Basics of Radial Artery Access

Familiarity and practice with radial access techniques will lead to shorter access times and higher rates of successful cannulation.

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Of the more than 1 million coronary angiographies performed in the United States in 2009, the majority involved percutaneous intervention and were performed from the femoral approach.[1] Life-threatening access site bleeding is a well-described complication of angiographic procedures using femoral artery access, particularly when a percutaneous intervention is performed and anticoagulation and antiplatelet therapies are initiated. The radial artery approach reduces the risk of bleeding events dramatically.[2,3] A recent randomized trial evaluating multiple outcomes parameters concluded that the radial approach may be advantageous over the femoral approach in primary PCI.[4] Accumulating data favoring the radial approach, along with advancement of radial-specific equipment and techniques, has led to a recent widespread surge in radial procedures.[5]

There are several advantages of radial artery access over transfemoral and transbrachial techniques, including (1) reduced duration of postprocedure bed rest and length of stay, enhancing patient comfort; (2) lower incidence of access site complications, including bleeding, pseudoaneurysm, and arteriovenous fistulas; and (3) potential reductions in overall costs compared to femoral access. In a recently published study, coronary interventions via the radial artery had a lower bleeding rate and in-hospital mortality rate compared to the conventional femoral artery interventions.[3] Randomized trial data confirming these findings in ST-elevation myocardial infarctions led to the European Society of Cardiology's recommendation that the radial artery should be the preferred route of access for angiography and interventions in patients with ST-elevation myocardial infarctions.[4]

Despite widespread adoption in European and Asian countries, radial access for percutaneous procedures in the United States remains infrequent.[5] Reasons for operator reluctance to utilize radial access are unclear and varied. There are several limitations to radial access, including inability to use larger sheaths, potential for radial spasm, increased radiation exposure, and the potential for a need for crossover to femoral access. In addition, some operators may be deterred by lack of familiarity with radial-specific equipment and patient setup. Others may be discouraged by the 1% to 5% failure rate of radial artery cannulation for interventional procedures, which is significantly higher than for transfemoral or transbrachial approaches.[6] The steeper learning curve of radial access techniques compared to femoral techniques, smaller caliber of the radial artery, and existence of anatomical variations in the radial distribution may account for this increased failure rate.

Recent improvements in available radial-specific equipment, along with an upsurge of literature and training programs describing strategies for successful radial access, will likely improve successful cannulation rates and adoption of this approach.[7] In our practice, we have found that the keys to radial access success include a broad understanding of radial anatomy, familiarity with available equipment and access strategies, and extensive staff training on appropriate patient positioning, draping, and aftercare. If performed systematically and methodically, we believe that successful radial cannulation can be accomplished as efficiently and safely as femoral access.

PATIENT PREPARATION

Prior to entering the procedure room, the patient should undergo careful examination of their pulses,

Figure 1. The wrist is positioned on a movable arm board with the hand supinated and the wrist extended using a flexible wrist restraint. The area from the flexor crease to the mid-forearm is prepared in a sterile fashion.

including palpation of the bilateral radial arteries as well as femoral and distal lower extremity pulses in the event that radial access is unsuccessful. An Allen's test should be performed to confirm adequate collateral circulation to the palm. Both the radial and ulnar arteries are compressed until the palm blanches. The ulnar artery is then released and the blush response in the palm is noted. If the color of the palm returns to normal within 10 seconds of release of the ulnar artery, the blood supply to the hand is satisfactory via the ulnar artery and palmar arch.

To eliminate the contribution of subjectivity to the Allen's test, the Barbeau's test can be performed. The Barbeau's test is conducted by placing a pulse oximeter on the thumb of the ipsilateral hand. A normal waveform should be observed. Similar to the Allen's test, the radial and ulnar arteries are compressed simultaneously. However, instead of observing hand color when releasing the ulnar artery, the pulse oximetry tracing is examined. The tracing is initially blunted or flat when both the radial and ulnar artery are occluded, and should return to baseline within 10 seconds for the test results to be considered normal. The patient can continue to wear the finger oximeter during the procedure, which provides feedback on the integrity of the blood supply to the hand.

Once adequate collateral circulation has been confirmed, the patient should be adequately premedicated with analgesics and anxiolytics. Patient anxiety can increase vascular tone and the potential for radial artery spasm, which can diminish radial artery cannulation success. In our practice, we regularly give our patients at least 2 mg of midazolam and 50 mg of fentanyl before achieving access, depending on size and respiratory status.

PATIENT POSITIONING AND SETUP

The cath lab staff should be extensively educated on optimal patient positioning and setup for radial procedures. If a right radial approach is planned, the arm is placed close to the patient's side and immobilized, with the hand positioned in an extended position on a movable splint or armboard (Figure 1). Customarily, the operator stands on the patient's right side during the procedure, with the monitors on the patient's left. Left radial access may be preferred in cases of excessive right subclavian tortuosity or need to perform left subclavian/LIMA angiography. If a left radial approach is planned, the operator can maintain routine room/monitor setup by reaching over the body to the patient's immobilized left arm, or by draping the left hand across the lower chest in a "Napoleonic" pose. Many operators prefer, particularly when patients are large, to stand on the patient's left side to gain access to the left radial artery, then to walk around to the patient's right to perform the procedure. Towels should be placed underneath the immobilized arm for patient comfort.

The wrist area is prepared by sterilizing the area from the flexor crease to the mid-forearm. The groins should also be scrubbed in the event of a need to achieve femoral access due to unsuccessful radial cannulation or need for mechanical support. The arm and hand are draped so that only the area from the styloid process of the radius to approximately 4 cm proximal is exposed (Figure 2). Table positioning should be adjusted so imaging from the wrist to approximately 5 cm above the elbow can be performed. The height of the table should be adjusted so that the operator can perform imaging and radial artery cannulation without having to bend or strain.

RADIAL ARTERY CANNULATION AND SHEATH INSERTION

To avoid excess spasm caused by multiple punctures, it is ideal if radial artery access is achieved on the first attempt. Therefore, access planning is critical. Before local anesthesia and cannulation, the operator should take time to carefully palpate the radial artery. The approximate diameter and course of the artery should be estimated. If desired, ultrasound can be used during this step to visually identify the location and depth of

Figure 2. The right wrist is draped in a sterile fashion using a brachial drape with the skin over the radial artery exposed. Custom single drapes incorporating femoral and radial fenestrations are also commercially available.

Figure 3. Local anesthetic (1–2 mL) is administered through a 25-gauge needle, and a wheal is raised over the puncture site. Nitroglycerin (50–150 µg) may also be administered subcutaneously in the event of a low-volume radial pulse or radial spasm.

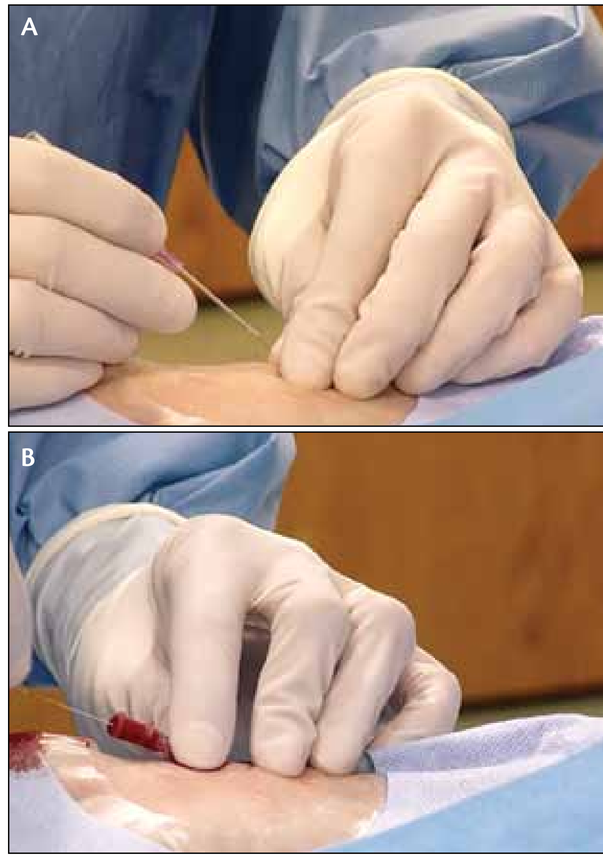

Figure 4. The radial artery is immobilized with the left hand, and the anterior wall of the radial artery is carefully punctured using a 20-gauge Angiocath needle system (BD Medical, Franklin Lakes, NJ). Once a flash of arterial blood is seen in the barrel of the Angiocath, the entire apparatus is advanced 2 to 3 mm further, puncturing the posterior wall of the radial artery (radial counterpuncture) and fixing the vessel against the flat portion of the radius bone behind it (A). The needle is then removed and the plastic Angiocath (without the needle) is slowly withdrawn until brisk, pulsatile flow is obtained. The guidewire (0.018–0.021-inch) is then advanced through the Angiocath. Any degree of resistance is abnormal and warrants visualization under fluoroscopy and careful manipulation (B).

the radial artery.[8] The ideal position of entry is approximately 2 cm proximal to the radial styloid. A sterile marker should be used to mark the position of planned vessel entry.

The radial artery is stabilized between the thumb and forefinger of the left hand and 1 to 2 mL of subcutaneous lidocaine is used to create a wheal over the zone of planned entry (Figure 3). Care should be taken not to inject the artery wall with lidocaine because this can also increase spasm. If spasm is suspected, 50 to 150 µg of nitroglycerin can be injected subcutaneously at the access site to promote arterial dilatation.

For access, the operator can elect to use a double-wall through-and-through approach with an Angiocath, which is our preferred approach, or a single-wall anterior puncture with a micropuncture needle. If a double-wall approach is used, a 20-gauge Angiocath is positioned at approximately 45° from the skin's surface and is slowly inserted to puncture the anterior wall of the radial artery (Figure 4A).

Once a flash of arterial blood is seen in the barrel of the Angiocath, the entire apparatus is advanced 2 to 3 mm further, puncturing the posterior wall of the radial artery (radial counterpuncture) and fixing the vessel against the flat portion of the radius bone behind it. The needle is then removed, and the plastic Angiocath (without the needle) is slowly withdrawn until brisk pulsatile flow is obtained (Figure 4B). This confirms the position in the arterial lumen. This approach is similar to that initially described technique for femoral arterial access (the true Seldinger technique). Randomized trial data suggest that this approach may be superior to the single-wall (modified Seldinger) technique due to higher success rates and shorter access times.[9]

If a single-wall approach is used, a 4-F micropuncture needle (although any 19- to 21-gauge needle that is 2 to 5 cm in length can be used) positioned at approximately 45° from the skin surface is advanced until the front wall of the radial artery is punctured. Brisk blood flow (which may not necessarily be pulsatile) signifies that the needle tip is within the vessel.

The use of ultrasound to assist in radial artery assessment and cannulation has been previously described.[8] Briefly, when an operator is prepared to cannulate under ultrasound guidance, the transducer is placed 0.25 to 0.5 cm proximal to the area where the artery will be cannulated, and the radial artery is aligned in the center of the screen. With the needle positioned at approximately 45° from the skin surface, the subcutaneous tissue is penetrated while observing the approach on ultrasound. The needle appears linear and echogenic on ultrasound when it enters the subcutaneous tissue.

Indirect evidence of the artery being compressed can give an idea of the needle tip position if the needle itself is difficult to visualize. Specifically, tenting of the front wall of the radial artery may be detected as the needle exerts pressure on the tissue immediately above the artery. Gentle pressure is exerted upon the needle as it is advanced. A tactile "pop" of the needle may be detected as the needle passes through the front wall of the artery. The needle tip can often be seen in the lumen of the vessel on ultrasound.

When the interventionist is convinced that the Angiocath or needle tip is within the true lumen of the artery, the angle to the skin surface is decreased slightly, and a 0.018- to 0.021-inch micropuncture wire (generally 30 to 50 cm in length, with floppy tip and more rigid shaft) is threaded into the lumen of the Angiocath or needle. The 0.018- to 0.021-inch guidewire is our preferred wire for radial sheath placement for several reasons. First, these lower-profile, 0.018- to 0.021-inch wires have improved steerability compared to 0.035-inch wires.

Figure 5. The sheath is advanced over the 0.021-inch guidewire into the radial artery. Dedicated radial sheaths (5–6 F, 10–11 cm, with a hydrophilic coating) are commonly used. The long, smooth taper of these sheaths usually precludes the need for a dermotomy ("skin nick") before advancement into the vessel (A). The radial artery sheath is flushed with saline and usually secured in place with sterile Tegaderm film to avoid migration out of the wrist. A spasmolytic/anticoagulant cocktail is immediately administered through the sidearm of the sheath to minimize radial spasm and ensure vessel patency during and after the procedure. Components of the cocktail commonly include nitroglycerin, verapamil or nicardipine, and unfractionated heparin (B).

In addition, the rigid shaft and increased core diameter of the 0.018- to 0.021-inch micropuncture wire, when compared to 0.014-inch wires, provides superior support for sheath introduction.

The wire should be advanced carefully until the wire traverses the elbow. There should be free movement of the wire at the tip and advancement should occur easily;

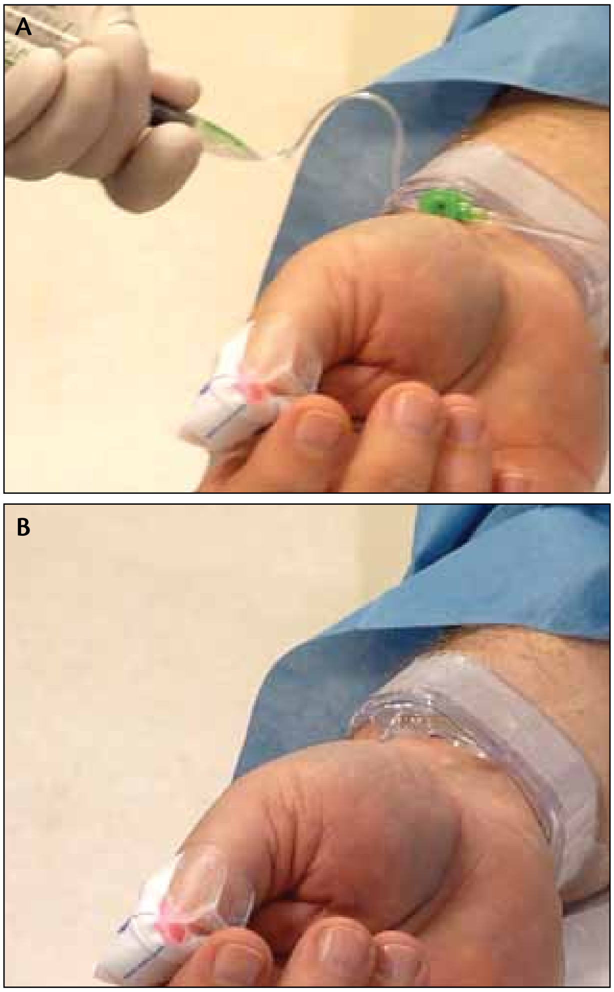

Figure 6. At the conclusion of the procedure, an external hemostatic device is applied over the entry site of the sheath and inflated to achieve hemostasis. Once the sheath is removed, patent hemostasis should be confirmed by removal of enough pressure to allow plethysmographically documented flow in the radial artery with surface hemostasis (A). With the sheath removed and the compression bracelet in place, the patient is able to sit up immediately and move about freely. The compression bracelet should remain in place for approximately 60 to 120 minutes (longer if glycoprotein IIb/IIIa agents were used), with gradual release of pressure during this time (B).

any degree of resistance is abnormal and warrants visualization under fluoroscopy. Difficulty advancing could signify that the wire tip is in a small branch or is subintimal. If this occurs, the wire should be immediately withdrawn and redirected.

Radial sheaths are generally 5 F or 6 F in diameter, 10 to 11 cm in length, with a hydrophilic coating and a specialized tapered tip and smooth transition between the sheath and dilator. The size of the sheath selected should be based on the minimum inner diameter needed to accommodate the equipment used for the procedure. Currently, 7- and 8-F introducer sheaths with tapered dilators specific for radial access are not available in the United States. If 7- or 8-F guide support is needed for bifurcation stenting or rotablation, a sheathless technique can be considered, although is not advisable for the novice radial operator. The incidence of radial artery occlusion is higher when the ratio of radial artery inner diameter to sheath outer diameter is less than 1.[10] Radial artery-to-sheath diameter ratios can vary between male and female patients[10]; thus, sheath size should be planned accordingly. After removal of the Angiocath or needle, the sheath should be carefully introduced over the wire (Figure 5A) and should be immediately aspirated and flushed with heparinized saline (Figure 5B).

A "radial cocktail" should be administered expeditiously through the sidearm of the sheath to prevent vasospasm and thrombosis. Operators have varied preferences for the components of this cocktail. Generally, it should consist of an antithrombotic (heparin) and one or more vasodilators (nitroglycerin, verapamil, or nicardipine). A higher dose of heparin (5,000 units vs 2,500 units) reduces the risk of thrombosis. Verapamil should be used cautiously in patients with cardiomyopathy and bradycardia. We prefer a radial cocktail consisting of 2.5 mg of verapamil, 100 µg of nitroglycerin, and 5,000 units of heparin. Diluting the mixture with 20 mL of blood and injecting slowly (over approximately 1 minute) can prevent patient discomfort during injection.

After the cocktail is administered, we routinely perform radial angiography using 5 mL of undiluted contrast through the sidearm of the sheath. The angiogram is useful to confirm radial and ulnar patency and to identify loops or other anatomic anomalies prior to introduction of larger-bore wires and catheters. When sheath position and radial patency is confirmed, the sheath should be fastened to the patient's wrist with a transparent adhesive dressing or suture to prevent inadvertent sheath removal during the procedure.

At the conclusion of the angiographic procedure, sheath removal should be performed in a methodical fashion. Hemostasis should be achieved using enough external compression to stop bleeding from the puncture site, while maintaining antegrade blood flow (patent hemostasis). To achieve patent hemostasis, an external hemostatic device should be applied to the patient's wrist and inflated until hemostasis is achieved (Figure 6A). Enough air should be removed from the system so that adequate antegrade flow is documented by

(Continued on page 36)

(Continued from page 31)

plethysmography (pulse oxymetry tracing derived from patient's ipsilateral thumb), while maintaining surface hemostasis. With the sheath removed and the compression bracelet in place, the patient is able to sit up immediately and move about freely (Figure 6B). Compression should be maintained for 60 to 120 minutes (up to 4 hours if glycoprotein IIb/IIIa inhibitors are used), with gradual release of pressure during this time. The compression device can be removed when hemostasis is visually confirmed.

CONCLUSION

Utilization and demand for radial access procedures in the United States is increasing. Cannulation of the radial artery should be accomplished using a systematic, stepwise approach. Operators should familiarize themselves and their cath lab staff with optimal patient setup and positioning, as well as radial-specific equipment. Increasing experience and familiarity with the radial technique will lead to shorter access times and higher rates of successful cannulation. ■

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