Effectiveness and safety of transradial artery access for cardiac catheterization

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The transradial approach for coronary angiography and angioplasty, while not new, is gaining momentum again as a viable alternative to the transfemoral approach. While technically it may have some challenges, there are significant benefits including reduced patient discomfort, improved time to ambulation, reduction in costs, and reduction in potentially life-threatening complications. The technique is not difficult to learn, and the equipment is similar to that used in more traditional approaches. To expand awareness of this method, this article discusses the history of the technique, reviews the data comparing it to the more widely used transfemoral technique, and discusses some of the experience at Baylor University Medical Center at Dallas, where this approach has been gaining popularity.

In 2007, over 1 million diagnostic coronary angiograms and over 1 million coronary angioplasties were performed (1). Since this is an invasive procedure, there are risks including (but not limited to) death, stroke, and bleeding. The risk of a life-threatening complication is low, roughly 1 in 1000 (2, 3). This overall risk has remained stable over the last few decades, despite increased utilization of blood thinners and ad hoc angioplasty as a commonplace occurrence (4). The most common complication associated with coronary angiography is bleeding at the access site (5). Since most coronary angiograms are performed through the transfemoral technique, most of the bleeding complications that are seen tend to be related to femoral access. Arterial access through the transradial approach was described in the late 1980s for both diagnostic angiography and percutaneous coronary intervention (PCI) (6, 7). Lately, this technique has been gaining acceptance from the interventional community as an alternative to traditional femoral access (8). This report focuses on the advantages of the transradial over the transfemoral approach.

THE RADIAL TECHNIQUE

Unlike transbrachial artery access, with transradial access there is less of a chance of limb-threatening damage since there is usually adequate collateral blood supply from the ulnar artery to the palmar arch *(Figure 1)*. Prior to accessing the radial artery, Allen's test can be helpful for evaluating patency of ulnar artery circulation (9). To perform this test, the patient's radial and ulnar arteries are compressed and then the patient is asked to make a tight fist with that hand. This compresses the blood from the hand and blanches the palm. The ulnar artery is then released, and the time it takes for the hand to return to a normal color is measured. Typically, the test is considered "positive" or "normal" when the time to return of normal color is 5 or 6 seconds (10). This test can be performed using plethysmography, which is useful in patients with darker-colored skin or in patients whose radial or ulnar pulses are difficult to accurately palpate (11).

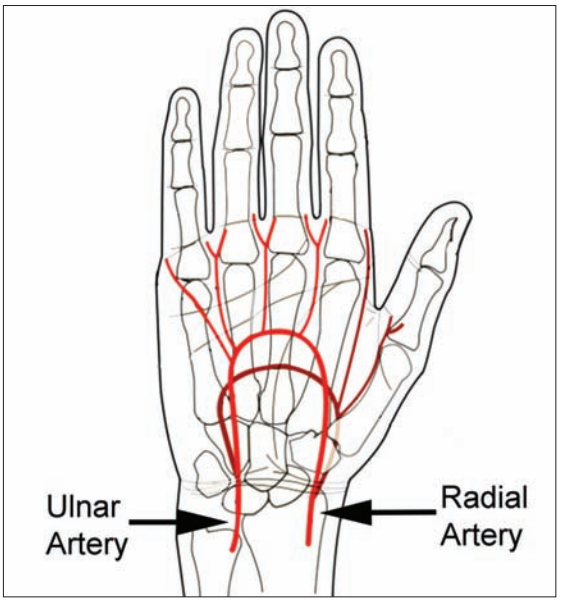

Figure 1. The dual circulation of the hand, with arterial flow from both the radial artery and the ulnar artery. If a patient were to incur damage to the radial artery, there is less chance of significant vascular compromise of the hand due to collateral arterial flow through the ulnar artery.

Patients are placed in a standard supine position on the catheterization lab table. Their right arm is placed immobilized and the wrist is hyperextended and then draped in

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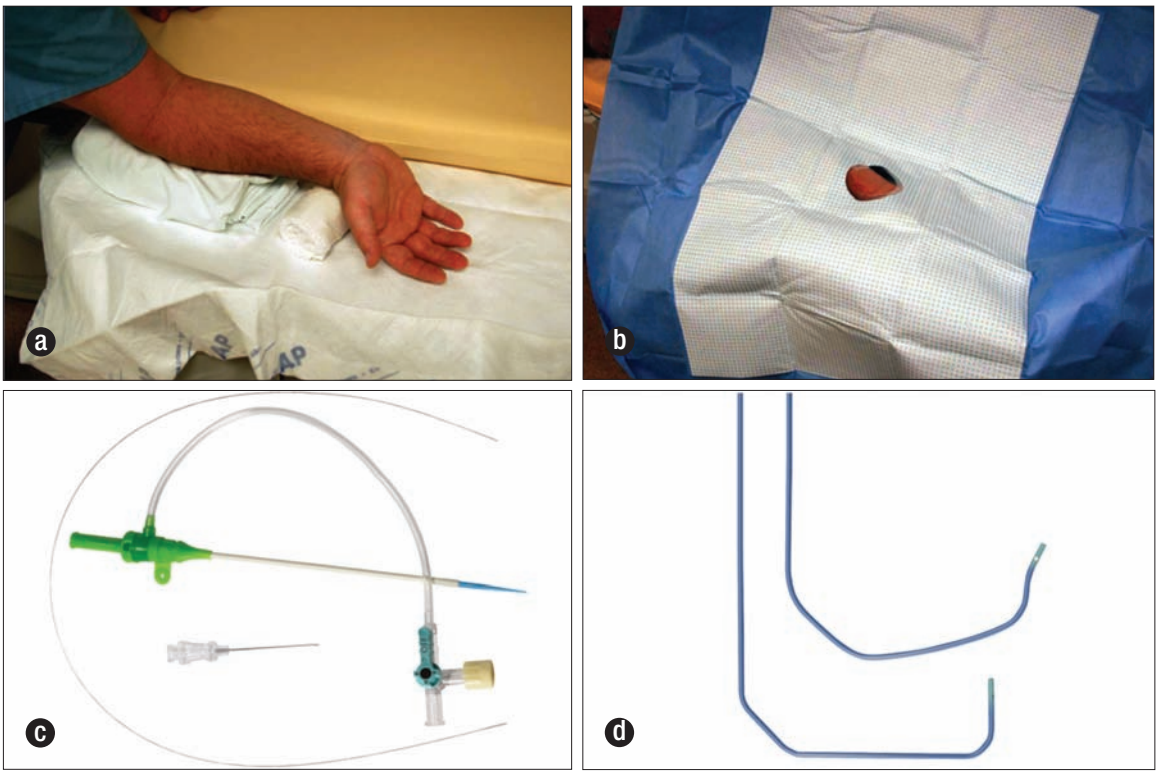

Figure 2. (a) For coronary catheterization, the patient's arm is placed on a side board (e.g., Rad Board pictured), and the wrist is supported and hyperextended to expose the radial artery. **(b)** The wrist is sterilely prepared and draped with a separate fenestrated drape. **(c)** A micropuncture kit is used with a highly tapered, hydrophilic sheath, which reduces the trauma of insertion and removal. **(d)** Newer-shaped catheters have been developed that allow a single catheter to be used for ventriculography as well as right and left selective coronary injections. (Images courtesy of Radial Assist, Roswell, GA, and Terumo Cardiovascular, Ann Arbor, MI.)

sterile fashion *(Figures 2a and 2b)*. The radial artery is accessed using a direct or modified Seldinger technique, and a sheath is inserted over a guide wire using a vascular micropuncture kit and a highly tapered, hydrophilic sheath *(Figure 2c)* (12). Hydrophilic sheaths make both insertion into the artery and removal much less traumatic than with traditional arterial sheaths (13).

The right radial artery is usually accessed, as it is closer to where the operator is standing. Accessing the left radial artery is equally feasible and may be less challenging when the great arteries are tortuous (14). For patients who have had previous coronary bypass grafting, the left radial approach provides better access to the left internal mammary artery (15).

Once the sheath is in place, the patient is given medication to reduce spasm as well as anticoagulants to reduce the chance of thrombosis. Medications that seem to work best to reduce spasm include either verapamil (up to 5 mg) or nitroglycerine (50–100 mcg) given directly through the sheath into the radial artery immediately after sheath insertion (16). Heparin reduces the chances of thrombosis, and it doesn't seem to matter if it's given through the access sheath or systemically (17). Standard dosing regimens have included weight-based approaches (50–70 U/kg up to 5000 U maximum) and weight-independent approaches (3000–5000 U) (16–18). Anticoagulants such as bivalirudin seem to be as effective as heparin in reducing thrombotic events (18).

After the patient receives drugs to reduce arterial spasm and thrombosis, diagnostic catheters are inserted and coronary angiography or angioplasty can be performed. In patients who are particularly tall, longer catheters (>110 cm) may be necessary because the distance between the wrist and the coronaries is greater than from the femoral artery to the heart. Coronary catheters that are shaped for use through the femoral artery approach may be used from the wrist. A number of specially shaped catheters *(Figure 2d)* have been created, which enable the operator to obtain both left and right coronary angiograms as well as a ventriculogram without having to switch to a different catheter *(Figure 3)*.

COMPARISON BETWEEN THE TRANSRADIAL AND TRANSBRACHIAL TECHNIQUES

Transbrachial access has a success rate similar to that of transradial approaches (19). However, it is technically more difficult if a cutdown is used, and theoretically there is less risk of limb ischemia with the radial approach (20).

COMPARISON BETWEEN THE TRANSRADIAL AND TRANSFEMORAL TECHNIQUES

Compared with the transfemoral approach, the biggest benefit of the transradial technique is the *reduction of access site complications*. Metaanalyses of smaller trials have suggested reductions in bleeding, as well as trends towards reductions in myocardial ischemic events and death due to these bleeding reductions (21). Patients who underwent coronary procedures through the radial artery had a statistically significant reduction in both major and minor bleeding (4.2% vs 1.96%, $P = 0.03$) and death or myocardial infarction (3.1% vs 0.6%, $P = 0.005$) (22). This reduction of bleeding was present when patients were randomized to either radial or femoral artery access and was even more dramatic in patients who were sickest (e.g., acute

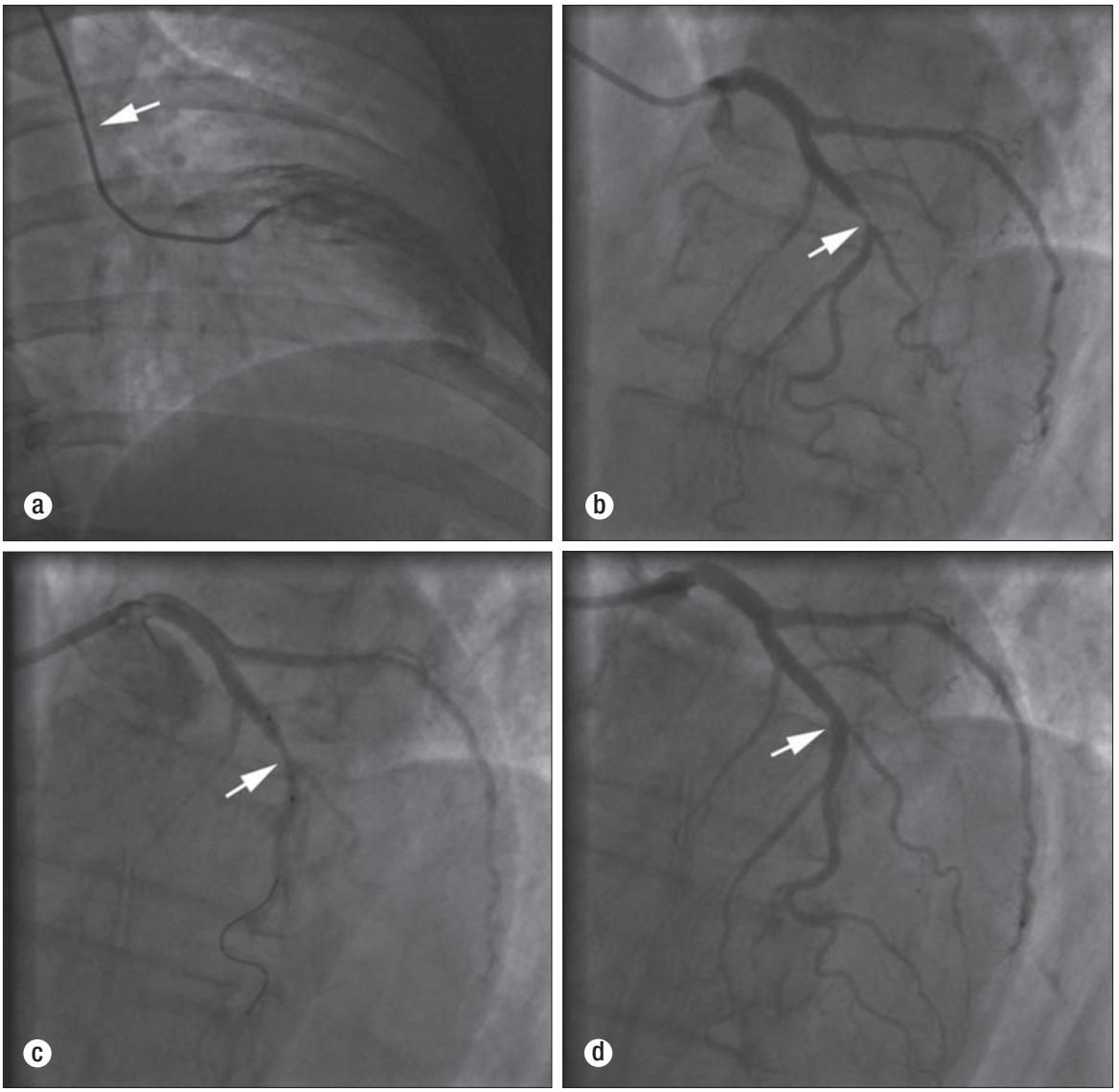

Figure 3. An example of a cardiac catheterization performed through the radial artery approach. **(a)** A ventriculogram is performed using a multi-purposed catheter. **(b)** The same catheter is used to perform selective coronary injection, which shows a high-grade lesion (arrow) in the left anterior descending artery. **(c)** A standard guiding catheter is used through the radial artery approach, through which a stent is placed across the coronary lesion (arrow). **(d)** The final result of the coronary intervention is good, without residual stenosis. Even with anticoagulation for the coronary intervention, there is no risk of groin complications and a minimal requirement for bed rest, as the entire procedure was performed through the wrist.

myocardial infarctions) and patients who were the most heavily anticoagulated (23–27).

The second benefit from the transradial approach is *patient satisfaction*. Since patients need not remain flat (as required after femoral access), they tend to have less overall discomfort related to their procedure, and this is reflected in improved satisfaction (28, 29).

CHALLENGES WITH TRANSRADIAL PROCEDURES

One of the biggest concerns about performing cardiac catheterization through the radial artery is obtaining access. The technique is similar to the transfemoral technique, but given the smaller size of the radial artery and the tendency of the radial artery to spasm, it is sometimes harder to place a sheath. Once operators have gained some experience in the micropuncture technique, there is very little difference in rates of successful access (30). There is also very low rate of crossover to a femoral site when converting from diagnostic angiography to angioplasty (21, 30–32).

There are also challenges when it comes to catheter manipulation. Since the radial artery is of a caliber close to that of the catheter itself, radial artery spasm can occur, which can make manipulation of the catheters much more difficult (33). Much of this can be mitigated by use of sheath sizes that are appropriate to the caliber of the patient's radial artery as well as through the use of medicines to reduce spasm (16, 34). Some of the difficulty with catheter manipulation relates to the course the catheter must take to navigate the right subclavian artery to the ascending aorta. Although this manipulation is typically not insurmountable in experienced hands, there is evidence that an approach from the left radial artery may minimize some of these difficulties (35). There is also significant variation in forearm arterial anatomy, some of which is difficult to traverse with even flexible coronary catheters (36).

OVERALL BENEFITS

Despite the aforementioned difficulties, the benefits of the transradial approach lie in its *earlier ambulation times* and *reduced need for painful clamps*. Patients' satisfaction was higher with this approach than with the transfemoral approach (28, 29). There is also a *cost savings* with this approach, both directly due to reduced

equipment needs and indirectly due to the reduced need for post-procedure observation and reduction in bleeding complications (29, 37). The transradial approach can even facilitate outpatient PCI with safe same-day discharge (38, 39).

BAYLOR DALLAS EXPERIENCE

Until a few years ago, most radial procedures at Baylor University Medical Center at Dallas were performed on patients because of difficulties obtaining femoral access. Radial procedures were relegated to those patients who had severe peripheral arterial disease (e.g., occluded distal aorta) or who were morbidly obese. With the newer generations of sheaths, the newer catheter shapes, and the renewed interest of the interventional community in the transradial approach, it is increasingly being utilized as a routine strategy for patients undergoing coronary angiography and angioplasty.

In our catheterization lab, the patient's femoral artery is prepped and draped in standard fashion as a backup access site in case the transradial approach fails. Hydrophilic sheaths and micropuncture kits are used universally for obtaining radial access. Once the sheath is in place, a 5-mg dose of verapamil is used as the agent of choice to reduce radial artery spasm. A lower dose of heparin (2500 U, not weight based) is used as a baseline antithrombotic, and then bivalirudin is used if ad hoc angioplasty is performed. In general, for smaller patients, a 5 Fr diagnostic catheter is used and then upsized to 6 Fr if intervention needs to be performed.

The catheters used for diagnostic evaluation vary, but most cases begin with a multipurpose catheter such as a Jacky or Tiger catheter (Terumo Cardiovascular, Ann Arbor, MI), which can be used for both ventriculography and coronary angiography (Figure 3). Most of the time, a single catheter is needed for the entire procedure. If a coronary intervention is necessary, standard guides are used. At this time, we are typically not using the transradial approach for cases of acute myocardial infarction. However, this approach has been used in our lab in such cases when femoral access is not feasible.

After the procedure, all equipment is removed, and a TR Band hemostatic device (Terumo Cardiovascular, Ann Arbor, MI) is placed over the arteriotomy and inflated. The sheath is then removed in the lab before the patient leaves. In our diagnostic-only cases, patients go directly to the floor. The nursing staff has a protocol for removal of the hemostatic band. Patients who receive angioplasty or stents go to a recovery area for approximately an hour and then go to the floor, where the TR Band is removed per protocol. Since very little heparin is given for diagnostic cases, typically hemostasis is achieved in <2 hours. Our interventional patients, most of whom receive bivalirudin, spend several hours after leaving the recovery area with the hemostatic band in place before it is removed by the nursing staff on the floor.

The success rate for diagnostic angiography through the radial artery is well over 90%, and it is rare to need to switch to a femoral approach. To date, there have been no major access site complications related to any radial artery procedure at our institution.

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