

Radial Access for Coronary Angiography and Percutaneous Coronary Artery Intervention

A step-by-step guide to this technique and best practices.

**BY RAMYA SMITHA SURYADEVARA, MD,
AND KIMBERLY SKELDING, MD, FACC, FAHA, FSCAI**

Coronary angiography and percutaneous coronary artery intervention are important tools for the diagnosis and treatment of coronary artery disease. Despite both technical and pharmacologic advances, bleeding and vascular complications remain problematic. Procedures can be performed via transradial, transfemoral, or transbrachial access. Although femoral access remains the dominant approach, life-threatening retroperitoneal bleeds, pseudoaneurysms, arteriovenous fistulas, and hematomas make this approach challenging. Brachial access, with complication rates mirroring transfemoral access, is predominantly utilized when neither radial nor femoral access is possible. The threat of limb loss from vascular injury or neurologic complications from ulnar nerve compression cannot be ignored with this access choice, and it has largely fallen out of favor.

With recent trials supporting the safety and decreased bleeding risk associated with the radial approach, radial access has become more popular,^{1,2} and conferences instructing on this technique are often standing room only.^{1,2} Recent studies show a trend toward improvement in outcomes of death and myocardial infarction,³ whereas previously, the data only supported decreased bleeding, early ambulation, and improved patient satisfaction.^{4,5} These data will continue to increase the number of operators choosing this approach as their default.

The first transradial central arterial catheterization and coronary artery imaging was described using radial artery cut-down and 8- to 10-F catheters,⁶ and in 1989, Campeau and Kiemeneij described the first successful attempts at transradial percutaneous coronary stenting.^{7,8} Radial access

is also currently being adopted for several other peripheral arterial interventions, such as renal, mesenteric, carotid, superficial femoral, and pediatric percutaneous procedures, with much success.⁹⁻¹² The radial artery ensures a safer route due to its lack of major adjacent nerves, presence of dual circulation, ample collaterals, and ease of compression.

CHALLENGES OF THE TRANSRADIAL APPROACH

Given the smaller size of the radial artery, one of the initial challenges is to achieve access. Multiple unsuccessful attempts at initial access will make spasm more likely and may increase the difficulty in manipulating catheters throughout the procedure. Narrow-caliber vessels can limit guide catheter size, although a surprising number of men will have a radial artery large enough to accept a 7-F catheter. Most interventions can be performed with a 6-F system, and sheathless systems are being used when sheath size is an issue.

In older patients and in patients with longstanding hypertension, subclavian stenosis may also, at times, challenge the novice radial operator. Hence, a learning curve for developing expertise in the transradial approach has been described.¹³ Procedure times may be longer in the early phases of transradial training, as well as increased operator exposure to radiation.¹⁴ However, once operators gain experience in the micropuncture technique and utilize a vasodilator regimen, very little difference is noted in the rates of successful radial procedures, time to complete the procedure, and radiation exposure.¹⁵ When converting from diagnostic angiography to angioplasty, low femoral crossover rates are noted.¹⁵⁻¹⁷



Figure 1. Modified Allen's test: ulnar and radial arteries compressed.

Overall, there is a large amount of evidence suggesting that the transradial approach is superior to the transfemoral approach because of lower complication rates, lower cost, and higher patient satisfaction. But adoption remains low in the United States due to challenges in obtaining the necessary training or interest in restarting a learning curve by experienced operators in order for this procedure to be equally successful. In this article, we describe a step-by-step approach for performing radial procedures to serve as a training tool to overcome some of the inherent challenges with this technique.

STEP 1: PATIENT SELECTION

Selecting appropriate patients for the procedure is the first step. The transradial committee of the Society for Cardiovascular Angiography and Interventions, in their executive summary, lists the following as ideal patient characteristics: patients with hemodynamic stability, age not older than 70 years, no history of transradial or brachial procedures on the same side, patients with a large palpable radial artery with a strong pulse, and normal results of an Allen's test.¹⁸ Relative contraindications to the radial approach are noted as an abnormal Allen's test result, the absence of a radial pulse, the presence of a severe vasospastic condition (such as Raynaud disease), a planned or present arteriovenous shunt for dialysis, the potential use of the radial artery as a conduit for aortocoronary bypass, and myocardial bypass procedures.¹⁸ Notably older, smaller women can be the most challenging subset to access but have the most to gain from this approach and should be the group to aspire to treat. In addition to this group, patients with severe peripheral vascular disease, lower extremity tortuosity, abdominal aortic aneurysms, and patients who request the procedure either due to severe



Figure 2. Modified Allen's test: pressure on the ulnar artery is released.

back pain, inability to lie flat, or desire to increase procedural safety, can also benefit from the radial approach.

STEP 2: VERIFYING COLLATERAL CIRCULATION

Prior to initiation of the procedure, an Allen's test (Figures 1 and 2) is used to assess whether there is adequate blood flow through the palmar arch and ulnar artery. An Allen's test could be performed through visual assessment or using a pulse oximeter. For performing an Allen's test with visual assessment, the patient should be asked to make a fist, pushing blood from the hand. The radial and ulnar arteries are simultaneously occluded. The patient is then asked to open the palm, which appears blanched. Ulnar artery release and return of pink hand color within 8 seconds suggests good blood flow.

An oximetric Allen's test, also called the *modified Allen's test*, is performed using a finger pulse oximeter and waveform plethysmography. The pulse wave is noted with both arteries open. The radial artery is compressed, and the pulse wave of ulnar flow is observed. The test is graded as type A if there is no change in pulse wave, type B if there is a dampened but distinct pulse wave, type C if there is loss of phasic pulse waveform that returns in 2 minutes, or type D if there is loss of waveform with no recovery in 2 minutes. A reverse Allen's test is performed in a manner similar to the Allen's test, but the radial artery is released first.

The modified Allen's test is recommended over the regular Allen's test because it is more sensitive,¹⁹ as well as objective, and hence should be routinely performed for all patients before the procedure. Patients with a type D result of a modified Allen's test should not undergo radial artery cannulation (a relative contraindication with type C). A reverse Allen's test should be performed in patients undergoing repeat radial artery cannulation. A reverse Allen's test

should also be performed using the pulse oximetric method. Patients with an abnormal result of a reverse Allen's test (type D) should not undergo a repeat radial artery procedure. The data to support the use of this test are sparse, thus its universal adoption among transradial operators has not occurred; however, it is currently the only objective clinical test available, and for medical-legal purposes, it should be documented.

STEP 3: PATIENT SETUP

Intravenous access should be performed in the contralateral arm, if possible, and a blood pressure cuff is placed on the contralateral arm or a leg. A pulse oximeter should be placed on the ipsilateral thumb. If a transradial board is used, the access arm can be placed to allow abduction of the arm. Commonly, the arm is placed next to the body supinated on a pillow to raise it to the level of the femoral access. This provides the operator the added ease of having the table utilized in the same manner as femoral procedures (Figure 3). Hyperextension of the wrist should be done by placing a rolled towel or splint-like device underneath the wrist, which makes the skin and subcutaneous tissues taut.

Early on, the femoral site should be prepared and draped to serve as a backup in case of access failure. Even after gaining sufficient experience, operators continue to prep the femoral artery site to allow balloon pump placement in the setting of acute myocardial infarction or cardiogenic shock, if necessary. A separate fenestrated drape or a readily available radial-specific drape is used to sterilely prepare and drape the radial site. The right radial artery is usually preferred because it is closer to where the operator is standing. A left radial artery approach is beneficial in cases of tortuous great arteries, shorter patients, and potentially in the setting of right mastectomy. The left radial approach provides better access to the left internal mammary artery and is easier to utilize in patients who have undergone coronary artery bypass grafting, although experienced operators can utilize the right radial approach for left internal mammary artery access as well. Patients undergoing radial access may have the most discomfort during sheath insertion and, if spasm should occur, with catheter manipulation and sheath removal. Conscious sedation needs to be titrated to address this discomfort proactively.

STEP 4: ACHIEVING RADIAL ACCESS

The skin and subcutaneous tissues are anesthetized with a small amount of lidocaine. Repeated trauma to the artery may cause spasm, hence every effort should be made to achieve access on the first attempt by careful planning and location of the vessel by palpation. A through-and-through puncture approach has been found to have a shorter



Figure 3. Arm positioning.

learning curve for beginners, but many operators continue to utilize the modified Seldinger technique exclusively for any access. If using the angiocatheter for a through-and-through puncture, it should be held at a 30° to 45° angle. The needle is advanced through the posterior wall of the artery after arterial blood flow is identified until flow stops. The plastic cannula is slowly pulled back until an arterial backflow of blood is identified after removing the needle.

STEP 5: SHEATH PLACEMENT AND CATHETER ADVANCEMENT

A small incision can be made on the skin over the needle after access, or before access after radial palpation, to facilitate insertion of the dilator and the sheath. Hydrophilic sheaths are preferred because they cause less trauma and are easy to insert and remove and may obviate the need for any incision. Sheaths with a highly pointed tip and 5- or 6-F sizes are recommended due to the narrow caliber of the artery. The sheaths should have a side arm to help with delivery of medications.

To reduce vascular tone and prevent arterial spasm, calcium channel blockers and/or nitrates should be administered; there are a number of "cocktails" utilized for this indication. One simple choice is 2.5 to 5 mg of verapamil, which must be diluted and infused slowly with continued hemodilution to decrease the warmth and burning sensation that can accompany this medication. Heparin can be given either intravenously or intra-arterially; no standardized dose has been studied, although the use of 5,000 units



Figure 4. Jacky catheter.

has been found to be sufficient to decrease the rate of radial occlusion. A smaller-caliber, J-tipped wire should be used to advance the catheter. Fluoroscopy should be deferred until resistance is met or until the catheter is in the subclavian artery.

STEP 6: ADVANCING THROUGH THE RADIOBRACHIAL REGION AND CHEST ARTERIES

If any resistance is noted during advancement of the wire or catheter, angiography should be performed, and if wire movement continues to meet resistance, radiobrachial angiography can be performed to identify if spasm, tortuosity, or if a radial loop is the culprit. Careful use of a hydrophilic wire for tortuosity or large loops is a reasonable first choice. The use of a single 0.014-inch wire to traverse and straighten the loop should be considered in cases of smaller loops in the radial artery. Use of a second wire or a hydrophilic catheter can also be attempted in the case of a difficult loop, but this should not be the approach for a novice operator until mastery of radial procedures without radial loops has been achieved.

In instances when difficulty is encountered in placing the wire into the ascending aorta and continued access to the descending aorta is achieved, the patient should be asked to take a deep breath to straighten and move the subclavian aortic junction downward. Hydrophilic 0.035-inch wires can also be used to direct catheters into the ascending aorta when significant subclavian tortuosity is identified. A thorough review of a transradial procedural atlas, such as *Patel's Atlas of Transradial Intervention: The Basics and Beyond*, is quite helpful for understanding the many anomalies one may come across when using the transradial approach and will help with planning once they are identified.²⁰

STEP 7: ENGAGING THE CORONARY ARTERIES

Specialized catheters for the transradial approach have been developed. Universal catheters (Jacky, Tiger, Sarah [Terumo Interventional Systems, Inc., Somerset, NJ], and Kimney [Boston Scientific Corporation, Natick, MA]) to engage the right and left coronary arteries, as well as to perform left ventriculography, can be used with a transradial approach (example of Jacky catheter in Figure 4). Right coronary arteries with an inferior take-off from the aorta may pose a problem due to the tendency to engage the conus branch; by introducing a 0.035-inch guidewire in the catheter and straightening the shaft of the catheter, the right coronary artery can be engaged. Traditional catheters, such as a JL, can be used with half-size downsizing. Guides such as extra backup (EBU, Medtronic, Inc., Minneapolis, MN) Voda (Boston Scientific Corporation) can be used for intervention via the transradial approach with good support. Each catheter company has developed (or is developing) a toolbox of transradial catheters, which can be confusing to the novice operator. Choosing a few catheters to learn the technique and gain mastery is a good plan prior to the utilization of exceedingly specialized catheters.

STEP 8: SHEATH REMOVAL AND POSTPROCEDURE HEMOSTASIS

The vascular sheath should be removed after completion of procedure without delay. Once the sheath is removed, bleeding from the radial artery should be seen, and a radial artery band should be placed immediately. Nonocclusive (ie, patent) hemostasis is the key for achieving a balance between hemostasis and continued arterial flow by applying optimal pressure.²⁰ A HemoBand (HemoBand Corporation, Portland, OR) should be placed around the forearm at the site of entry when the sheath is retracted to a distance of 4 to 5 cm. The needle cap and gauze composite should be placed over the site of entry.

The sheath is removed after the HemoBand is tightened until the ipsilateral ulnar artery is occluded (noted by absence of plethysmographic signal on the pulse oximeter). The HemoBand is then released until a plethysmographic signal returns or bleeding occurs. If bleeding occurs at the pressure needed to maintain patency, manual compression should be used.²¹ Patency of the radial artery should be checked at least every hour. It is recommended to apply hemostasis for at least 30 minutes for diagnostic procedures and for 90 minutes to 2 hours for interventions.

CONCLUSION

Despite the learning curve, radial artery access can be easily mastered. Therefore, further training resources need to be made available to current and future cardiologists. ■

Ramya Smitha Suryadevara, MD, is a cardiology fellow in the Department of Cardiology, Geisinger Medical Center in Danville, Pennsylvania. The author has no financial interests.

Kimberly Skelding MD, FACC, FAHA, FSCAI, is Director of Cardiovascular Research and Cardiovascular Genomics, Department of Cardiology, Geisinger Medical Center in Danville, Pennsylvania. The author has no financial interests. Dr. Skelding may be reached at kskeldingmd@yahoo.com.

1. Jolly SS, Amlani S, Hamon M, et al. Radial versus femoral access for coronary angiography or intervention and the impact on major bleeding and ischemic events: a systematic review and meta-analysis of randomized trials. *Am Heart J*. 2009;157:132-140.
2. Brueck M, Bandorski D, Kramer W, et al. A randomized comparison of transradial versus transfemoral approach for coronary angiography and angioplasty. *JACC Cardiovasc Interv*. 2009;2:1047-1054.
3. Pristipino C, Trani C, Nazzaro MS, et al. Prospective registry of vascular access in interventions in Lazio Region Study Group. Major improvement of percutaneous cardiovascular procedure outcomes with radial artery catheterisation: results from the PREVAIL study. *Heart*. 2009;95:476-482.
4. Louvard Y, Lefevre T, Allain A, et al. Coronary angiography through the radial or the femoral approach: the CARAFE study. *Catheter Cardiovasc Interv*. 2001;52:181-187.
5. Molinari G, Nicoletti I, De Benedictis M, et al. Safety and efficacy of the percutaneous radial artery approach for coronary angiography and angioplasty in the elderly. *J Invasive Cardiol*. 2005;17:651-654.
6. Radner S. Thoracic aortography by catheterization from the radial artery; preliminary report of a new technique. *Acta Radiol*. 1948;29:178-180.
7. Campeau L. Percutaneous radial artery approach for coronary angiography. *Cathet Cardiovasc Diagn*. 1989;16:3-7.
8. Kiemeny F, Laarman GJ. Percutaneous transradial artery approach for coronary stent implantation. *Cathet Cardiovasc Diagn*. 1993;30:173-178.
9. Casserly IP. Trans-radial treatment of in-stent stenosis of the superficial femoral artery—the importance of case selection. *Catheter Cardiovasc Interv*. 2009;74:499.
10. Raghu C, Louvard Y. Transradial approach for percutaneous transluminal angioplasty and stenting in the treatment of chronic mesenteric ischemia. *Catheter Cardiovasc Interv*. 2004;61:450-454.
11. Folmar J, Sachar R, Mann T. Transradial approach for carotid artery stenting: a feasibility study. *Catheter Cardiovasc Interv*. 2007;69:355-361.
12. Davenport JJ, Lam L, Whalen-Glass R, et al. The successful use of alternative routes of vascular access for performing pediatric interventional cardiac catheterization. *Catheter Cardiovasc Interv*. 2008;72:392-398.
13. Louvard Y, Lefevre T, Monice MC. Radial approach: what about the learning curve? *Cathet Cardiovasc Diagn*. 1997;42:467-468.
14. Brasselet C, Blanpain T, Tassin-Mangina S, et al. Comparison of operator radiation exposure with optimized radiation protection devices during coronary angiograms and ad hoc percutaneous coronary interventions by radial and femoral routes. *Eur Heart J*. 2008;29:63-70.
15. Guédès A, Dangois V, Gabriel L, et al. Low rate of conversion to transfemoral approach when attempting both radial arteries for coronary angiography and percutaneous coronary intervention: a study of 1,826 consecutive procedures. *J Invasive Cardiol*. 2010;22:391-397.
16. Kiemeny F, Laarman GJ, Odekerken D, et al. A randomized comparison of percutaneous transluminal coronary angioplasty by the radial, brachial and femoral approaches: the access study. *J Am Coll Cardiol*. 1997;29:1269-1275.
17. Jolly SS, Niemelä K, Xavier D, et al. Design and rationale of the radial versus femoral access for coronary intervention (RIVAL) trial: a randomized comparison of radial versus femoral access for coronary angiography or intervention in patients with acute coronary syndromes. *Am Heart J*. 2011;161:254-260.e1-4.
18. Caputo PR, Tremmel JA, Rao SR, et al. Transradial arterial access for coronary and peripheral procedures: executive summary by the Transradial Committee of the SCAI. *Catheter Cardiovasc Interv*. 2011;78:823-839.
19. Barbeau GR, Arseneault F, Dugas L, et al. Evaluation of the ulnopalmar arterial arches with pulse oximetry and plethysmography: comparison with the Allen's test in 1010 patients. *Am Heart J*. 2004;147:489-493.
20. Patel T, Shah S, Pancholy S. Patel's Atlas of Transradial Intervention: The Basics and Beyond. Malvern, PA: HMP Communications; 2012.
21. Pancholy S, Coppola J, Patel T, Roke-Thomas M. Prevention of radial artery occlusion—patent hemostasis evaluation trial (PROPHET study): a randomized comparison of traditional versus patency documented hemostasis after transradial catheterization. *Catheter Cardiovasc Interv*. 2008;72:335-340.