

Compartment Syndrome After Radial Artery Catheterization

A review of the literature.

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Radial artery catheterization continues to gain increasing popularity due to a lower risk of bleeding and vascular complications as compared with the transfemoral approach.¹ Compartment syndrome of the forearm or hand as a complication of radial artery catheterization has been reported.²⁻¹¹ Despite its rare occurrence, with a reported incidence ranging between 0.004% and 0.13%,^{3,5,7,8,10} sufficient knowledge of this condition is critical for early recognition to prevent potentially devastating outcomes, which include neurologic dysfunction and Volkmann contracture.

PATHOPHYSIOLOGY

Compartment syndrome occurs when a rise in pressure within a limited space results in compromised tissue perfusion and viability.³ Anatomically, the forearm is divided by fascia into three compartments, whereas the hand is divided into 10 compartments. The most widely accepted theory regarding development of compartment syndrome is the arteriovenous pressure gradient theory.¹² As initially described by Matsen et al,¹³ the increase in local tissue pressure leads to collapse of the thin-walled venules. The pressure head from the arterial side of the circulation results in a progressive rise in intraluminal venous pressure causing them to reopen but only to drain at a higher pressure, thus reducing the arteriovenous pressure gradient and compromising capillary flow. If this cycle continues, metabolic demands of the tissue can no longer be met, and ischemia ensues. In addition, there is progressive buildup of edema as well as collapse of lymphatic vessels, leading to a further increase in pressure and perpetuating the cascade of events.^{14,15}

ETIOLOGY

Any cause of increased volume within a nonexpandable compartment, such as bleeding, edema, or extraneous fluids, can result in compartment syndrome. After radial artery catheterization, bleeding can occur at the access site due to inadequate compression or, more proximally, as a result of side branch perforation from wire-induced injury (particularly if hydrophilic).³ Radial artery laceration can also occur during sheath insertion or removal in the setting of severe radial artery vasospasm.³ Predictors of hematoma formation in patients undergoing radial artery catheterization have been previously identified, and include female sex, smaller patient size, creatinine clearance < 60 mL/min, procedure duration, and sheath size.⁹ There have been case reports of compartment syndrome developing in the forearm after radial artery catheterization with little or no evidence of hematoma.^{4,9} In these cases, the authors hypothesized that arterial spasm induced by the radial sheath or catheter resulted in ischemia of the forearm muscles and subsequent tissue edema. Another potential cause for compartment syndrome in patients undergoing cardiac catheterization is intravenous infiltration of medications or even saline solution through a misplaced intravenous catheter.^{16,17}

CLINICAL PRESENTATION AND DIAGNOSIS

Diagnosis of compartment syndrome of the forearm and hand is primarily clinical. Thus, maintaining a high index of suspicion is essential to establish an early diagnosis. The five Ps (pain, pallor, pulselessness, paralysis, and paresthesia) have been historically taught as the classic hallmarks of compartment syndrome. However, most of these symptoms occur late in the

COMPARTMENT SYNDROME AT A GLANCE

Incidence	0.004%–0.13%
Etiology	<ul style="list-style-type: none"> • Bleeding (inadequate compression, wire-induced side branch arterial injury and radial artery laceration during sheath insertion/removal in the setting of severe vasospasm) • Swelling secondary to vasospasm-induced muscle ischemia • Intravenous infiltration
Signs and symptoms	<ul style="list-style-type: none"> • Early: tense swelling, pain aggravated by passive stretching • Late: paresthesia, paralysis, and pulselessness • Long term: Volkmann contracture
Diagnosis	Clinical signs and symptoms, intracompartmental pressure measurement
Management	<p>When forearm bleeding is suspected:</p> <ul style="list-style-type: none"> • Manual pressure • Inflation of blood pressure cuff to 15 mm Hg < systolic blood pressure for two 15-minute periods • Management of elevated blood pressure including with analgesia • Discontinuation of glycoprotein IIb/IIIa inhibitors • Partial reversal of heparin with protamine <p>If conservative measures fail or if diagnosis of compartment syndrome is established:</p> <ul style="list-style-type: none"> • Urgent surgical consultation

course of the disease, and outcomes are poor in this stage even if fasciotomy is performed.¹⁸ Patients with compartment syndrome experience tense swelling of the involved compartment. Pain that is aggravated by passive stretching of the affected muscles is the most sensitive and earliest clinical finding.¹⁹ If left untreated, evolution into a paralysis, dysesthesia, and loss of pulse eventually occurs. In the long term, an array of disabilities can develop, ranging from a slight contracture and loss of sensitivity of the first three fingers to a complete contracture and disability of the hand and wrist (Volkmann contracture).³ Although the diagnosis is mostly clinical, measurement of intracompartmental pressure (normal, up to 9 mm Hg) can be useful, particularly in deciding the timing of surgical fasciotomy. An absolute pressure of > 30 mm Hg, or a difference of ≤ 20 mm Hg between the diastolic blood pressure and the intracompartmental pressure have been suggested as indicators for requiring emergent fasciotomy.^{18,19}

MANAGEMENT

If pain, swelling, or induration develops in the hand or in the forearm after radial artery catheterization, bleeding into the forearm should be suspected. Initial conservative measures to prevent progression into

compartment syndrome include applying manual pressure to control bleeding and assessing for possible infiltrated intravenous lines. When manual pressure is inadequate, inflating a blood pressure cuff at the site of induration to 15 mm Hg below the systolic blood pressure for 15 minutes has been suggested. Cuff pressure can be subsequently adjusted to maintain arterial flow using an oximeter probe. Management of elevated blood pressure, pain control, discontinuation of glycoprotein IIb/IIIa inhibitors, and partial reversal of heparin are all additional important steps to consider. If symptoms persist and progression to compartment syndrome is suspected, urgent surgical consultation should be sought.³

CONCLUSION

With the increasing number of radial artery catheterization procedures, one must be diligent in recognizing potentially disabling, albeit rare, complications, such as compartment syndrome. ■

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