

# Compartment Syndrome of the Hand:

## A Rare Sequela of Transradial Cardiac Catheterization

Jennifer Jue, MD  
Joseph A. Karam, MD  
Alfonso Mejia, MD, MPH  
Adhir Shroff, MD, MPH

A 64-year-old man who underwent percutaneous coronary intervention via right radial artery access reported right-hand pain and swelling 2 hours after the procedure. He had developed compartment syndrome of the hand, specifically with muscular compromise of the thenar compartment but with no involvement of the forearm. He underwent emergency right-hand compartment release and carpal tunnel release, followed by an uneventful postoperative course. In addition to our patient's case, we discuss compartment syndrome of the hand and related issues. (*Tex Heart Inst J* 2017;44(1):73-6)

**T**he transradial approach to percutaneous coronary intervention (PCI) has lower rates of bleeding and vascular sequelae than does the femoral approach.<sup>1</sup> Compartment syndrome of the forearm is a rare vascular sequela associated with radial access. We describe an unusual case of compartment syndrome of the hand without involvement of the forearm.

### Case Report

In September 2015, a 64-year-old, right-handed man with a medical history of hypertension and end-stage renal disease (on hemodialysis) presented for elective outpatient cardiac catheterization. He had a systolic blood pressure (BP) of 190 mmHg. The patient's body mass index was 17.6 kg/m<sup>2</sup> (weight, 52 kg; height, 1.7 m). He had fair cardiac functional capacity and normal left ventricular function (ejection fraction, 0.55) on echocardiography.

**Key words:** Cardiac catheterization/methods; compartment syndromes/diagnosis/etiology/prevention & control/surgery; fascia/surgery; hand/surgery; percutaneous coronary intervention/adverse effects; postoperative complications; radial artery/physiopathology; transradial access; treatment outcome

The patient's preprocedural laboratory values included an international normalized ratio of 1.0, a prothrombin time of 10.9 s, a baseline hemoglobin level of 9.1 g/dL, and a platelet count of 202,000/μL. He was given 325 mg of aspirin on the morning of the procedure.

**From:** Section of Cardiology, Department of Medicine (Drs. Jue and Shroff) and Department of Orthopaedic Surgery (Drs. Karam and Mejia), University of Illinois at Chicago, Chicago, Illinois 60612

We attained, on the second attempt, right radial artery access with use of the front-wall (bare-needle) technique, and we inserted a 5F hydrophilic sheath 10 cm in length. Intra-arterial verapamil (5 mg) and intravenous unfractionated heparin (UFH) (5,000 U) were given at this point. Diagnostic cardiac catheterization revealed a mild stenosis involving the distal left main coronary artery (LMCA). The first obtuse marginal branch of the left circumflex coronary artery was a moderate-caliber vessel with a 90% eccentric stenosis. The sheath was upsized to 6F, and a 6F extra-backup guiding catheter engaged the LMCA without incident. The patient was given an additional 7,000 U of UFH, which resulted in an activated clotting time of 413 s. We successfully performed PCI of the obtuse marginal branch, using 2 drug-eluting stents. There was a good angiographic result—Thrombolysis in Myocardial Infarction-3 flow and no evidence of dissection. After the procedure, we gave the patient a 600-mg loading dose of clopidogrel.

**Address for reprints:**  
Adhir Shroff, MD, Section of Cardiology, University of Illinois at Chicago, M/C 715, 840 S. Wood St., Chicago, IL 60612

Upon completion of the procedure, we removed the right radial arterial sheath and placed an air-filled, transradial vascular hemostasis band over the access site. A small hematoma was noted proximal to the wristband, so a second vascular band was placed over that area. Pre- and postprocedural Barbeau tests with use of combined plethysmography and pulse oximetry recordings revealed normal findings consistent with patent radial and ulnar arteries. The patient was admitted to the inpatient medical service for post-PCI monitoring.

**E-mail:** arshroff@uic.edu

Two hours later, nurses reported substantial bleeding upon initial deflation of 3 cc of air from the wristband, which was immediately reinflated per protocol. How-

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ever, examination of the patient's right hand revealed significant swelling that restricted the normal range of motion of the digits—especially the thumb, with the thenar eminence tense and tender to palpation (Fig. 1). The patient reported that symptoms rapidly progressed over a course of about 15 min, culminating in severe pain that required the administration of intravenous hydromorphone for mild relief. Of note, the swelling was limited to the hand, with none in the forearm proximal to the wristband. The decision was made not to reverse anticoagulation, for fear of stent thrombosis.

In the meantime, conservative measures were taken to reduce blood flow, including inflation of a BP cuff to 15 mmHg below systolic BP over the right brachial artery; we also elevated the arm and placed a cold pack for symptom relief. The vascular band remained in the correct position, but when it was briefly removed for closer inspection of the wrist, the radial artery was still bleeding profusely. Concern about hand compartment syndrome prompted us to consult a hand surgeon immediately.

The patient was transferred, on an emergency basis, to the orthopedic hand-surgery service at one of our referring hospitals. Upon arrival, he had substantial pain in the hand, severe paresthesia, diffuse swelling, and almost no active range of motion in the hand. His passive range of motion was very limited, secondary to pain. He did have brisk capillary refill at the tips of all fingers, but decreased diffuse sensation. He was transported immediately (within 4 hr from the onset of hand-swelling) to the operating room for fasciotomy. A well-padded tourniquet was placed on the right upper arm but not inflated before removal of the hemostasis wristbands. Preoperative BP was 133/60 mmHg. An intracompartmental measuring device indicated that



**Fig. 1** Photograph shows acute swelling of the right hand, especially in the thenar eminence, and 2 transradial vascular compression wristbands at the distal forearm to control bleeding at the wrist.

pressure was 35 mmHg in the hypothenar compartment and 68 mmHg in the thenar compartment, both above the usual threshold of 30 mmHg for fasciotomy. At this point, we initiated surgical intervention for emergency decompression. All 10 compartments of the hand were released, including the 4 dorsal interosei, the 3 volar interosei, and the adductor pollicis compartments through one thenar, one hypothenar, and 2 dorsal incisions. A carpal tunnel release procedure was also performed. We found bulging of the thenar muscles upon fascial incision, together with dark coloration of the muscles, both of which suggested ischemic change (Fig. 2). Straw-colored fluid in the dorsal incisions was also seen (Fig. 3). The fasciotomy wounds were kept open, but we applied (by means of regular skin staples) a shoelace closure with vessel loops (Fig. 4). The carpal tunnel incision was closed primarily.

On postoperative days 3 and 8, the patient returned for tightening of vessel-loop closure and wound explora-



**Fig. 2** Intraoperative photograph shows bulging dark muscle within the thenar eminence fasciotomy.



**Fig. 3** These dorsal incisions reveal straw-colored interstitial fluid.

tion for hemostasis, while continuing antiplatelet therapy. At his 16-day follow-up visit, the vessel loops and staples were removed. One month postoperatively, the patient had well-healed incisions, resolution of edema, and full passive and active range of motion of his hand, which obviated the need for occupational therapy (Fig. 5). He was motivated to perform home exercises to overcome some residual weakness. He had no neurologic deficits in the right upper extremity.



**Fig. 4** At the end of surgical release, vessel-loop shoelace closure was applied at the fasciotomy sites by means of regular skin staples.



**Fig. 5** Photograph one month after fasciotomy shows well-healed incisions and resolution of swelling.

## Discussion

The transradial approach to coronary angiography and PCI has been increasing and has been shown to have lower rates of bleeding and vascular sequelae than does the transfemoral approach.<sup>1</sup> Transradial catheterization sequelae include radial artery spasm, occlusion, hematoma, perforation, and pseudoaneurysm.<sup>2</sup> There have been rare reports of compartment syndrome that involved the forearm.<sup>3-9</sup> In transulnar catheterization, investigators in a small single-center prospective study showed a low incidence of vascular sequelae, in which 2 patients (0.4%) had developed major forearm hematomas that resolved without clinical consequences.<sup>10</sup> In a large prospective study of more than 10,000 patients, the overall vascular sequela rate in transradial percutaneous coronary procedures was 0.5%, and there were 2 cases of compartment syndrome.<sup>11</sup> In a larger retrospective review<sup>5</sup> of more than 50,000 cases, the incidence of forearm compartment syndrome necessitating surgery was 0.004%: two patients with low body surface area and low creatinine clearance had received excess anticoagulation.<sup>5</sup> To our knowledge, ours is the first reported case of isolated hand compartment syndrome after transradial cardiac catheterization.

Acute compartment syndrome occurs when there is an increase in pressure with compression of nerves, blood vessels, and muscle inside the upper limb compartments, leading to ischemic tissue necrosis.<sup>12</sup> It is important to recognize the early signs and symptoms of compartment syndrome, which include tension upon palpation, acutely worsening pain, swelling, decreased sensation, and decreased motor function. The hand contains 10 muscle compartments; intracompartmental pressures of 15 to 25 mmHg have been suggested as the threshold for diagnosis in a tense swollen hand, although a reference standard for hand compartment syndrome does not yet exist.<sup>13</sup> To determine the need for fasciotomy, 30 mmHg has been used as the threshold.<sup>14,15</sup>

In addition to evaluation of the hand, there should be evaluation of bleeding in the forearm, which is separated into volar (anterior), dorsal (posterior), and radial compartments. The classification of upper-extremity hematoma consists of 4 grades, on the basis of size: grade 1 hematoma, <5 cm; grade 2, 5–10 cm; grade 3, extending distal to the elbow; and grade 4, extending proximal to the elbow.<sup>14</sup> Initial conservative measures include applying a BP cuff at the site of induration and inflating the cuff to 15 mmHg below the systolic BP for 15 min. Arterial flow can then be measured with an oximeter probe. Other considerations include managing elevated BP, stopping glycoprotein IIb/IIIa inhibitors, partially reversing heparin with protamine, and providing analgesia. If swelling, pain, or induration persists after 2 inflations of 15 min, urgent surgical consultation should be pursued.<sup>5</sup>

The potential causes of uncontrolled bleeding leading to compartment syndrome include excess anticoagulation during or after the procedure, inappropriate position of the compression band relative to the actual arteriotomy site or shifted position of the compression band, insufficient air inflated into the vascular band to compress the puncture site, distal puncture site of the radial artery, multiple access attempts at different points in the forearm, perforation of small arterial branches with wires, and radial artery laceration during sheath insertion or removal. Finally, impeding venous outflow could elevate compartmental pressure, as evidenced by the straw-colored interstitial fluid seen in our patient.

In this case of hand compartment syndrome, there was no instrumentation with wires or catheters in the hand; therefore, access-site bleeding must have been the source. The most likely factors contributing to the problem were excessive UFH in a patient with renal failure and a possible shift in the compression wristband's position after placement. In our patient, the swelling was limited to the hand without involvement of the forearm, which makes his an unusual case.

Transradial access for cardiac catheterization has a low risk of vascular sequelae relative to transfemoral access. Among patients at high risk of bleeding, the absolute rate of bleeding is lower with the radial than with the femoral approach, but these patients still have a higher risk of bleeding than do low-risk transradial patients. When bleeding occurs, it is important to monitor access-site bleeding, as well as venous outflow. Despite our early recognition of this sequela, our patient needed urgent surgical treatment.

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