure of 30 mm Hg.¹⁴ Nerve conduction disturbance can occur with pressures within 30 mm Hg below the diastolic blood pressure, with conduction stopping at 50 mm Hg.^{15–18} Gelberman and colleagues¹⁷ discussed both motor and sensory responses of nerves were completely blocked at a threshold of 50 mm Hg. The critical pressure threshold found in the canine model for ischemic muscle necrosis was 20 mm Hg less than the diastolic blood pressure.¹⁹ In human subjects, the progression of neuromuscular deterioration (with compartment pressure of 35–40 mm Hg less than diastolic blood pressure) was, in order: gradual loss of sensation, subjective complaints of pain, reduced nerve conduction velocity, decreased muscle action potential amplitude, and motor weakness.¹⁸

Reversible muscle damage occurs after 4 hours of compression and it becomes irreversible by 8 hours.²⁰

The normal compartment pressures can vary between individuals with normal interstitial fluid pressures between 0 and 25.2 mm Hg.^{21–23} In canine studies,^{15,24} ischemia and abnormal metabolism occurs with pressures within 20¹⁵ to 30²⁴ mm Hg of diastolic blood pressure. When tissue pressures reach this threshold,

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Box 1 Compartment syndrome etiologies

Trauma
Fractures
Crush injuries
Prolonged limb compression
Direct muscular contusion
Burns
Electric
Thermal
Muscle overuse
Exercise
Tetany
Seizures
Constrictive cast or bandages prolonged traction
High pressure injection
Infiltrated intravenous line/infusions
Infection
Abscess
Necrotizing fasciitis
Reperfusion injury
Bleeding
Hypercoagulable state
Vascular injury
Bite
Crotalid envenomation (snakes)
Insect (spider, scorpion, etc)
Suction

extraluminal pressure will cause vascular collapse and tissue hypoxia.^{13,25} Whitesides and associates²⁶ discussed the experimental and clinical techniques of measuring tissue

pressures within a closed compartment, and noted that inadequate perfusion and relative ischemia was found if the compartment pressure was within 30 mm Hg of the patient's diastolic blood pressure. Most authors agree and recommend releasing compartments when compartment pressures are within 30 mm Hg of the diastolic pressure when subjective and physical examination signs are unreliable.^{15,26–29}

Anatomy

Compartments are defined as enclosed myofascial spaces bound by thicker connective tissues or bones.^{5,13,25} The myofascial spaces in the hand are the hypothenar, thenar, adductor, carpal canal, finger, and 4 interosseous compartments.^{30,31} The hand itself in cross-section can be divided into 10 compartments (Fig. 2).

The thenar compartment consists of the abductor pollicis brevis, opponens pollicis, and flexor pollicis brevis innervated by the recurrent median nerve with some contributions from the ulnar nerve. The abductor digiti minimi, flexor digiti minimi, and opponens digiti minimi comprise the hypothenar muscles, innervated by the ulnar nerve. The adductor compartment consists of the adductor pollicis between the volar interossei and the lumbricals on the radial side of the hand. There are 4 dorsal and 3 volar interosseous muscles that have been identified as each distinct compartments that can show variations³¹ whose physiologic relevance must be confirmed clinically.^{5,32} Ling and Kumar³³ postulate that the overlying skin can serve as a constrictive layer in addition to thicker fascial compartments that contributes to increased intracompartmental pressures. The carpal canal, although not a separate muscular compartment, is a defined space that with swelling or fracture can present with median nerve compression and acute carpal tunnel

Compartment Syndrome Pathophysiology

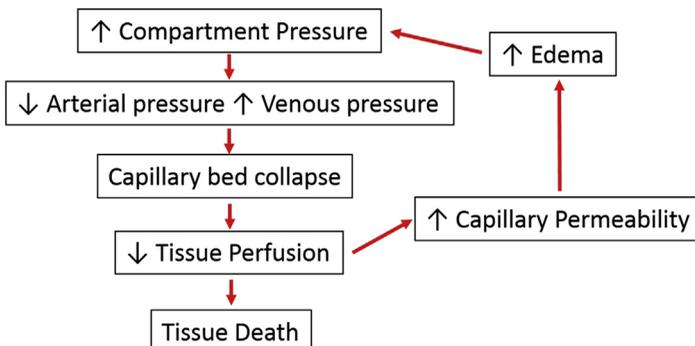


Fig. 1. Compartment syndrome pathophysiology. ↓, decreased; ↑, increased.

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