Transradial Cardiac Catheterization and Intervention—Observations on Its Place in the Catheterization Laboratory

George T Broderick, Jr, MD, FACP, FACC, FSCAI

The use of the radial artery to achieve vascular access to perform cardiac catheterization and percutaneous coronary intervention is an inherently appealing approach, with its potential to improve patient satisfaction and lower bleeding complications. Transradial catheterization has been employed for over 20 years, yet it is still not practiced frequently in most catheterization centers in the US. Currently, only 1–3% of coronary catheterizations in the US are performed transradially,[1] but many operators are using this approach in the overwhelming majority of their procedures. There is seemingly a strong reticence in the US for operators to take up the gauntlet of transradial catheterization, most likely related to an underestimation of the benefits to patients in its use and an exaggerated concern about the learning curve in acquiring expertise in the technique. Operators who are quite comfortable using the femoral approach and who do not perceive that the approach is associated with an excess of vascular complications in their hands see little reason to take on the 'burden' of learning the technique, mastering the anatomic differences inherent in transradial access, and becoming comfortable with its use. Fortunately, the learning curve for experienced operators is not steep and, with persistence and dedication, operators can quickly become adept in the transradial technique.

Transradial catheterization and percutaneous intervention have definite advantages in terms of patient comfort and satisfaction, in addition to easing nursing and post-procedure care and reducing the rate of vascular complications. There are pitfalls with the technique, such as difficulty in gaining access through tortuous vascular anatomy and difficulties in adequate guide support and coronary cannulation, but with increasing operator experience these problems can be minimized. Establishing a successful transradial cardiac catheterization program can be a boon for patients and staff as well as the operator. The safety of this approach has been consistently demonstrated compared with femoral access, and this benefit as well as patient convenience is driving the push toward transradial access.

Patient Selection and Access

Although experienced transradial operators can successfully perform most coronary interventional procedures, initial patient selection is critical in facilitating the learning curve and leading to early success in learning the technique. The initial selected patients should be stable patients without acute coronary syndromes who are less than 70 years of age with an easily palpable radial pulse and who are not small in stature. Elderly patients, especially those with a long history of hypertension, can have tortuous subclavian systems that make entrance into the ascending aorta and cannulation of the coronary ostia problematic. Small, thin elderly patients in general will have smaller radial arteries that make initial access more challenging. Middle-aged larger males with excellent radial pulses make the ideal candidates for initial radial training. It is also prudent to perform initial percutaneous interventional procedures on more straightforward anatomic situations and avoid chronic occlusions, complex bifurcations, and cases in which guide support is difficult to obtain.

- Associate Clinical Professor of Medicine, Wright State University School of Medicine, Dayton, OH, and Medical Director of Cardiology, Good Samaritan Hospital, Dayton, OH
- Correspondence: E: gidge3241@sbcglobal.net

Figure 1: 5Fr Sheath Introducer Kit with Vasodilator Cocktail

Figure 2: Inserting the Angiocatheter Through the Radial Artery

Absence of a palpable radial pulse is a contraindication to transradial catheterization. The modified Allen's test is used to establish the presence of a well functioning collateral arch system in the hand between the radial and ulnar arteries.[2] While palpating and then obliterating both the radial and ulnar pulses, the patient clenches his or her fist until skin blanching occurs and then, with the release of ulnar pressure, the time until normal skin color returns to the palm is measured, which is normally within seven seconds. Some laboratories also use a modified technique using pulse oximeter oxygen saturation (SpO_2) with finger plethysmography. Practically, the modified Allen's test is a fast and accurate technique to establish an appropriate collateral circulation in the hand in order to be able to proceed with transradial catheterization.

The radial artery is prone to vasospasm due to its high level of alpha-1 adrenoceptors.[3] Adequate sedation of the patient seems to lower the chance of radial artery spasm. Radial artery spasm can occur in 3–20% of cases, but is markedly reduced if there is direct injection of vasodilator cocktails after arterial access is obtained. Typically, a cocktail of 3,000 units of heparin, 1,500ucg of verapamil, and 120ucg of nitroglycerin is injected through the inserted sheath. Some operators inject up to 2–3mg of verapamil. This injection lowers the chance of spasm and radial artery occlusion. Radial artery occlusion is the most common complication of radial artery access and may occur 3–9% of the time.[4] Heparin delivered either intravenously or through the arterial sheath lowers the chance of radial artery occlusion. In general, radial artery occlusion is well tolerated. Repeat access can frequently be obtained in the same radial artery during the same admission in the rare chance of a staged procedure if the modified Allen's test is normal and there is a persistent good radial pulse.

The right radial artery is normally used for access due to operator convenience with the typical catheterization table set-up. The left radial artery can be used, but often can be an inconvenience for operator and patient given the need for adduction of the left arm across the patient's torso. This can be difficult in patients who are overweight. Surgeons who use radial conduits for coronary bypass procedures will generally use the non-dominant hand, and this requirement needs to be taken into consideration when planning the procedure.

Our laboratory has found that placing a rotating arm board under the shoulder extending out under the arm facilitates ease of movement and placement of the radial sheath. The arm and wrist can be conveniently abducted to allow the operator to easily obtain radial access, and then to allow adduction of the arm to enable the procedure to continue. We also have found that a two foot by three foot Plexiglas board placed under the patient and extending out toward the operator from the table allows enough room to work with the diagnostic and interventional equipment, and is more convenient for the operator and technologist.

Various catheter companies now make convenient radial sheath kits in 5 and 6Fr sizes. These kits come with hydrophilic-coated sheaths with more graduated introducers to limit radial artery spasm and facilitate introduction, various micropuncture needles or small-gauge intravenous catheters to puncture the radial artery to gain initial access, and an 0.018-inch guidewire (see *Figure 1*). With the wrist in

the hyper-extended position, a very small amount of lidocaine is injected at the radial pulse site. It is important to attempt cannulation 1–2cm proximal to the flexor crease and radial stylus. Using the small-gauge intravenous catheter in the kit, most operators puncture through the anterior to the posterior wall of the radial artery, remove the needle, and slowly pull back the plastic catheter until vigorous backflow of blood is seen (see *Figures 2* and *3*). Next, the 0.018-inch guidewire is inserted. The guidewire should be rotated while being inserted to avoid the occasional inadvertent insertion into a side branch, which rarely can lead to a small perforation. A 5 or 6Fr sheath is inserted over the wire, and the vasodilator cocktail is then given intra-arterially. The patient's arm is then placed in the adducted position; the operator inserts a diagnostic catheter over a 0.035-inch guidewire and slowly advances the wire and catheter into the subclavian artery and the ascending aorta (see *Figures 4* and *5*).

Right heart venous catheterization can be performed simultaneously through the cephalic or brachial vein or one of their branches using the identical 5Fr guidewire kit used for radial access. Numerous companies supply 5Fr flow-directed balloon catheters that can be used for right heart catheterization. Judicious use of small injections of intravenous contrast often helps with passage of catheters through the peripheral venous system to the right heart. Patients can be fully evaluated for valvular disease such as aortic stenosis or pulmonary hypertension through arm access at the same time as the left heart is being evaluated transradially. This approach can be especially gratifying in elderly patients with aortic stenosis and severe peripheral vascular disease.

Post-procedure, the sheath is removed in the catheterization laboratory; most operators now use various compression devices such as the Terumo TR Band to facilitate sheath removal and hemostasis (see *Figures 6–8*). Patients can literally walk out of the laboratory with no sedation considerations. The compression devices, which have markedly contributed to patient and nursing satisfaction, are removed after one to two hours depending on whether an intervention was performed. Patients who have had coronary procedures from both the femoral and radial approaches overwhelmingly prefer the radial approach due to its advantageous effects on bleeding, lack of access-site discomfort, minimal back and leg pain, and ambulation.

Peripheral Anatomic Considerations

Once radial access is obtained, placement of coronary catheters over a 0.035-inch guidewire through the radial, brachial, axillary, and subclavian arteries into the ascending aorta overwhelmingly goes smoothly. Certain anatomic considerations and anomalies, however, can make gaining access into the ascending aorta problematic. Anatomic variations of the radial and axillary arteries are not uncommon[5] and can contribute to unsuccessful radial catheterization. Tortuous radial arteries, radial artery spasm, rare radial artery atherosclerosis, radioulnar loops, and tortuous subclavian systems can all contribute to difficulty in accessing the ascending aorta and, ultimately, the coronary tree.

Figure 3: Slowly Withdrawing the Catheter After Needle Removal—Excellent Blood Flow Is Obtained, and the 0.018-inch Guidewire Is Inserted

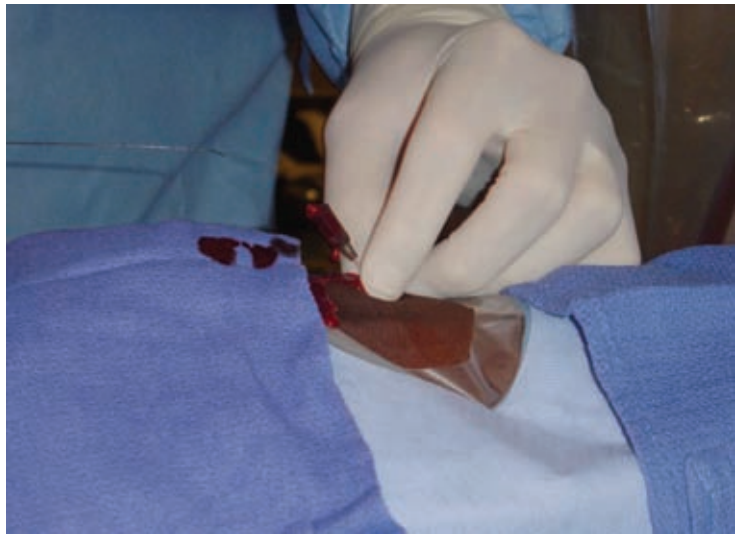

Figure 4: After the Sheath Is Inserted and the Vasodilator Cocktail Is Injected, the Catheter Can Be Inserted Over a 0.035-inch Guidewire into the Ascending Aorta

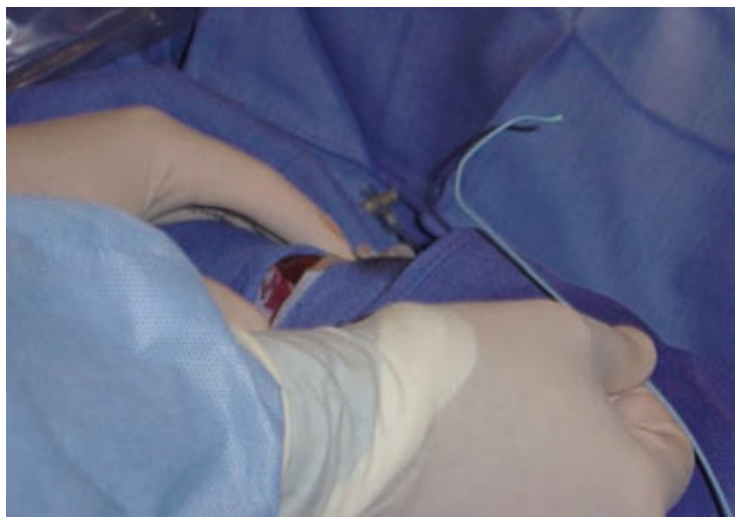

Figure 5: The Catheter Is Advanced into the Ascending Aorta Over the 0.035-inch Guidewire

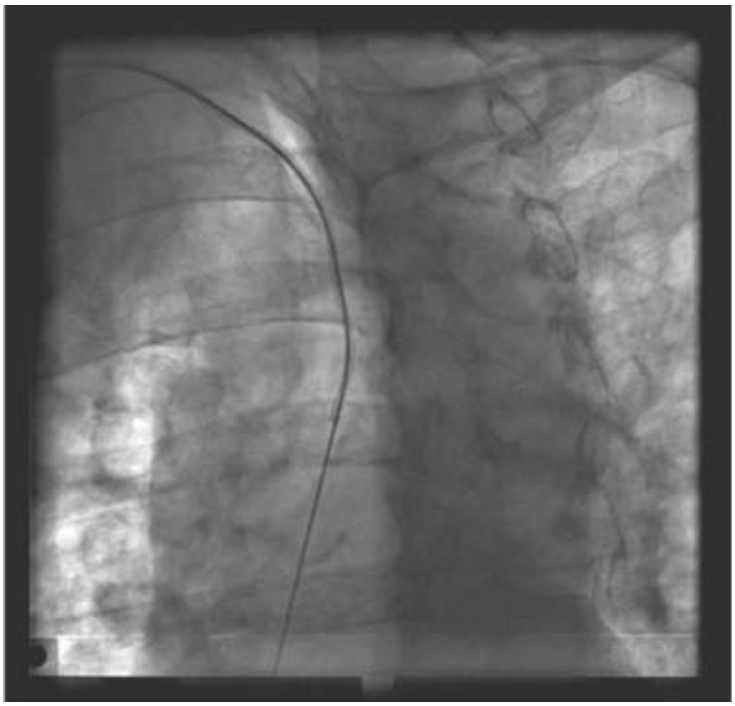

Figure 6: The Terumo TR Band Is Placed Over the Radial Access Site at the End of the Procedure with the Patient Under Full Anticoagulation

Radioulnar loops can occur in up to 2% of patients[6] and occur as a loop near the site where the radial joins the ulnar artery to form the brachial artery. The loop can be quite problematic and usually a 0.035-inch guidewire will not pass through it. It is important for the operator to always slowly advance the initial guidewire placement through the radial and brachial system to avoid damaging and causing perforations in small side branches or radioulnar loops. Frequent use of small dye injections with angiography of areas where the wire cannot pass easily will allow for passage of 300cm 0.014-inch percutaneous transluminal coronary angioplasty (PTCA) guidewires such as the Runthrough or BMW wires, which usually can be advanced easily through radioulnar loops or tortuosities, allowing subsequent passage of coronary catheters. Typically, the radioulnar loop will straighten out and further coronary angiography and intervention can be easily performed.

The subclavian artery can be tortuous, especially in elderly hypertensive females. Having the patient take a breath usually straightens out the subclavian/innominate artery junction descending into the ascending aorta and allows for its access. Care must be taken not to push the wire or catheter aggressively near the innominate/aortic junction as rarely dissections and embolization have occurred. Once ascending aorta access has been obtained, all catheters should be exchanged from the aorta with a 260cm 0.035-inch exchange wire to avoid trauma or spasm in the radial and brachial system. Surprisingly, after obtaining aortic access through a tortuous radial system or radioulnar loop, intervention can still easily be performed due to the ease and straightening out of the radial arterial system. It is important to use exchange wires when removing angulated catheters such as a pigtail catheter or left internal mammary artery (LIMA) catheter, as these catheters can cause damage to the radial system during abrupt removal.

Diagnostic and Interventional Catheters

Most operators will initially use a 5Fr sheath and catheters for initial angiography. The Jacky catheter from Terumo has a double angle and side holes and can be used for left ventriculography, ascending aortography, or coronary angiography, allowing the operator to use one catheter for the diagnostic procedure. The catheter can be a little tough to manipulate at times, especially given the 5Fr size, and while learning the operator may use a typical Judkins left 3.5 or 3.0 catheter and a Judkins right 4.0 catheter. Over time, operators will use most of the diagnostic catheters normally utilized in the femoral system, including EBU, XB, and Amplatz designs. Cannulating the coronary ostia is more challenging using the radial approach, but the operator rapidly becomes experienced in the nuances of engaging the ostia. Occasionally, inadequate engagement necessitates subsequent femoral access to complete the procedure, but this situation becomes markedly less frequent with continued experience.

Percutaneous intervention is now typically performed through 6Fr systems; not uncommonly, after diagnostic catheterization with a 5Fr system the sheaths are exchanged for a 6Fr system. Given the technical advances in 5Fr interventional guides and advanced delivery options with newer stent platforms, many straightforward interventional cases can be performed with 5Fr guides. Operators need to closely evaluate issues of guide support, coronary calcification, and tortuosity and angulation before proceeding with 5Fr systems for intervention from the radial site. If there are any questions concerning guide support or device delivery, a 6Fr system should be used. Operators have performed quite advanced interventional procedures transradially, including directional rotablation, complex bifurcation procedures, left main interventions, and chronic occlusions.[7,8] Rarely, 7Fr systems can be used in larger patients, but in general this is avoided. During the learning curve it is not uncommon for operators to perform diagnostic angiography transradially and find technical and anatomic characteristics of the coronary anatomy that suggest a concomitant femoral approach for intervention is warranted. These situations markedly disappear with increasing operator clinical transradial experience.

As the operator gains increasing experience, progressively complex procedures can be attempted. It is imperative, however, for the operator to always be aware of the balance between intervening in a complex anatomic situation from a transradial versus femoral approach and making sure he or she is comfortable with the decision to intervene from the site that is safest for the patient while also ensuring a successful procedure.

Vascular Complications—Femoral versus Radial

Although transradial catheterization and coronary intervention are associated with increased rates of patient satisfaction and convenience, the main importance of the use of the radial access site is the significant reduction in vascular complications that can be obtained with its use. Recent interventional clinical trials over the last decade have consistently shown the importance of bleeding and vascular complications for overall clinical morbidity and mortality. The importance of bleeding complications is currently a major focus of interpretation of clinical interventional trials, and the continued aggressive approach to limiting these important complications highlights the distinct advantage transradial percutaneous intervention offers to patients.

The radial artery is easily compressible as it sits just anterior to the radius bone. Bleeding and vascular complications are significantly reduced using the transradial approach. Several observational and randomized trials have demonstrated the superiority of transradial over femoral access in terms of vascular and bleeding complications. Brueck and colleagues performed a randomized trial of patients undergoing cardiac catheterization and coronary interventions, looking at outcomes and vascular complications. One thousand and twenty-four patients were randomized on a one-to-one basis to either radial or femoral artery access. Vascular complications were higher in the femoral access group (3.71%) versus the transradial approach (0.58%; p=0.0008).[9] Vascular complications are particularly dangerous for elderly patients, and the prospective comparison of transradial and

Figure 7: The Sheath Is Withdrawn After Inflation of the TR Band

Figure 8: The TR Band Deployed and the Patient Ready to Ambulate

transfemoral approaches for coronary angiography and angioplasty in octogenarians (OCTOPLUS) study reported on octogenarians undergoing cardiac catheterization and intervention via either the femoral or radial approach.[10] Patients were randomized to the femoral approach (n=185) versus the radial approach (n=192). By intention-to-treat analysis, the incidence of vascular complications was significantly lower in the radial group (1.6 versus 6.5%; p=0.03).

The persistent and significant reductions in bleeding and vascular complications alone should be a critical driver in having interventional cardiologists strongly consider using the transradial access technique. One difficulty may be that most operators do not perceive that these vascular complication data relate to their anecdotal clinical experience. Operators may also conclude that the improvement in vascular complications is not significant enough that the extra effort in learning transradial intervention would have an overall effect on their clinical outcomes. More education in the cardiology community is needed to improve patient access to this safer approach to coronary intervention.

Transradial Pitfalls and Complications

Transradial cardiac catheterization and intervention are not without limitations. Although patient satisfaction is higher, bleeding and vascular complications are lower, and length of stay and nursing satisfaction are higher, there can be problems with the technique. The procedure can be associated with a higher use of intravenous contrast and, at times, a greater use of radiation and fluoroscopy. Success rates are generally slightly lower than with transfemoral access, although this varies markedly with operator experience. This slight variation in success rates compared with the two vascular approaches is probably the major reason operators are reticent about becoming radialists. Lower-volume operators probably do not wish to devote the time to learning a new method of vascular access with its attendant difficulties compared with the ease of transfemoral access. Rarely, vascular complications such as arm hematomas and compartment syndromes can occur, usually from aggressive wire advancement causing perforation of a radial or brachial artery or one of their side branches. This is a rare complication, with a reported incidence of 0.4%,[11] although rarely it can be hypothesized to be caused by diffuse radial artery spasm. Rare sterile or infected abscesses have been reported at the site of radial sheath removal.

Conclusion

Transradial cardiac catheterization and coronary intervention has been in use for over 20 years and is associated with improved patient satisfaction, shorter time to patient ambulation, easier nursing care, and lower bleeding and vascular complications compared with femoral access. The use of transradial access by operators in the US is still very low, although this will change with increased physician and patient education and awareness of the distinct advantages of transradial access. Establishing a transradial program or becoming a radialist requires commitment and dedication on the part of the cardiac catheterization laboratory administrators, staff, and physicians, but the advantages pay off in the end in terms of the procedure's numerous advantages. The use of transradial cardiac catheterization and intervention will continue to increase in the US and internationally as physicians and patients become more aware of the benefits it brings. ■

1. Rao SV, Ou FS, Wang TY, et al., Trends in the prevalence and outcomes of radial and femoral approaches to percutaneous coronary intervention: a report from the National Cardiovascular Data Registry, *JACC Cardiovasc Interv*, 2008;1(4):379–86.
2. Patel T, Shah S, Ranjan A, *Patel's Atlas of Transradial Intervention: The Basics*, Seattle: Seascript Company, 2007;1:2–5.
3. He GW, Yang CQ, Characteristics of adrenoceptors in the human radial artery, *J Thorac Cardiovasc Surg*, 1998;115:1136–41.
4. Kern MJ, Cardiac catheterization on the road less traveled: navigating the radial versus femoral debate, *JACC Cardiovasc Interv*, 2009;2:1055–6.
5. Lo TS, Nolan J, Fountzopoulos E, et al., Radial artery anomaly and its influence on transradial coronary procedural outcome, *Heart*, 2009;95(5):410–15.
6. Valsecchi O, Vassileva A, Musumeci G, et al., Failure of transradial approach during coronary interventions: anatomic considerations, *Catheter Cardiovasc Interv*, 2006;67:870–78.
7. Prasad SB, Malaiapan Y, Ahmar W, Meredith I, Transradial left mainstem rotational atherectomy and stenting: Case report and literature review, *Cardiovasc Revasc Med*, 2009;10(2):136–9.
8. Ziakes A, Klinke P, Mildenberger R, et al., Comparison of radial and femoral approaches in left main PCI: A retrospective study, *J Invasive Cardiol*, 2004;16(3):129–32.
9. 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(110):1047–54.
10. Louvard Y, Benamer H, Garot P, et al., Comparison of transradial and transfemoral approaches for coronary angiography and angioplasty in octogenarians (the OCTOPLUS study), *Am J Cardiol*, 2004;94:1177–80.
11. Araki T, Itaya H, Yamamoto M, Acute compartment syndrome of the forearm that was not caused by bleeding or hematoma formation, *Catheter Cardiovasc Interv*, 2010;75(3):362–5.