

# Forearm Compartment Syndrome

## Evaluation and Management



Justin M. Kistler, MD<sup>a,\*</sup>, Asif M. Ilyas, MD<sup>b</sup>,  
Joseph J. Thoder, MD<sup>a</sup>

### KEYWORDS

• Compartment syndrome • Forearm trauma • Volkmann • Upper extremity trauma • Fasciotomy

### KEY POINTS

- Compartment syndrome is largely a clinical diagnosis and requires a careful history and physical examination.
- Compartment syndrome hallmarks have been the 5 Ps: pain out of proportion, pallor, paresthesias, paralysis, and pulselessness. Pain out of proportion and pain with passive stretching of the fingers are considered the first and most sensitive signs of compartment syndrome in an awake patient.
- In an obtunded patient, a compartment pressure measurement within 30 mm Hg of the diastolic blood pressure and/or an absolute pressure greater than 30 mm Hg is considered diagnostic for compartment syndrome.
- Adequate decompression of the forearm requires fascial release of both the dorsal and volar compartments, with the volar compartment best released from the carpal tunnel distally to across the lacertus fibrosus proximally.
- Fasciotomy wounds must be assessed every 48 hours to 72 hours and additional soft tissue coverage procedures for wound closure are common.

### INTRODUCTION

Compartment syndrome of the forearm is an uncommon but well recognized diagnosis that can lead to significant morbidity and mortality if not diagnosed and treated early in the clinical course. Compartment syndrome is an increase in pressure within fascial compartments that can lead to decreased tissue perfusion. Compartment syndrome of the forearm typically presents with swelling of the forearm and patients complain of pain and difficulty with hand and wrist motion, particularly with passive motion. It may also be

accompanied with paresthesias of the hand depending on the clinical course. The compartment syndrome may or may not be preceded by fracture or traumatic injury.

There are a variety of causes, both traumatic and nontraumatic, that can lead to forearm compartment syndrome, which can make the diagnosis and clinical decision-making process extremely complex. One of the most common causes reported are fractures of the forearm, including both diaphyseal forearm fractures and fractures of the distal radius.<sup>1</sup> Elliot and Johnstone<sup>2</sup> reported that 18% of all forearm

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<sup>a</sup> Department of Orthopedic Surgery and Sports Medicine, Temple University, 3401 N. Broad Street, 5th Floor Boyer Pavilion, Philadelphia, PA 19104, USA; <sup>b</sup> Department of Orthopedic Surgery, Rothman Institute at Thomas Jefferson University, 925 Chestnut, Philadelphia, PA 19107, USA

\* Corresponding author.

E-mail address: [Justin.kistler2@tuhs.temple.edu](mailto:Justin.kistler2@tuhs.temple.edu)

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compartment syndromes were caused by fractures of the forearm. In contrast, it was reported that only 23% of all forearm compartment syndromes are caused by some form of soft tissue trauma not involving fractures. There are more unusual causes of forearm compartment syndrome, including reperfusion injury, angioplasty or angiography, intravenous line extravasations, injection of illicit drugs, coagulopathies or bleeding disorders, hematoma in patients treated with anticoagulants, and even insect bites.<sup>1,3-11</sup>

The diagnosis of compartment syndrome is predominantly clinical, but several techniques have been described and studied. Yet, controversy persists on the best diagnostic techniques. Regardless, timely diagnosis and subsequent treatment are needed to avoid its sequelae. The purposes of this article are to review the history and nature of forearm compartment syndrome, review the pertinent anatomy, describe the potential etiologies, and review the pathophysiology, treatment strategies, and potential outcomes and complications.

## HISTORY

Volkman is credited with the original description of compartment syndrome in 1881.<sup>12</sup> He attributed the end result of myonecrosis to splints that led to diminished arterial inflow, which ultimately led to muscle ischemia and cell death. Hildebrand, in 1890, is credited with first using the term *Volkman contracture*, described later. The first myofascial release for impending compartment syndrome was described in 1890 by Bardenhauer.<sup>13</sup> Sixty years after the first description of compartment syndrome by Volkman, in 1940, Griffiths described arterial injury and reflex spasm of the collateral vessels as the source of muscle ischemia. He also minimized the role of tight dressings and splints as the cause of diminished arterial inflow.<sup>13,14</sup> Also described in Griffiths' original work are what is now known as the 5 Ps of compartment syndrome: pain, pallor, paresthesias, paralysis, and eventually pulselessness.

Since the 1970s, understanding of the basic science and pathophysiology of compartment syndrome has considerably increased. Rorabeck and Clarke<sup>15</sup> recognized that there was not only damage to muscles due to compartment syndrome but also that associated nerves traversing the compartment also had the potential to be damaged. They showed that if compartmental release was performed within 4 hours of onset that nerve conduction velocity always returned to normal regardless of the amount of pressure applied or the length of time the pressure was

applied. If the release was performed after 12 hours, however, then nerve conduction velocity did not return to normal at any pressure or time condition, demonstrating the possibility of irreversible nerve damage if compartment syndrome is not diagnosed and treated early.

Experimental studies by Whitesides and colleagues<sup>16</sup> focused on muscle damage and introduced the concept of measuring tissue pressures to identify the need for fasciotomy in suspected compartment syndrome. They showed that after 4 hours of muscle ischemia less than 5% of muscle cells were damaged; however, if ischemia time was prolonged to 8 hours then nearly 100% of muscles were damaged.<sup>14</sup> Whitesides and colleagues<sup>16</sup> described inadequate perfusion of muscle cells when the tissue pressure within a closed compartment rose to within 10 to 30 mm Hg of the diastolic blood pressure.

## ETIOLOGY

There are a variety of causes of forearm compartment syndrome reported in the literature. Fractures of the forearm and fractures of the distal radius are the most common causes of forearm compartment syndrome (Fig. 1).<sup>1</sup> There is no difference in reported compartment syndrome occurrences between open and closed fractures of the forearm.<sup>17</sup> Other causes, such as burns, crush injuries, penetrating trauma, constrictive dressings or casts, infections, bleeding disorders, extravasation of drugs or intravenous fluids, reperfusion injury, and arterial injury, have all been reported.<sup>18</sup> The wide variety of reported causes necessitates a thorough history and physical examination by the treating surgeon, which can be particularly difficult in polytraumatized patients with distracting injuries or patients who are obtunded. The obtunded patient with a potential forearm compartment syndrome poses a particularly difficult challenge. These patients may also include the "found down" population, who come in obtunded with no history; therefore, the onset and duration of symptoms is most often unknown unless a friend or family member accompanies them.

## PATHOPHYSIOLOGY

Compartment syndrome is defined as a condition in which a closed osseofascial compartment's pressure increases to such an extent that there is a compromise of the microcirculation to that compartment leading to tissue damage.<sup>19</sup> Tissue perfusion is proportional to the difference between capillary perfusion pressure and the interstitial fluid pressure. The normal resting pressure in the adult

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