CHAPTER 2

Radial/Ulnar Arterial Access Considerations: Step-by-Step, Troubleshooting, and Tips-and-Tricks

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1. Patient and access site selection

A "radial first" strategy should be considered in all diagnostic and interventional cardiac catheterization cases, including primary percutaneous coronary intervention (PCI) for ST segment elevation myocardial infarction (STEMI), to reduce bleeding and local vascular complications, decrease mortality, and improve patients' comfort.[1] Right radial artery (RA) access is the default site to optimize both the patient's and the operator's comfort during the procedure, but consideration for left transradial access (TRA) should be taken in older (≥75 years old) and short stature patients, especially women, since catheter manipulation and delivery to the ascending aorta can be more challenging with right radial access due to right subclavian artery tortuosity and short ascending aortas. A meta-analysis of randomized trials comparing right with left radial access showed no difference between procedural times, vascular complications, and cross-over rates between left and right TRA. [2]

Other indications to favor a left TRA include known right-sided severe tortuosities, previous access failure, radial artery occlusion (RAO), absence of RA pulse, orthopedic impediment, or presence of a dialysis graft. Left TRA access should also be considered if a left internal mammary artery (LIMA) injection is required, since selective injection of the LIMA can be more challenging from the right, although feasible (**Figure 1**).

The higher radiation exposure for the operator associated with left compared to right TRA PCI can be a deterrent for adopting left TRA access, as well as ergonomic concerns for both the patient and the operator. The latter can be mitigated by maintaining the patient's wrist in place on the abdomen using a banding system or pillows under the arm. Distal left TRA (dlTRA) access can be obtained to allow a more ergonomic positioning of the patient's arm over the lower abdomen, palm facing down. [3] The distal left RA is located in the anatomic "snuff box," between the tendon of the extensor pollicis brevis and abductor pollicis longus on the lateral side, and the extensor pollicis longus on the medial side. From distal to proximal, the course of the RA dives into the anatomic snuff box, so access is more easily obtained by using a steeper entry angle than usual (approximately 70°) with the access needle. If a failed RA access results in loss of radial pulse, the ipsilateral ulnar artery can be used.

Step-by-step technique for trans-radial access

1. Prepare and drape the wrist of the patient in a sterile fashion, exposing the radial and ulnar areas, and position the extended arm on the side of the patient. Attach the fingers and the arm on a rigid radial board, positioned on the dorsal face of the arm. Some commercially available radial boards allow wrist extension to facilitate RA access, but a rolled towel can also be positioned between the wrist and the radial board to obtain a mild dorsiflexion.
2. Inject 1-2 mL of subcutaneous local anesthetic at the puncture site.
3. The RA can be accessed using either an anterior wall puncture or a counterpuncture technique, according to the preference of the operator, and it is best performed 1-2 cm proximal to the radial styloid. With the anterior puncture technique, advance a 20 to 22-gauge needle at a 45° angle, guided by pulse palpation with the index finger of the other hand of the operator. Once a flash of arterial blood emerges, reduce the needle angle to approximately 30°, and insert the

0.018-0.021” wire provided with the access kit in the artery and advance smoothly. A 30-45° bend at the tip of the wire can facilitate its advancement by avoiding small branch engagement.

4. With the counterpuncture technique, also called ‘through-and-through’ technique, advance the catheter-over-the-needle system subcutaneously in the RA at a 45° angle. Once arterial blood fills the barrel, advance the system approximately 3 mm beyond the artery, through its posterior wall. Remove the needle from the angiocatheter, which is then pulled back slowly until a pulsatile blood flow is visualized at the hub. Insert the wire provided with the access kit in the catheter, and push it forward smoothly in the artery.
5. With either technique, once the wire is in place and the needle or angiocatheter is removed, advance the arterial sheath with its tapered dilator over the wire and inside the artery.
6. While pushing the sheath/introducer system forward, ensure that the wire remains free by performing push-and-pull motions. If the wire encounters resistance, do not further advance the sheath, since it might be in an extra-arterial position. Gently pull back on the system without losing access, and try to re-advance the free wire with continuous rotations. Fluoroscopic visualization of the wire can be useful to assess its position if resistance is encountered.

Step-by-step technique for distal left trans-radial access

1. Extend the patient’s thumb to facilitate the localization of the anatomic snuff box.
2. Once localized, adduct the thumb and palpate the distal RA in the snuff box to identify the area of maximal impulse. Mark the area with a marking pen.
3. Fold the thumb of the patient loosely inside the palm, and fix the hand and the forearm on a radial board with fastening tape. Let the arm rest alongside the patient’s left body or across the abdomen, according to the operator’s preference, and drape it. Access can be obtained from either the patient’s left side or the right side.

4. Administer a subcutaneous local anesthetic agent at the access site. It is recommended that more anesthetic agent than usual is administered, since touching the underlying periosteum of the trapezius and scaphoid carpal bones with the needle is frequent and uncomfortable for the patient.
5. Access the radial artery (consider using an anterior only technique). Ultrasound can be useful to facilitate access.
6. Following sheath insertion, seat the arm palm down on the right lower abdomen, in a comfortable position for the patient, with support placed under the left elbow.
7. After the procedure is completed, apply a large size radial hemostasis device. Depending upon the device used, it may be necessary to position it in a position opposite to that typically used to adapt to the anatomy. An inflatable device is recommended over a rigid compression device, since it can conform more easily to the shape of the wrist at the level of the distal RA. To avoid proximal slippage of the device, fix it with self-adhering band dressings.

Step-by-step technique for LIMA angiography through the right TRA

1. Use a left Judkins diagnostic or universal catheter to engage the left subclavian artery. A 0.035” J-wire can be used inside the catheter to open its secondary angle in the aortic arch in direction of the subclavian.
2. Deliver a 0.035” interventional access wire (preferably with a hydrophilic distal portion and a stiff proximal shaft) in the left subclavian, and advance this wire beyond the elbow in the left radial artery. Compared with a standard J-tipped exchange wire, the distal floppy portion is advantageous for navigation, while the proximal stiff portion supports the catheter and prevents its prolapse back into the descending aorta.

3. Bend the patient's left arm to anchor the wire distally to the elbow and to improve support for the exchange of the left Judkins catheter for an IMA, 3DRC, or IM VB1 diagnostic catheter.
4. Remove the exchange wire, turn the catheter counterclockwise without pulling it back to engage the LIMA and perform selective LIMA angiography. If selective cannulation of the LIMA is still not feasible, inflation of a pressure cuff (above the systolic pressure) over the left brachial artery and during non-selective injection of the left subclavian artery can improve opacification of the LIMA by favoring contrast flow.

2. Assessment of RA patency

The ulnopalmar arch is supplied by multiple collaterals, and assessment of its patency can be performed with the Allen or the Barbeau tests. The requirement to perform these tests systematically before TRA has been challenged by a study that showed no ischemic complication after RA access in patients with abnormal baseline Barbeau test,[4] which suggests that the ulnopalmar arch can recruit collaterals to supply flow to the hand even when baseline patency is compromised. Currently, assessment of the ulnopalmar patency is not recommended before catheterization. However, the reverse Barbeau test or ultrasound assessment of RA patency before discharge and at the first follow-up visit should be considered to assess for RAO, in order to apply mitigating interventions such as ulnar compression or subcutaneous low molecular weight heparin if necessary.[5]

Step-by-step technique for reverse Barbeau test

1. Apply a plethysmograph to the thumb of the involved hand and observe the waveform.
2. With your fingers, apply a firm occlusive pressure on the ulnar artery at the level of the wrist.
3. If the oximetry waveform stays normal, it indicates that radial flow is patent.
4. If the waveform becomes blunted or absent, it indicates that the RA is not patent.

3. Real-time ultrasound guided access

Real-time ultrasound can help localize the RA and follow the subcutaneous path of the needle. In the Radial Artery access with UltraSound Trial (RAUST) trial, systematic use of ultrasound decreased time to access and the number of forward needle attempts compared to access guided by palpation only.[6] However, ultrasound use did not decrease bleeding, spasm, or patient pain; thus, the primary utility of ultrasound guidance is to facilitate access. Real-time ultrasound can prove particularly useful when the radial pulse is faint, or when failed attempts to cannulate the artery result in a hematoma impeding pulse palpation.

4. Severe arterial loops, calcification, spasm, or stenosis

Once access is obtained, radial or brachial loops, calcification, spasm, or stenosis can make advancement of an 0.035” guidewire challenging if not impossible. In these situations, trying to advance the wire forcefully may result in RA perforation and should be avoided. A gentle diluted contrast injection through the sheath or directly through the catheter can aid in defining RA anatomy and identify the reason leading to the inability to deliver the wire. If the wire is in a small side branch, it can simply be retracted and re-advanced in the main RA. In the most difficult cases, an 0.014” coronary or 0.018” peripheral wire can be used to negotiate the vessel. Other options include using a 0.035” floppy tipped wire or a hydrophilic-coated wire to cross loops, severe tortuosity, spasm and calcification. Importantly, hydrophilic wires should only be advanced under fluoroscopic guidance to avoid perforation or dissection. Intra-arterial injection of a spasmolytic cocktail (verapamil or nitrates) should be attempted to treat spasm.

In the situation when the wire can cross a challenging RA or brachial anatomy, but there is significant resistance to advancing the catheter, the first step is to use the smallest profile catheter as possible to achieve the goal of the procedure. For example, a 5 French catheter is usually sufficient to perform a diagnostic angiogram. Balloon-assisted tracking (BAT) can prove useful to facilitate catheter advancement in difficult anatomy.[7] The principle of the BAT technique is to use the smooth, conical, and atraumatic surface of an angioplasty balloon to reduce the transition between the catheter tip and the wire, thus minimizing the "razor" effect of the catheter on the vessel lumen (**Figure 2**). When difficulty is encountered while attempting to advance a 6F guide catheter, a 5F diagnostic catheter (e.g. 125 cm MPA2) can be telescoped through the guide catheter to offer a smoother transition.

Step-by-step technique for balloon-assisted tracking

1. Deliver any workhorse 0.014" coronary guidewire to the subclavian artery or beyond.
2. Over the guidewire, position the catheter tip distal to the complex zone to cross. Ideally, a universal catheter, shaped specially to engage both coronary ostia, may be preferred to avoid the need for catheter exchange during the procedure.
3. Position a small (1.5 mm for 5 French diagnostic or guide catheters, 2.0 mm diameter for ≥6 French catheters) angioplasty balloon of 12-20 mm length halfway protruded out of the catheter.
4. Inflate the balloon to low pressure (3-6 atmospheres).
5. Push the catheter/balloon system over the coronary wire.
6. If there is still resistance to the passage of the catheter/balloon system, a buddy wire can be placed alongside the system to facilitate delivery.
7. Once the catheter reaches the aortic cusps, remove the wire and the balloon and perform the coronary angiography as usual.

5. Radial artery occlusion

In the absence of mitigating measures, RAO can occur in 7-10% of patients following TRA at 30 days.[8] Most of the time, RAO is asymptomatic, but it can preclude future use of the artery for procedures or invasive arterial pressure monitoring, and can rarely lead to chronic pain syndromes or ischemic complications. It is recommended to assess the presence of RAO before discharge and at the time of the first follow-up visit.[5] Strategies to decrease the risk of RAO include: [5]

1. *Anticoagulation*: The optimal dose of intravenous or intra-arterial unfractionated heparin to reduce the risk of RAO is still debated, but a recent meta-analysis suggests that a dose of 5,000 IU is more effective than a lower dose (2,000-3,000 IU). [9] A recent randomized trial also showed that heparin 100 UI/kg is associated with lower risks of RAO compared to 50 UI/kg. [10] Alternatively, bivalirudin can be used if heparin is contra-indicated. [5]
2. *Patent hemostasis*: This technique allows radial flow during radial hemostasis. [8] After withdrawing the sheath by 2-3 cm, apply the radial compression device and tighten/inflate it, then remove the sheath. Untighten/deflate the compression device slowly until you see pulsatile blood flash for about 2-3 cycles. Tighten/inflate the device slowly until bleeding is eliminated. To ensure the RA is patent, perform the reverse Barbeau test (see above). If the reverse Barbeau test shows no evidence of radial patency, untighten/deflate the device slowly until patency is restored without external bleeding. Hemostasis protocols vary but in general involve gradual decrease in pressure over the radial artery.
3. *Sheath selection*: Use of low profile and hydrophilic sheaths decreases the risks of RAO likely by reducing spasm. Sheath sizes that minimize trauma to the radial artery may reduce RAO.
4. *Prevention of radial spasm*: Systematic intra-arterial injection of spasmolytic cocktails (typically calcium channel blockers and/or nitrate derivatives) after gaining access and before sheath removal at the end of the procedure reduces radial artery spasm. This, in turn, facilitates

catheter manipulation, improves patient comfort, and decreases the risk of RAO. Other strategies to minimize spasm include avoidance of "overtorquing" the catheters, selection of low profile hydrophilic sheaths, and appropriate pre-procedural analgesia and sedation.

5. If post-procedural RAO is diagnosed, ulnar artery compression for 1 hour performed early following the procedure can help restore RA patency.

6. Local bleeding and vascular complications

Major bleeding following TRA PCI remains an extremely rare event, occurring in 1% of the cases when adjunctive glycoprotein IIb/IIIa inhibitors agents are used, and consists mostly of non-access related bleeding. Risk factors for bleeding after transradial PCI include larger sheath size, longer procedure duration, and creatinine clearance <60 mL/min. Albeit rare, significant access-site bleeding after a transradial PCI can result in catastrophic consequences. As part of routine post-procedure care, the presence of a hematoma should be actively monitored, since it can progress into forearm ischemia if unrecognized.

If a radial, ulnar, or brachial artery perforation is suspected while the sheath is still in place, it can be diagnosed easily by a gentle diluted contrast injection in the catheter or directly through the sheath. Extravasation of contrast in the soft tissues provides evidence of arterial perforation, which can be treated with catheter tamponade. It involves advancing a catheter (either diagnostic or guide) across the area of perforation using BAT if needed. The bulk of the catheter will tamponade the perforation site while the coronary angiography/PCI is performed. Once the procedure is completed, a final contrast injection distal to the perforation site is mandatory to confirm the resolution of the bleeding.
Vascular complications such as pseudoaneurysms and arterio-venous fistulae remain extremely rare following TRA. Definitive diagnosis of both complications is made by duplex ultrasound.
Pseudoaneurysms usually present as painless pulsatile swelling of the radial area between 1 day to 2

months following the procedure, and may form in the setting of ongoing antithrombotic therapy during and after the procedure. Conservative management with prolonged compression or local thrombin injection can be sufficient, but surgical repair is sometimes required. Arterio-venous fistula typically presents as local swelling with an audible murmur on auscultation, and its treatment is surgery. Rarely, local sterile giant-cell granuloma formation following TRA may mimic these vascular complications, but presents more frequently as a painful lump. This formation has been reported exclusively following hydrophilic sheaths. According to the severity of the symptoms, it can be managed conservatively or by surgical excision.

Troubleshooting: access-site hematoma[11]

1. As soon as a hematoma is recognized, mark its boundaries with a pen to monitor its evolution over time.
2. If possible, stop intravenous antiplatelet and anticoagulant agents.
3. Compression is the mainstay of the treatment and for preventing progression of the hematoma. It can be performed by either manual compression, with pressure dressings, or by using additional radial compression devices positioned along the forearm. For larger hematomas, a pressure cuff can be kept inflated over the hematoma for 15 minutes (at a pressure 20 mmHg lower than systolic pressure) to allow distal limb perfusion.
4. Control blood pressure with antihypertensive, analgesic, and anxiolytic medication.
5. Ice packs can be applied locally on the hematoma to prevent its progression.
6. If, despite these measures, the hematoma progresses above the elbow or is associated with signs or symptoms suggestive of compartment syndrome or limb ischemia, consult the surgical team for consideration of an emergent surgical repair with or without fasciotomy.

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Figure 1: Selective injection of the LIMA through the right TRA, using a diagnostic IMA catheter. The subclavian artery was engaged using a JL4 diagnostic catheter, which was exchanged for the IMA catheter over a stiff exchange wire.

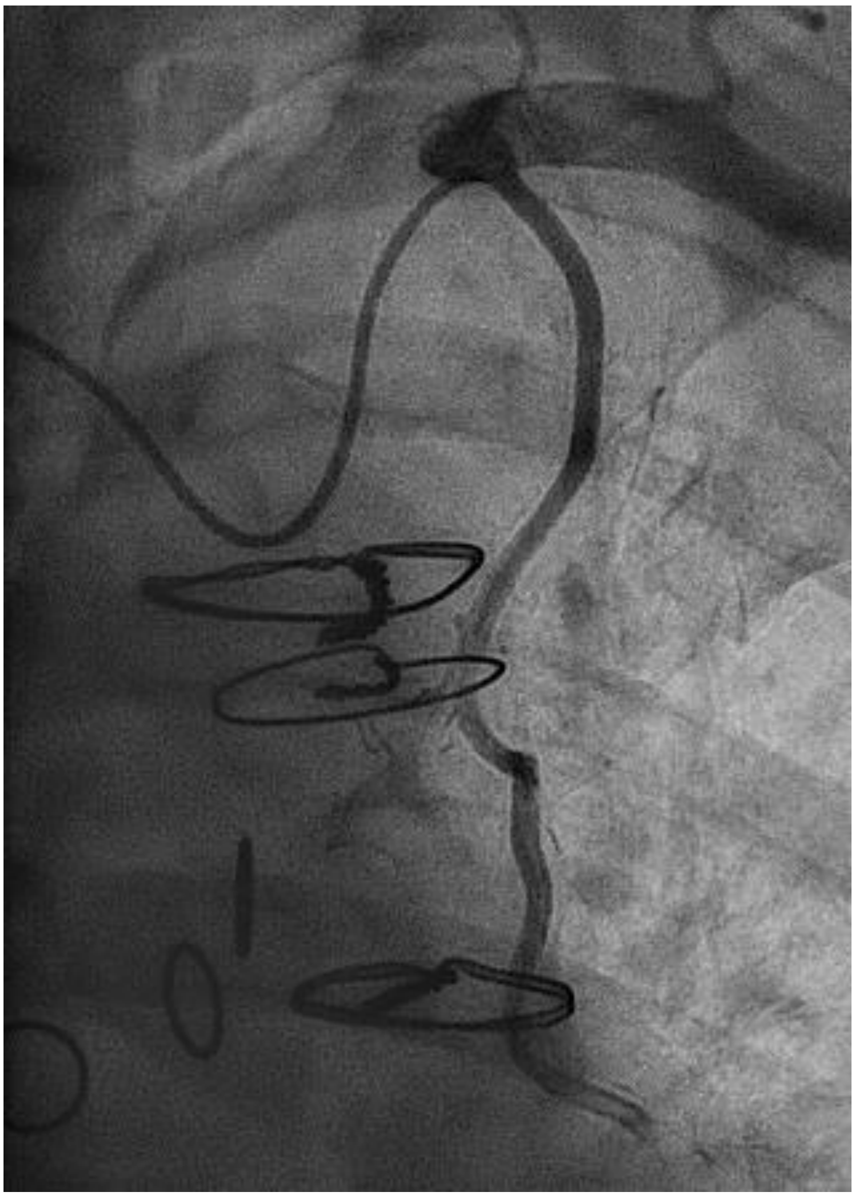
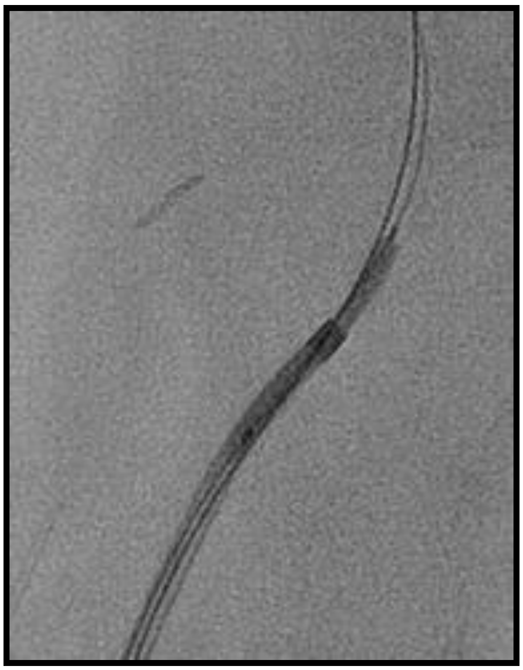


Figure 2: Balloon-assisted tracking (BAT) of a 6 French-sized left coronary bypass guiding catheter in a small and calcified left radial artery, over a standard workhorse coronary guidewire and a 2.0 X 20 mm compliant balloon protruding halfway out of the catheter, inflated at 6 atmospheres. In this case, a J-tipped 0.035” wire was maintained in the radial artery as a buddy wire to improve support and straighten the tortuosity.



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