

Managing Radial Access Vascular Complications

Recognizing complications associated with transradial access and available management options.

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Among patients undergoing diagnostic cardiac catheterization, transradial access leads to improved quality of life after the procedure, is strongly preferred by patients, and reduces hospital costs.¹ Transradial coronary angiography and angioplasty is safe, feasible, and effective, with results similar to those of the transfemoral approach.² Although complications are infrequent, they do occur (see *Complications* sidebar). It is imperative that physicians using the radial approach are cognizant of the incidence, predisposing factors, and available management strategies for such complications.

PROCEDURAL

Vagal Reactions

During sheath insertion, procedural hypotension requiring treatment with atropine occurs infrequently.³ Vagal reaction may be exacerbated by verapamil, often administered to counteract spasm. Although these reactions are usually mild and short-lived, we recently encountered a patient who became profoundly bradycardic and hypotensive, requiring brief inotropic support before completion of the case. Appropriate preprocedural sedation, analgesia, and adequate local infiltration anesthesia can aid in decreasing pain, anxiety, and associated vagal output.

Radial Artery Spasm

The radial artery is a muscular artery, richly supplied by alpha-1 and, to a lesser extent, alpha-2 adrenocep-

COMPLICATIONS ASSOCIATED WITH RADIAL ACCESS	
PROCEDURAL	POSTPROCEDURAL
• Vagal reactions • Radial artery spasm • Radial artery occlusion • Bleeding, iatrogenic perforation	• Compartment syndrome • Pseudoaneurysm • Sheath and hemostasis device-related complications • Chronic pain/neuralgia

tors. Stimulation of these receptors by circulating catecholamines leads to vasoconstriction,⁴ thereby mediating radial artery spasm. In addition, the relatively small size of the radial artery in relation to the arterial sheath predisposes to spasm, increasing frictional forces and potentially injuring the endothelium.

Spasm is a frequent complication of radial access; an angiographic study indicated that a majority of patients have severe and diffuse radial artery spasm during the procedure.⁵ However, most vasospasms are temporary and resolve spontaneously. We routinely use hydrophilic sheaths, which have been shown to aid in sheath insertion and withdrawal and reduce patient discomfort.⁶ Intra-arterial antispasmodics are administered immediately after sheath insertion. The use of nitrates may result in a 16% enlargement of the diame-

ter of the radial artery.⁷ We prefer intra-arterial verapamil because the duration of action is longer.

Reducing patient anxiety and discomfort, using smaller catheters, and restricting catheter maneuvers and exchanges can often avoid spasm encountered during the procedure. Anecdotally, J-wire exchanges can be a potent stimulus for spasm of the radial or brachial artery, a problem that can be avoided by either using an exchange length wire that is maintained in a stable position in the ascending aorta during catheter exchange, or by using hydrophilic guidewires that may cause less spasm. Selection of catheter size should be guided by patient size and gender. Diagnostic procedures can be performed with 4-F catheters, and a large proportion of interventional procedures may be performed using 5- to 6-F guide catheters.

A sheath entrapped by arterial spasm should never be forcibly removed because traumatic eversion endarterectomy of the radial artery may result.⁸ Repeat intra-arterial vasodilators, additional patient sedation and/or analgesia, and reinsertion of the introducer and guidewire may be necessary. In extreme and refractory cases, axillary nerve blocks or general anesthesia may be required for catheter removal.

Radial Artery Occlusion

Radial artery occlusion after transradial procedures has been reported to occur in 2% to 10% of patients.^{9,10} Occlusion may be related to prolonged cannulation, small diameter of the radial artery, ratio of the radial artery diameter to the sheath outer diameter, and anticoagulation during arterial cannulation.¹⁰⁻¹³

Thrombotic or traumatic occlusion of the vessel should not in theory endanger the viability of the hand if a double blood supply through the ulnar arch is present.¹⁰ Although some interventionists, therefore, emphasize the importance of a normal modified Allen's test before radial artery cannulation, this is controversial. The criteria for an abnormal Allen's test result are not agreed upon, and the significance of an equivocal or abnormal test result is unclear.¹⁴

First described in 1929 by Dr. Edgar Van Nuys Allen as a means to evaluate collateral circulation simultaneously in both hands of patients with thromboangiitis obliterans,^{15,16} the modified Allen's test has been subsequently used to assess the integrity of collateral blood flow to a single hand. The technique is simple; the examiner occludes the radial and ulnar arteries, and the patient is asked to clench his or her fist until palmar skin blanches. The patient is then asked to unclench and relax the fist, and the ulnar artery pressure is released while maintaining occlusion of the radial

artery. Falsely abnormal results can occur if the patient overextends the fingers.^{17,18} The time required for palmar capillary refill is noted. The inverse modified Allen's test is similar but with release of the radial artery pressure while maintaining ulnar artery occlusion.

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Among numerous limitations, there is fundamental variability in the primary endpoint—the time required for hand reperfusion, which also suffers from significant interobserver variability. Reported values have ranged from as little as 3 seconds up to 15 seconds.^{17,19, 20, 21-23}

The addition of plethysmography and oximetry has been described to improve both the sensitivity and objectivity of the test. Barbeau et al found that 80% of patients with an abnormal modified Allen's test results scheduled for transradial cardiac instrumentation had adequate collateral perfusion on plethysmography and oximetry tests.²¹ Conversely, this method has been found to overdiagnose normal hand circulation compared with the modified Allen's test.^{24,25}

Controversy notwithstanding, we routinely perform a modified Allen's and reverse Allen's test before transradial procedures.

Procedural anticoagulation should be standard in all procedures performed via radial artery access. Heparin should be administered at doses of 50 to 70 units/kg to maintain an activated clotting time of ≥ 250 seconds, or a direct antithrombin such as bivalirudin can be considered as a potential alternative. The sheath should be removed immediately after the procedure, while patients are still under the effects of anticoagulation. Without heparin anticoagulation, the rate of radial occlusion after angiography is in excess of 70%; this incidence decreases to less than 7% with doses $\geq 5,000$ units²⁶ and is currently closer to 1%.

Consequences of radial artery occlusion are usually benign and asymptomatic due to the dual blood supply to the hand. Hand ischemia with necrosis rarely occurs after prolonged cannulation of the radial artery for hemodynamic monitoring. This has not been reported in diagnostic or interventional procedures performed transradially, in which the sheath is removed immediately after the procedure.

Bleeding, Iatrogenic Perforation

The incidence of severe bleeding complications is significantly lower than femoral and brachial approaches. One of the most common reasons the radial approach is abandoned for a femoral approach, however, is iatrogenic vascular dissection or perforation. Usually the result of overzealous advancement of a wire when resistance is encountered, it is more readily avoided than treated. Hydrophilic wires, while useful in overcoming tortuous segments or radial loops, increase the risk of perforation.

Wires should never be advanced against resistance; gentle injection of dilute contrast through the end of the sheath or catheter often reveals the obstacle (eg, an anomalous artery, a loop, tortuosity, or spasm). In the event of an obstruction, necessary measures can then be taken, such as selection of a smaller catheter, utilizing the contralateral radial artery, or adopting a femoral approach.

If the radial artery is the only available access site for an intervention, and extravasation is identified during a procedure, the perforation can be traversed with a long sheath or a long 4-F multipurpose catheter. The 5- or 6-F guide catheter can then be advanced over the multipurpose catheter, essentially serving to seal the dissection/perforation plane until the procedure is completed.²⁷

When extravasation is diagnosed after a procedure, treatment options include reversal of anticoagulation, compression, and close observation. Compression can be achieved manually by using an adhesive pressure dressing or a blood pressure cuff at the arm or forearm level. The patient must be closely monitored for hand ischemia or compartment syndrome. Such conservative management is usually all that is needed.

Bertrand et al^{28,29} have classified forearm bleeding into a useful and practical spectrum; they categorize five possible grades, ranging from a local superficial hematoma (grade I) and extending to ischemic threat from compartment syndrome (grade V). Grades I and II are directly related to the puncture site and are best managed with analgesia, ice, and compression. Grades III and IV result from intramuscular bleeding, require more aggressive compression methods, and may portend compartment syndrome.

POSTPROCEDURAL COMPLICATIONS

Compartment Syndrome

The incidence of compartment syndrome after interventions via the transradial approach seems to be very low;³⁰⁻³³ an incidence of 0.4% is suggested,³⁴ but in our experience this is an overestimate. Possible etiologies include unrecognized perforation at a distance from

the puncture site, unsuccessful compression at the puncture site, or radial artery laceration induced at sheath insertion or removal because of severe spasm just distal to the distal end of the introducer sheath.²⁹

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Early appropriate management of hematomas, as described previously, is vital. Any symptoms or signs suggesting compartmental compression should result in early surgical consultation for limb-saving fasciotomy.

Pseudoaneurysm

This rare complication, encountered more frequently in the femoral location, presents with painful swelling at the wrist, forearm, or cubital fossa. Usually the result of inadvertent perforation of an anomalous radial artery, it may not be recognized for days to weeks after the procedure. Occasionally, it has been observed in the days after the procedure at the puncture site, especially in patients receiving prolonged systemic anticoagulation. Diagnosis is usually by ultrasound. If identified soon after the procedure, firm local pressure is indicated. Other measures, including thrombin injection, ultrasound-guided compression,³⁵ and surgical correction have been described.

Sheath and Hemostasis Device-Related Complications

Sterile abscesses rarely occur with the use of hydrophilic-coated sheaths.³⁶ They usually appear within 2 to 3 weeks after the procedure and are associated with subcutaneous remnants of silicone. In rare cases, abscess drainage is required.³⁷

Compression devices used for hemostasis should selectively deliver pressure without obstructing venous return. The major complication with these devices is arterial occlusion.¹¹

Chronic Pain

Radial access is generally preferred by patients and usually improves patient comfort.¹ However, prolonged, aggressive hemostatic compression at the access site may lead to vascular and/or neurologic complications, including persistent pain. Rarely, chronic regional pain syndrome 1 (reflex sympathetic dystro-

phy) may occur.^{38,39} Sympathetic blockade, analgesics, and physical therapy are potential management options. Fortunately, chronic pain is exceedingly rare.

CONCLUSION

The radial artery provides an ideal access site in many situations, expanding our options in subgroups of patients considered to be at high risk for the femoral approach. It has a lower incidence and severity of bleeding and vascular complications.⁴⁰ Although the radial artery has its own inherent risks, many shared by access sites in general, others are unique to the radial approach. Meticulous technique, appropriate preventive measures, and early recognition of problems are fundamental in avoiding unnecessary morbidity and mortality associated with these risks. Complications arising from radial arterial access are infrequent and are usually avoidable. ■

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