

Managing Complications of Transradial Catheterization

How to address challenges that may occur with this outcome-improving access procedure.

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During the 25 years since the first report of successful coronary catheterization via the radial artery,¹ transradial access for catheterization and intervention has evolved from a trendy idea with sporadic adoption to a routine practice and standard of care. Following on the heels of small series and meta-analyses suggesting a reduction in bleeding and access site complications, larger studies and randomized trials have consistently demonstrated that transradial access leads to reduced access site complications and improved outcomes.²⁻⁶ Despite these findings, the use of transradial access in the United States remains relatively low.⁷

Although there is little argument that the transradial approach is associated with decreased access site complications, it is important to remember that it is not completely benign. There are a number of complications that are unique to transradial catheterization. Although the majority of these are not clinically dramatic, they occasionally require dedicated management. These complications include arterial injury, spasm, occlusion, perforation, hematoma, and pseudoaneurysm. Additionally, and perhaps more importantly, many of these can be prevented by meticulous technique in access, procedural performance, and hemostasis. With relatively straightforward strategies, these complications can be managed without downstream issues. This article provides an overview of common transradial complications and outlines strategies for their management.

RADIAL ARTERY INJURY

The radial artery ranges in diameter from 2 to 4 mm, with an average of 3.1 ± 0.6 mm and 2.8 ± 0.6 mm in men and women, respectively.⁸ This is considerably smaller than the average nondiseased common femoral artery, which ranges from 7 to 9 mm in diameter. As a result, arterial injury can occur with standard equipment. For instance,

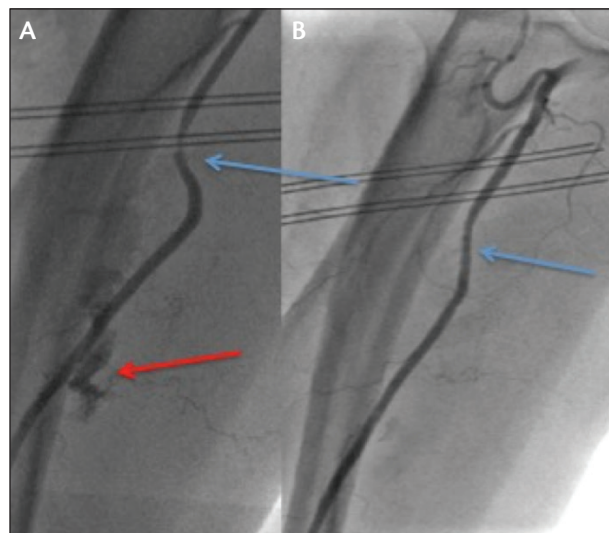


Figure 1. Radial artery spasm (blue arrows) with perforation (red arrow; A). Subsequent resolution of both spasm and perforation (B).

the outer diameter of most 6-F sheaths are approximately 2.6 mm, and passage of multiple wires and catheters through the radial artery raises the potential for damage. A number of studies have employed intravascular imaging techniques to assess the frequency and extent of radial artery injury during catheterization. In one such study, Yonetsu et al performed optical coherence tomography in 73 arteries in 69 patients. They found that 67% of radial arteries had some degree of intimal tear, whereas 35.6% of vessels exhibited medial dissection.⁹ Chronically, the vessels were found to have thickened intimal walls consistent with healing after previous injury. The degree of injury is often clinically silent, and usually, no specific management strategies are necessary.

RADIAL ARTERY SPASM

One of the more common complications of transradial catheterization that requires attention is spasm (Figure 1). Even with modern equipment, including hydrophilic sheaths, appreciable radial artery spasm occurs in up to 20% of cases, and it remains an important reason for procedural failure.^{10,11} It is most often recognized by difficulties in accessing the vessel or passing, manipulating, or withdrawing equipment. Additionally, spasm may lead to catheter kinking or entrapment because of increased resistance to catheter movement and excessive torque necessary to manipulate the catheter.

The management of radial artery spasm centers on preventive antispasmodic administration of a cocktail consisting of nitrates and/or calcium channel blockers. The exact formula or ratio of individual agents is largely a matter of style. When patients develop spasm, management options include a tincture of time, increased sedation, additional or alternative antispasmodic medications, catheter downsizing, or abandoning the access site altogether. In rare cases, a patient may require deep conscious sedation or even intubation (in order to achieve profound sedation) to manage spasm.

In a study of 1,868 patients (56.5% of whom underwent percutaneous coronary intervention), 188 cases of spasm were identified. Of these, 51 cases were classified as moderate or severe, defined as those requiring some form of dedicated intervention. The most common intervention was additional medication (42% of cases), and crossover to the contralateral radial artery or the femoral artery occurred in 25% of cases.¹²

RADIAL ARTERY OCCLUSION

Radial artery occlusion (Figure 2) is perhaps the most widely discussed complication of transradial catheterization. The perception that it occurs commonly and leads to ischemic complications remains a significant barrier to increased use of this technique. With modern equipment and technique, the incidence of radial artery occlusion is likely around 4% and ranges from 3% to 10%.^{13,14} The majority of these occlusions are asymptomatic, with resolution in approximately 50% at 30 days.¹⁴ Symptomatic radial artery occlusion is uncommon, but its occurrence is well documented both anecdotally and in case reports throughout the literature. Clinically significant sequelae are exceedingly rare, especially in the presence of adequate dual circulation, but ischemic complications can occur and are usually the result of thromboembolism.¹⁵

One commonly employed strategy in managing (or preventing the consequences of) radial artery occlusion is assessing dual circulation through either the modi-



Figure 2. Radial artery occlusion with evidence of retrograde flow through collateralization of the palmar arch (yellow arrow).

fied Allen test or the Barbeau test. In either case, patency of the ulnar artery is established before radial artery access to ensure adequate circulation to the hand if radial artery occlusion occurs. Although this remains the standard of care in many institutions, in a recent international survey, 23.4% of transradial operators do not routinely assess dual circulation.¹⁶ Importantly, there is no definitive link between poor dual circulation and hand ischemia, and sufficient collateralization of the palmar arch likely exists to allow safe transradial access in the absence of a normal Allen test result.¹⁷

Nevertheless, if for no other reason other than to preserve the access site for future use, radial artery occlusion is ideally avoided. Occlusion is associated with sheath size, lack of or underdosing of anticoagulation, occlusive hemostasis, and prolonged compression times. As previously noted, the sheath-to-artery diameter ratio of standard interventional equipment is almost occlusive in a significant minority of patients, and small sheath sizes are associated with lower risks of occlusion.⁸ Regarding anticoagulation, Spaulding et al published their initial transradial experience in 1996. Radial artery occlusion occurred in 71% of their first 49 patients, who received no anticoagulation, and it decreased to 4% in their later 210 patients, who received 5,000 units of unfractionated heparin upon vascular access.¹⁸ Although the ideal dose may vary by individual preference, most agree that procedural anticoagulation with at least 50 units/kg of unfractionated heparin is necessary to reduce the risk of radial artery occlusion.¹⁹

Another important practice for reducing radial artery occlusion is that of “patent hemostasis.” Compared to

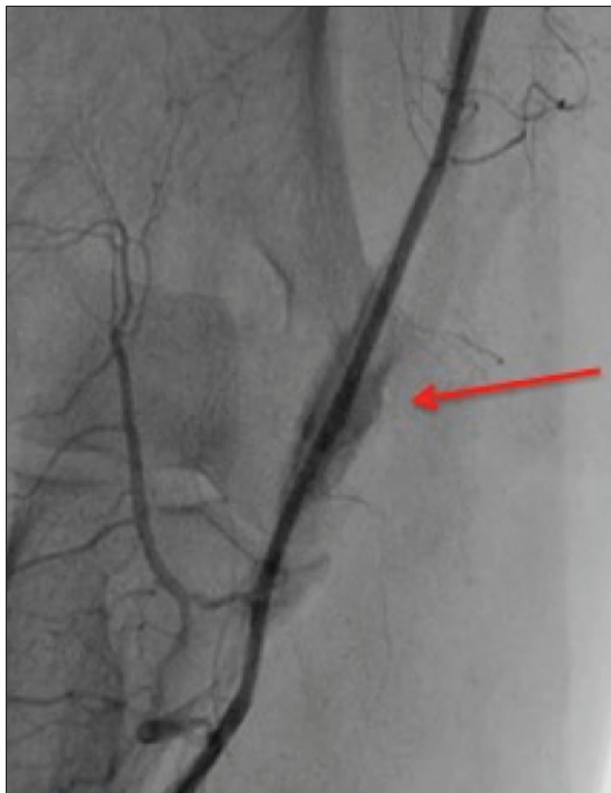


Figure 3. Radial artery perforation (red arrow) at the level of the brachial artery.

traditional compressive hemostasis, patent hemostasis uses various compressive devices to provide sufficient hemostatic pressure over the arterial puncture site, but not enough to prevent antegrade flow through the radial artery into the distal arterial bed. In a randomized study of 436 patients undergoing transradial catheterization, Pancholy and colleagues compared compressive hemostasis to patent hemostasis and demonstrated a significant 59% reduction in early occlusion (12% compressive vs 5% patent; $P < .05$) and a significant 75% reduction in late occlusion (7% compressive vs 1.8% patent; $P < .05$).¹³

As previously noted, early radial artery occlusion often resolves over time. However, techniques directed toward treating occlusion and potentially minimizing long-term issues are gaining popularity. Anticoagulation with low-molecular-weight heparin has been shown to reduce the 30-day incidence of symptomatic occlusion. In a study of 488 patients undergoing transradial catheterization, 51 (10.5%) had evidence of occlusion. Thirty of these patients had symptoms, and they were treated with 4 weeks of anticoagulation. The 30-day occlusion rate in these patients was 13.3%, compared to 80.9% of the 21 patients who were without symptoms and therefore were not treated ($P < .001$).²⁰

A more immediate technique for treating occlusion is forced ulnar compression. In this technique, the patient is anticoagulated, and the hemostatic device is shifted over to the ulnar artery, forcing flow through the occluded radial artery. In a study of 465 patients undergoing transradial catheterization with 5-F access and randomized as part of a larger study to either 2,000 or 5,000 units of unfractionated heparin, all patients were assessed for radial artery patency 4 hours after the procedure with a protocol specifying immediate 1-hour ulnar occlusion in the case of radial artery occlusion. The overall initial occlusion rate was 4.3% (5.9% with 2,000 units vs 2.9% with 5,000 units; $P = .17$). After ulnar compression, occlusion improved to 2.4% (4.1% with 2,000 units, 0.8% with 5,000 units; $P = .03$).²¹ This study not only confirms the benefit of an increased heparin dose, but also suggests further improvement with ulnar compression in the case of radial artery occlusion.

In cases of symptomatic occlusion, pain is the most common symptom, and it is usually self-limited. Patients with hand ischemia may develop signs of embolism including intractable pain, pallor, and eventual gangrene. Management strategies include conservative medical management with analgesia and/or anticoagulation or invasive management with intent to restore flow. Amputation has been reported secondary to gangrene.²² Although each of these strategies has merit, insufficient evidence exists to support a definitive recommendation for early management.

PERFORATION AND HEMATOMA

Additional complications of transradial catheterization include perforation (Figures 1 and 3) and hematoma. It is important to remember that the radial artery is relatively small compared to the femoral artery, and with variations in anatomy (loops, tortuosity, and accessory branches) occurring in up to 10% of cases, it is not uncommon to encounter resistance when advancing either the wire or the catheter. When this occurs, care must be taken to avoid pushing too hard and causing a perforation.

Perforation is usually discovered by contrast extravasation and staining beyond the normal architecture of the vessel. Once perforation has been established, management depends upon whether wire access is maintained. With wire access, the case can generally continue through the radial access site. Some operators recommend transitioning to a long sheath in order to tamponade the perforation and maintain access beyond the perforation site. In the case of lost wire access, the sheath should be removed with patent hemostasis maintained,



Figure 4. Asymptomatic pseudoaneurysm (white arrow) noted 1 week after catheterization.

and the patient should be monitored for hematoma formation.

Anatomically, hematoma can be divided into those related to the puncture site or intramuscular bleed-

ing occurring proximal or distal to the elbow (open- vs closed-space bleeding, respectively).²³ Hematoma originating proximally in the open space will manifest similarly to a retroperitoneal bleed, in which signs of hypotension, tachycardia, and anemia may indicate a significant issue. Hematoma originating distally in the closed space may manifest as tightness and expanding visible hematoma. The feared complication in such cases is compartment syndrome, an extremely rare (0.004%) but potentially catastrophic event.²⁴ For patients with visible hematoma, arm elevation and compression with either a bandage wrap or blood pressure cuff may help contain the hematoma. During compression, patients should be monitored by continuous pulse oximetry for digital ischemia.²⁴

PSEUDOANEURYSM

Pseudoaneurysm (Figure 4) is another rare complication that occurs from inadequate hemostasis at the radial access site. This complication is also associated with systemic anticoagulation.²⁵ It is recognized as a pulsatile mass and diagnosed either visually or by ultrasound or angiography. Treatment options include compression,

thrombin injection, or surgical ligation, depending on the presence or severity of symptoms.

NERVE DAMAGE

The radial artery is anatomically isolated from the major nerves that supply the hand, and significant neurological injury is rare. It is not uncommon for patients to report minor numbness of the hand or wrist following catheterization, and this often resolves after minutes to hours. On the other end of the spectrum, complex regional pain has been reported following transradial catheterization. The syndrome consists of continuous pain, allodynia, and hyperalgesia and may appear in two forms, type I or type II. The latter is differentiated by pain in the distribution of a demonstrably damaged nerve.²⁶ Both have been reported after transradial catheterization, and they are exceedingly rare issues with a spattering of case reports throughout the literature.^{27,28} Management is typically conservative and can include pain management, steroids, antidepressants, nerve blocks, occupational therapy, and counseling.²⁹

STERILE GRANULOMA

Granuloma formation has been reported following transradial catheterization. It is hypothesized that the coating on a specific hydrophilic sheath may lead to the formation of these sterile granulomas, although the hemostatic technique has also been implicated.³⁰⁻³² These granulomas are benign, with no specific management necessary.

CONCLUSION

There is little argument that transradial catheterization is associated with lower rates of access site complications. Although this has led to increased use of transradial access across the world, it is important to remember that transradial access is not without complications. Importantly, despite the significant reduction in access site complications with transradial access in the RIVAL (Radial vs Femoral Access for Coronary Intervention) trial, we must remember that the incidence of death, myocardial infarction, stroke, and major bleeding were similar between the transradial and transfemoral access groups.³ Additionally, as noted in this article, a number of complications unique to transradial catheterization exist, and although they are not necessarily clinically significant, they do require attention and respect. ■

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