Management of Forearm Compartment Syndrome

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KEYWORDS

- Volkmann's ischemic contracture • Fasciotomy • Surgical techniques • Forearm
- Compartment syndrome

KEY POINTS

- Forearm compartment syndrome is a potentially calamitous problem that can befall persons with either injuries or external compression of the forearm.
- The absolute necessities for a good outcome are early suspicion of forearm compartment syndrome and expeditious surgical intervention.
- One must be acutely aware of the prospect of compartment syndrome in the settings of forearm diaphysis and distal radius fractures.
- Delays in diagnosis and surgical intervention can lead to ischemic contracture of the forearm that can be manifested in varying degrees but ultimately can lead to greatly diminished function of the affected upper extremity.

Forearm compartment syndrome is an entity that has been noted with a variety of injuries, external compression, and other etiologies, and if left untreated can lead to devastating complications. The final state of these complications has been traditionally given the eponym of Volkmann's ischemic contracture, and can have varying degrees of severity.[1–3] Many authors have reported a variety of etiologies for forearm compartment syndrome ranging from the common to the unusual. Some of the more relatively frequent causes of forearm compartment syndrome include supracondylar humerus fractures in pediatric patients as well as distal radius fractures in adult and pediatric patients.[4–6] Other authors have reported more unusual etiologies including complicated Bier blocks, malfunctioning pneumatic tourniquets with elective hand surgery, spider bites, industrial vacuum accidents, ring avulsions, a variety of intravenous line extravasations, injection of illicit drugs, hematomas as a result of anticoagulation, inadvertent administration of intravenous hypertonic

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saline, infections, and snake bites.[5,7–22] Although it is difficult to determine the true incidence of forearm compartment syndrome as well as the mechanisms that are most likely to cause it, many surgeons agree that fractures of the forearm and the distal radius are responsible for a large number of forearm compartment syndromes. In one report it was estimated that 18% of all compartment syndromes, including both upper and lower extremities, are caused by forearm fractures.[4] In analyzing the epidemiology of pediatric forearm compartment syndrome, Grottkau and colleagues[5] used a review of a national trauma database to determine that the incidence of forearm compartment syndromes was just over 1% in the setting of pediatric upper extremity fractures, and more frequent in open fractures than in closed fractures. In an excellent review of compartment syndromes of both the upper and lower extremities, McQueen and colleagues,[6] attempted to quantify the number and incidence of forearm compartment syndromes. This series comprised 164 patients with compartment syndrome of all types. For classification purposes, patients were given the diagnosis of compartment syndrome when the pressure differential between the diastolic blood pressure and that of the affected tissue was less than 30 mm Hg. The second most common fracture in their series was that of the distal radius. Overall, they treated just over 6000 distal radius fractures during the time encompassed by this review, leading them to determine that the incidence of compartment syndrome with distal radius fractures was 0.25%. Also during this time they treated 13 patients with diaphyseal fractures of the forearm who had compartment syndrome. There were a total of 422 patients with this type of fracture, giving an incidence of 3.1% for forearm compartment syndrome in the setting of diaphyseal forearm fracture. The vast majority of patients with upper extremity compartment syndrome in their series were under 35 years of age. Furthermore, the difference in incidence of compartment syndrome in patients under 35 years old and those over 35 years old was significant. Based on their results, they recommended monitoring of forearm compartment pressures in patients who are under 35 years of age, and who have had high-energy fractures of the forearm diaphysis or distal radius.

PATHOPHYSIOLOGY

The most popular theory regarding the pathophysiology of compartment syndrome, including that of the forearm, is the arteriovenous pressure gradient differential theory.[23–25] This theory postulates that as the compartment pressure rises, intraluminal venous pressure also rises leading to a reduction in the arteriovenous pressure gradient. Because of the lack of musculature in the venule wall media, only a relatively small rise in pressure is required to collapse the venule walls. The diminishment of hydrostatic gradient causes reduced local perfusion. The reduced venous drainage seen with increasing compartment pressure causes a rise in the interstitial pressure with formation of tissue edema. This edema, combined with the collapse of forearm lymphatic vessels as a result of the rising pressure, helps contribute to increasing tissue pressure, thus perpetually repeating the cascade of events described above, at least until decompression is performed (**Fig. 1**).[4]

There have been animal studies that attempt to further clarify the pathophysiology of compartment syndrome. One was that of a mouse model with an induced closed soft tissue injury.[26] This group's analysis of the microcirculation following closed soft tissue injury seems to lend credence to the arteriovenous pressure gradient theory, and they further state that leukocyte endothelial cell interaction contributes to this positive feedback cycle in that intravascular leakage and edema formation further serve to cause tissue damage. Although this experimental method did not induce compartment syndromes per se in the mouse model, the mechanics of the