Transradial Arterial Access

9

Paula Dixon

9.1 Introduction

Relatively new to the interventional radiology (IR) world, transradial artery access (TRA) is quickly becoming the preferred primary site for catheterization. TRA's minimally invasive technique, low complication rates, quicker patient recovery, and higher patient satisfaction all lend to this new approach. The superficial location of the radial artery makes it easily accessible regardless of a patient's body habitus and no major nerves or veins are located near common access points. Patent homeostasis is easily achieved due to the radial artery superior position to the radius. Misconceptions about the increased stroke risk, higher radiation doses, and lack of appropriate training have hindered TRA use until recently. Several newly published research articles and meta-analysis studies show that TRA has similar or even fewer complication rates as transfemoral artery access (TFA) and many advantages over the TFA approach. In addition, no increase of neurological complications or radiation exposure to the patient or the procedure room personnel is noted using TRA. These studies also emphasize that the use of TRA in obese patients and patients with a higher risk for bleeding have decreased hemorrhagic and vascular complications, and decreased mortality rates.

Another advantage mentioned frequently in the literature on TRA is the decrease in procedure delays to correct certain coagulopathies that are inherent to the IR patient population. Without the need of costly blood products, the time needed for safe infusion, and the wait while retesting of laboratory values, TRA can result in quicker and less costly interventions. In addition, anticoagulation may not need to be held or reversed. The use of commercial devices to achieve patent homeostasis within moments after sheath removal results often in significantly reduced recovery times and same day discharge. With shorter length of stay, patients spend more time at home and less in the hospital setting increasing patient satisfaction. Patient satisfaction is also higher because unlike TFA the patient can immediately sit up or even ambulate after a procedure instead of spending hours in a supine position with limited mobility. This translates into reduced costs to the institution and the ability to reduce labor costs.

9.2 Pre-procedural Planning and Radial Artery Evaluation

One of the most crucial aspects of procedure planning is obtaining safe and effective arterial access. Now with recent advancements in catheter and sheath technology, along with longer

P. Dixon, MSN, RN, CCRN, CEN (✉)
Department of Cardiology,
Medical University of South Carolina,
Charleston, SC, USA

K. A. Gross (ed.), *Advanced Practice and Leadership in Radiology Nursing*,
https://doi.org/10.1007/978-3-030-32679-1_9

rapid exchange systems and wires, IR procedures that were limited to TFA can now be considered for TRA. However, proper technique and equipment approved for use with the TRA approach are paramount to the safety and success of the procedure. Hands on learning workshops help the operator navigate through the common technical radial problems encountered. Before considering TRA as an alternative to TFA, institutions and operators need to ensure the proper training with learned skills and the availability of specialty equipment. Ideally the access site should be determined through the assessment of the individual patient's anticipated anatomical variants and pathologic conditions resulting in the safest approach. Selection of the correct vessel should be done before the patient arrives in the procedure suite. Pre-procedural evaluation plays an important role in determining the best treatment plan based on the individual patient's needs and preexisting factors. Previous procedures and surgeries, body habitus and obesity, concern for possible bleeding due to pharmacological therapies or organ dysfunction, and previous patient experience should all factor into initial access site consideration.

Whenever radial artery access is being considered, pre-procedural evaluation ensures a relatively low complication rate. Ensuring adequate collateral perfusion to the hand is critical before cannulation is achieved. The deep palmar arch is formed by the radial artery (laterally) and the deep palmar branch of the ulnar artery (medially) (Fig. 9.1a). The two most commonly used tests are the Allen and Barbeau. Using the Allen and/or Barbeau tests and measuring the diameter of the artery through sonographic evaluation ensures adequate circulation to the hand through the ulnar artery in case of radial artery spasming or other complications. Before proceeding with further testing ensuring a palpable radial pulse is mandatory.

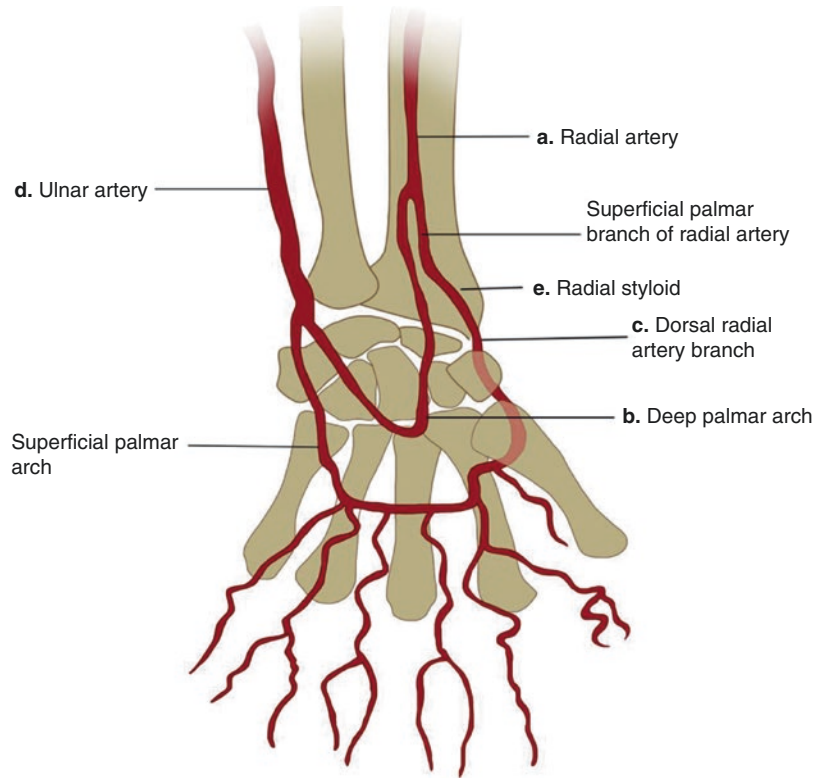

Fig. 9.1 Anatomy of the hand with the (**a**) radial artery, (**b**) deep palmer arch, (**c**) dorsal radial artery branch (**d**) ulnar artery and (**e**) radial styloid. (Source: Marisa Dixon)

9.2.1 Allen Test

The Allen test is performed by first having the patient make a fist. The evaluator then occludes both the radial and ulnar arteries. The patient then opens the hand which should appear blanched with pallor at the fingernails. Release of the ulnar artery occlusion should result with the return of normal capillary refill within 3–10 s. This is considered a normal Allen's test, and ensures a complete palmar arch (Fig. 9.1a) confirming that radial access can be considered.

9.2.2 Barbeau Test

Unlike the Allen's test the Barbeau test involves the use of pulse oximetry and is considered a more sensitive test excluding only 1.5% of patients. A pulse oximetry probe is placed on either the thumb or index finger, the area of the hand supplied by the radial artery. After noting a waveform the ulnar and radial arteries are then occluded which causes the waveform to either dampen or flatline. The ulnar artery is released and a waveform should reappear or undampen. The Barbeau classifies the results as Barbeau type A, B, C, and D (Fig. 9.2). Patients with Barbeau type A, B, and C are considered candidates for radial access. In Barbeau type A, no change in waveform is seen. Barbeau type B occurs when the waveform is temporarily dampened but returns to normal amplitude after occlusion of the ulnar artery is released. Barbeau type C is defined as the flatline of the waveform during ulnar occlusion and a return of a dampened waveform after ulnar release. Barbeau type D is the flatline of the waveform after ulnar occlusion with a continued flatline after ulnar release for 2 min or longer. Barbeau type D is not recommended for radial access.

9.2.3 Ultrasonographic Evaluation

Once a patient is deemed eligible for radial access cannulation, the most appropriate sheath size can then be determined with the assistance of ultrasonography evaluation. The artery is visualized approximately 1 cm above the styloid process with the ultrasound machine setup to measure the anterior-posterior (AP) diameter. The artery is measured from inner wall to inner wall. Careful attention should be taken to

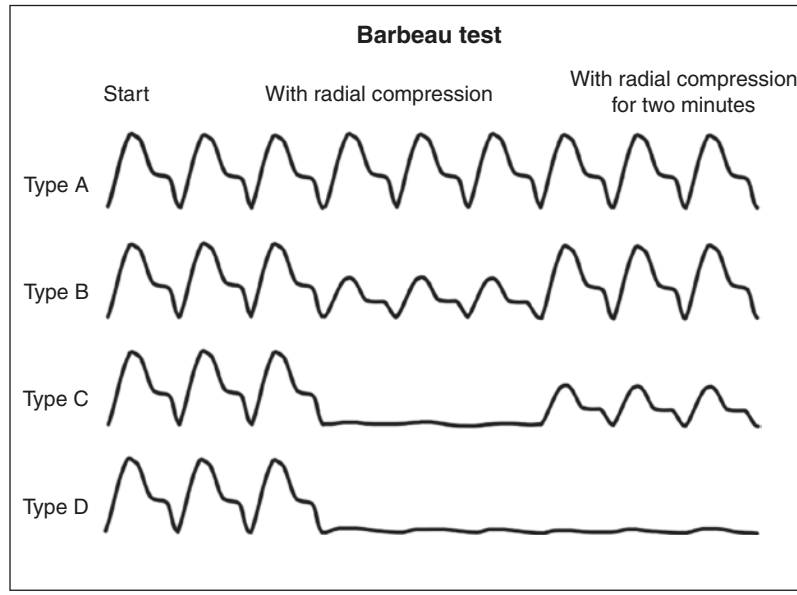

Fig. 9.2 Barbeau Type A, B, C, D. (Source: Marisa Dixon)

avoid excessive compression while measuring which could result in an underestimate of the true AP diameter. A minimum of 1.8 mm is recommended; however, diameters as small as 1.6 have been successfully accessed. If prior radial access has been obtained scanning the artery to the brachial artery bifurcation is advised. The size of the inner diameter should either be printed from the machine or documented in the patient's record for future considerations.

9.2.4 Selection and Contraindications for Radial Access

Patients with a positive Allen test and/or Barbeau type A, B, or C with a radial artery diameter of 1.6 or greater are candidates for the radial approach. Sheath determination is based on the radial artery diameter and can range from 4 French to 7 French depending on the manufacturer's recommendations, with the most common access using a 5 or 6 French. The mean diameter of radial arteries measured by ultrasound is 2.6. Absolute contraindications for use of upper extremity access include same side dialysis graft, patient refusal, absence of radial pulses, and known asymptomatic radial stenosis calcification. Relative contraindications include abnormal tests for dual circulation, upper extremity vascular disease, patients with chronic renal failure that may require future permanent dialysis access and operator inexperience. Alternative upper extremity sites are discussed in Sect. 9.6.

9.3 Setup and Positioning

The patient's arm can be positioned in several different ways. The most common is to position the patient's arm next to their side mimicking groin access and allowing for equipment used to be placed on the sterile drape the same as TFA (Fig. 9.3). The use of a slide board can help in the positioning and securing of the arm. There are several commercial immobilization devices available specifically to help optimize access and stabilize the wrist throughout the procedure (Fig. 9.4a). Slight hyperextension of the wrist can also be achieved with the use of a rolled-up towel directly under the access site (Fig. 9.5a).

The arm can also be positioned and maintained abducted at a 70- to 90-degree angle (Fig. 9.5b)

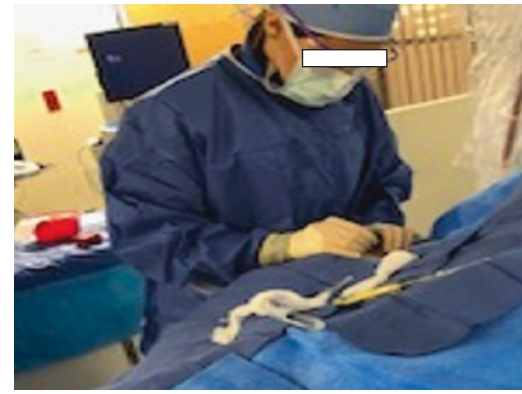

Fig. 9.3 Right radial access. Right radial access with arm adjacent to groin, note the operator is in the same position as TFA

Fig. 9.4 Use of wrist positioning device and arm board. (**a**) Use of a wrist positioning device. The device is hooked onto the arm board for stabilization and optimal wrist placement. (**b**) The pulse ox is placed on the index finger for monitoring radial artery patency during the procedure. (**c**) An IV is placed ipsilateral and out of the area where the procedure will occur

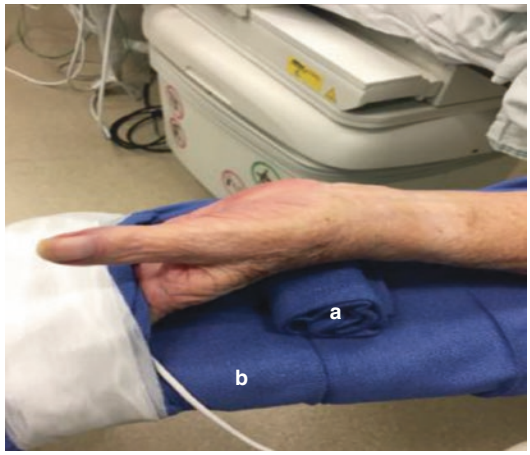

Fig. 9.5 Left radial access. (**a**) Use of a rolled-up towel for hyperextension of the left wrist. Note the fingers are secured in a pocket made with towels and the pulse ox in place for monitoring. (**b**) A padded arm board is used to abduct the left arm to facilitate radial access insertion

with the use of an arm board. While this may initially help the operator gain access, it is more difficult to exchange devices and limits the movement of fluoroscopy equipment, requiring delays while the arm is repositioned closer to the body for certain fluoroscopy scans. If the left radial site is required, access can be obtained on the left side and the patient's hand can be positioned over the lower abdomen/groin area to facilitate working from the preferred right side. Determining left versus right radial access depends on the type of procedure and equipment available. For procedures below the diaphragm, left-sided access is recommended because of the shorter distance to the target area. Although the difference may only be several centimeters, this helps ensure that correct catheter lengths are available. Using left TRA also prevents the sheath or guiding catheters from being positioned over the great vessels in the aorta and theoretically decreases the chance of cerebral embolus or thrombus formation.

Avoidance of radial artery spasming is key to ensure access. Medications for sedation and utilization of lidocaine for infiltration help prevent radial spasming. Other techniques involve topical anesthetic cream applied to the wrist in the preprocedural setting. This helps reduce the amount of lidocaine used to infiltrate over the access site and decrease the chance of obscuring the radial pulse. Nitroglycerine (NTG) ointment can also be applied on the site to help with dilation and decrease radial artery spasming. Another strategy involves mixing NTG 200 micrograms in 1 mm with lidocaine 1% for infiltration. This not only helps reduce the chances of arterial spasming and but also helps predilate the artery.

Placing a pulse oximetry probe on the thumb or forefinger of the arm being accessed helps identify arterial spasming (Fig. 9.4b). Ideally intravenous (IV) access should be in the contralateral arm. If this is not possible, then an IV placed in the ipsilateral arm should be as far away as possible from the access site to ensure proper prepping and homeostasis can be achieved (Fig. 9.4c). A common place for blood pressure monitoring is on the patient's legs, as to not interfere with IV infusions.

9.4 Radial Access and Sheath Introduction

The wrist area is prepped following sterile technique with a standard antiseptic scrub solution. The area prepped extends from the upper palm to the right and left lateral points, and five-finger breadths above the radial artery pulsation. The drape is placed with the fenestrated area over where the radial pulse is palpable. The point of access is 1–2 cm proximal to the radial styloid (Fig. 9.1b). A sterile marker should be used to mark where the entry should take place. The most common method to obtain access is with ultrasound guidance and the Seldinger technique using a micropuncture needle (Fig. 9.6). Alternative methods include a modified Seldinger technique. Similar to the standard Seldinger technique the needle, catheter, guidewire, and sheath are all parts of a single radial access kit. Dilators included with the radial sheaths are tapered to 0.018 in. to allow sheath introduction without an incision or wire exchange. Access can also be obtained by the use of an angiocath needle. The angiocath technique differs in the Seldinger and modified Seldinger method because of the use of a through-and-through approach. The angiocath

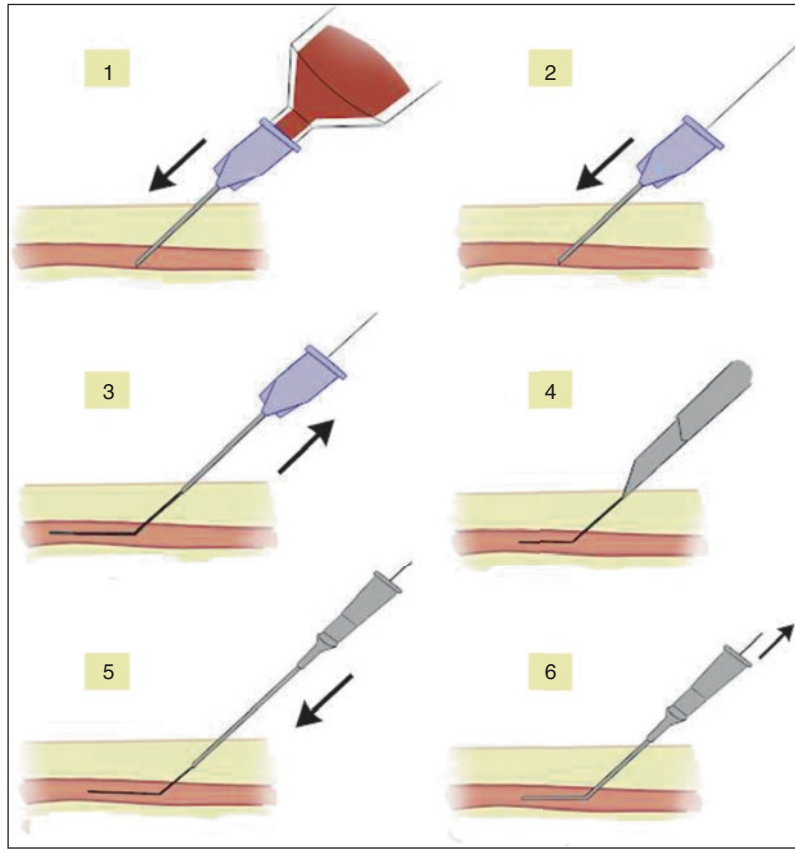

Fig. 9.6 Seldinger technique. Step 1. After proper skin prep and sterile draping, the radial artery is palpated. The skin is entered at approximately a 30–45°. When the needle is through the skin, the operator begins pulling back on the plunger of the syringe. Needle advancement is stopped when blood (flash) starts to enter into the syringe. The needle is stabilized in place with the operator's non-dominant hand and then the syringe is removed. With the same hand that is stabilizing the needle in place, place the thumb over the hub to prevent both blood loss or to prevent air from entering the needle. (Air entering the needle can lead to an air embolism if negative pressure is created.) Step 2. The guide wire in then carefully inserted into the hub of the needle and advanced. There should be no resistance while advancing the guide wire. Resistance could mean the guide wire is no longer inside the lumen of the vessel, dissection of the vessel wall has occurred, thrombus is present, or vessel spasm is occurring. Step 3. When the guide wire is at the appropriate place, the operator should continue to hold onto the guide wire and retract the needle. While holding the guide wire in place, the operator removes the needle from the guide wire. Step 4. If enlargement of the insertion site is needed to place a larger catheter, a #11 blade scalpel is used. Care is needed to avoid touching the blood vessel. Step 5. While the operator holds the guide wire, the distal end of the catheter is placed over the tip of the guide wire and the catheter is advanced until the guide wire comes out of the catheter. The operator advances the catheter into the vessel while still maintaining a hold on the guide wire. Step 6. Once the catheter is in the vessel, the guide wire is very gently removed. After catheter placement is confirmed (blood return verified and then flushed per protocol) it is secured in place per routine. (Source: Marisa Dixon)

needle is sent through the posterior wall of the radial artery under direct palpitation and then slowly pulled back until blood appears in the chamber. This method ensures access through the true lumen of the vessel. Preference of access should be determined by the operator skill and the equipment available.

Regardless of technique implemented, if any resistance while advancing the wire is met, fluoroscopy for direct visualization should be used. Once the wire is able to be advanced only a sheath with a hydrophilic coating is recommended. Research demonstrates the lubricating polymers of the coating, not the length or size of

the sheath, reduce the likelihood of arterial wall irritation, spasming, and associated pain [1].

Once the sheath is introduced, a "radial cocktail" is utilized. Medications are given intra-arterially directly into the sheath and/or intravenously. These cocktails are used to help prevent arterial spasm, relax vascular tone, and reduce clotting. Nitrates and/or calcium channel blockers in combination with heparin or bivalirudin are used in various amounts and combinations and given at certain time intervals. This practice varies greatly in different institutions with no current consensus on an ideal amount or frequency in the interventional community.

If the sheath moves easily, advance it to the hub. If resistance is met during sheath introduction and placement has been verified through fluoroscopy, remove the wire and inject a vasodilator directly into the sheath (nitroglycerin 100–200 μg, verapamil 2.5–5 mg, and nicardipine hydrochloride 500–1000 μg). Reinsert the wire and the dilator and continue to advance under fluoroscopic guidance. Once the sheath is in place, flushed, and medications to reduce spasming are given, the sheath can be secured using a clear plastic covering or a suture.

Once the sheath is secured, the arm can be repositioned if needed to prepare for catheter insertion. A catheter is advanced with the use of a guidewire. A standard 0.035-in. J-wire is most commonly used with a small J-curve. A J-curve is recommended as it helps with steerability and prevents the wire from entering into small branches. Other wires can be used based on operator preference and experience. A coated hydrophilic wire may be used with caution because of the ability to easily travel into smaller vessels or become subintimal, thus increasing the potential of perforating a vessel. If any resistance of the wire and/or catheter is met while advancing up the arm fluoroscopy can be used with small "puffs" of contrast to ensure proper placement into central circulation. Fluoroscopy is always used when reaching the central circulation to ensure a safe passage through the aorta. Once the guiding catheter has passed into the aorta procedural catheters and wire selection will be based on the final destination and the procedure.

9.5 Patent Homeostasis in TRA

Patent homeostasis is the balance between applying just enough pressure to avoid bleeding or oozing but not so much pressure as to cause tissue necrosis or nerve damage and artery occlusion. This concept is demonstrated when manual pressure is held on the femoral artery and distal pulses are checked to ensure there is still blood flow. Patent homeostasis begins with preprocedural planning. The Allen and Barbeau test, anticoagulation, appropriate sheath size selection with ultrasonography, limiting the number of sheath and catheter exchanges, and patent homeostasis all play a vital role in minimizing the risk for radial artery occlusion. With a skilled operator and well-trained team these measures are instituted routinely. The goal of TRA is the maintenance of radial artery patency to ensure future use. Awareness to the importance of long-term patency should be a hallmark in all levels of training and education.

9.5.1 Sheath Removal and Post-procedure Care

A number of commercial devices are available for homeostasis. The more common designs involve a clear plastic bracelet that allows for visualization of the access site (Fig. 9.7a). These devices have some kind of bladder for air to be added into and then gradually removed after a certain amount of time. The device is placed on the wrist and over the sheath prior to sheath removal. Although instructions will greatly vary depending on the type of homeostasis device used. Regardless of the device there are several critical steps to follow. Place the devices around the wrist, ensuring the appropriate size based on the options and manufacturer recommendations. The compressing component of the device should be over the entire insertion site including any skin nicks and the sheath. A piece of gauze can also be placed under the sheath. This allows for any blood to be wicked onto the gauze (Fig. 9.7b). The device is then injected with a predetermined amount of air (usually 15–20 mL)

Fig. 9.7 Wristband for homeostasis. A syringe with air being injected into the bladder of the wristband. A piece of gauze is used to wick away blood after proper amount of air is determined

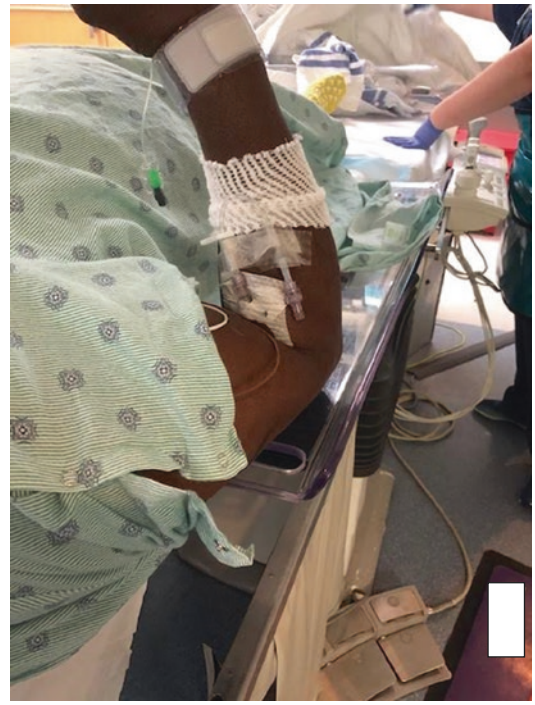

Fig. 9.8 Patient transfer technique. Patient using elbow to transfer back to stretcher immediately after placement of wristband

while the sheath is then slowly removed. Ideally the air should be injected as the sheath is slowly retracted. Patent homeostasis is accomplished once there is no active bleeding and the patient is free from pain or discomfort from overfilling of the device. After the device is applied patients are instructed to place no pressure on the hand or wrist and to continue to not use the wrist or hand while the device is still on. The patient is instructed to use their elbow to help transfer and reposition after the procedure (Figs. 9.8 and 9.9). If the patient is still sedated or having difficulty remembering instructions, the immobilization device used during the procedure can remain in place.

- To ensure there is no radial artery occlusion a reverse Barbeau test can be performed by occluding the ulnar artery and ensuring a waveform on the pulse oximetry reading. If type A, B, or C is seen with radial artery compression patent homeostasis is confirmed. If Barbeau type D occurs, air should be released; if bleeding occurs, reinsert the air and move the patient to the recovery area. Repeat the test after 15 min. Patent homeostasis can often be achieved after a short amount of compression time. Staff involved in the care of the patient while the compression device is utilized should be well versed in assessing for patent homeostasis and monitoring of the extremity to ensure there is no ischemia or hematoma formation. Until the practice of TRA access is well established in the institution, any findings suspicious of hematoma and/or hand pain, unrelieved with deflation of the device, requires *immediate* notification of the interventionalist. Mild hematoma formation can be treated with analgesics, an ice pack and/or the use of another compression device or blood pressure cuff. Frequent assessment and early detection of hematoma formation are crucial to avoiding complications. Ensuring that the same high standards of care occur in the post-procedure area as in the pre- and intra-

Fig. 9.9 Patient transfer onto stretcher. Patient using elbow to sit up immediately after placement of homeostasis device and transfer onto stretcher

procedure setting is essential to ensure there is no radial artery occlusion and the artery is preserved for future use.

Protocols for the post-procedure area vary greatly but for most institutions standard site checks are done the same as for femoral access with no removal of air from the device for 60–90 min. Air removal standards also vary greatly but are usually done every 15 min and 1–4 mL of air or one-fourth of the initial total amount of air inserted into the device is removed. Most recovery areas start with a minimal amount of air removal and gradually increase the amount. If bleeding is noted after air removal, the air is reinserted for another 15 min, then removal can be attempted again withdrawing a smaller amount of volume. Usual deflation takes about an hour. Patient compliance with restricted wrist usage is critical to ensure deflation can occur in a timely manner. If noncompliance with wrist restrictions is observed, the securement device used during the procedure or other type of arm board device can be applied to help limit the movement of the wrist. Once the compression device is completely deflated it remains on the wrist for another 60 min in case reinsertion of air is necessary. A dressing is placed over the site for 24 h. The average time in from placement to removal of the hemostasis device is 3 h. After the device is removed the patient can be discharged or released to an area that is not familiar with post-radial access care. Patient discharge instructions focus mainly on limited use of the arm for 5–7 days and not lifting anything heavier than five pounds with the hand.

9.6 Alternate Sites to TRA Access

Good pre-procedural planning includes always determining and prepping a backup site. Although many institutions still use the TFA as backup if TRA access cannot be achieved, studies have shown that transulnar artery (TUA) access and dorsal transradial artery access (dTRA) or "snuff-box" access can also be acceptable backups or even primary sites if TRA is unsuccessful or contraindicated [2, 3]. Both sites have similar reduced major vascular and bleeding complications and offer the patient the same benefits of early patient ambulation, and reduced hospital stay when compared with TFA. All members of the health care team should anticipate a small amount of TRA complications regardless of the amount of preparation and testing when determining TRA eligibility. The majority of complications present themselves during initial TRA attempts. Artery spasming, smaller than expected inner artery diameter, radial stenosis calcification, tortuosity in any part of the artery, and other anatomic issues can all be causes to unsuccessful TRA.

9.6.1 Ulnar Artery Access

Since the ulnar artery is not as superficial as the radial artery, palpation is more difficult. To palpate the ulnar artery, hyperextend the hand and palpate at the fold of the wrist. Hyperextension of the wrist is critical for a successful procedure. Most common complications involve inability to advance the wire despite adequate blood flow.

TUA is not considered a primary site due to transulnar cannulation failure results and should only be attempted by highly skilled interventionalists [3]. After successful TUA access the intra- and post-procedure care is identical to that of TRA.

9.6.2 Distal Transradial Artery Access

Distal transradial artery access (dTRA or "snuffbox" access) involves the sheath insertion on the back of the hand in the anatomical location where the dorsal radial artery can be palpated, known as the "snuffbox." This access is preferable for patients who are unable to supinate their wrists due to orthopedic injuries and decreased range of motion. It can also be used instead of left TRA so the arm can be pronated towards the right side of the patient for right-sided procedures. The arm is placed in a neutral position with a rolled-up towel or rolled-up gauze placed in the hand to maintain neutrality. The dorsal radial artery is superficially located and may have one or two veins surrounding it. Ultrasound guidance is recommended for the same reasons as traditional TRA. Traditional TRA bands tend to move out of position too easily with the most subtle movements of the wrist in this area and are not recommended. Instead patent homeostasis is achieved with the use of a bulky pressure dressing using gauze and an elastic wrap. Staff are instructed to monitor the site with the same guidelines as TRA but since the dressing tends to loosen over time little manipulation of the area is required. Slow release of pressure usually occurs without assistance from the staff; however, the same attentiveness to site assessment is required.

9.7 Conclusion

TRA has been successfully performed by interventional cardiologists for three decades. In many practices cardiologists believe in the "radial first" approach, and it is quickly becoming the standard of care. In 2015, the European Society of Cardiology (ESC) gave the highest degree of recommendation for TRA over the TFA approach for coronary angiography and percutaneous coronary intervention in patients with acute coronary syndrome without persistent ST-segment elevations citing its superior results in fewer events concerning major bleeding, vascular complications, and on reducing all causes of mortality [4]. This endorsement also cautioned to ensure proficiency is maintained in both the TRA and the TFA approach, as both access sites are indispensable in the care of all heart disease patients. Many advocates for the TRA approach anticipate that following the recommendations of the ESC many other organizations will join in concluding that radial access is an equal and valuable approach. In 2018, the American Heart Association (AHA) published a scientific statement to affirm and recommend the "radial-first" strategy for patients with acute coronary syndrome in the United States [5]. With all the praise given to the TRA approach the benefits attributed emphasize there is a steep learning curve. To optimize procedural outcomes and success rates emphasis is attributed to expertise and skill of the operator and institution in the pre-, intra-, and post-procedure settings.

References

1. Fischman AM, Swinburne NC, Patel RS. A technical guide describing the use of transradial access technique for endovascular interventions. Tech Vasc Interv Radiol. 2015;18(2):58–65. https://doi.org/10.1053/j.tvir.2015.04.002.
2. Zybulewski A, Edwards M, Nowakowski FS, Patel R, Tabori N, Lookstein R, Fischman A. Transulnar approach as an alternative to transradial approach in non-coronary intervention: safety, feasibility and technical factors. J Vasc Access. 2017;18(3):250–4. https://doi.org/10.5301/jva.5000691.2017.
3. Hahalis G, Deftereos S, Bertrand OF. Ulnar artery: the Ulysses ultimate resort for coronary procedures. Hell J Cardiol. 2016;57(4):238. https://doi.org/10.1016/j.hjc.2016.07.006.
4. Roffi M, et al. 2015 ESC guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: task force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation of the European society of cardiology (ESC). OUP Academic, Oxford University Press,

14 Jan 2016, https://academic.oup.com/eurheartj/article/37/3/267/2466099.

5. Mason BJ, Shah B, Tamis-Holland JE, Bittl JA, Cohen MG, Safirstein J, Drachman DE, Valle JA, Rhodes D, Gilchrist IC. An update on radial artery access and best practices for transradial coronary angiography and intervention in acute coronary syndrome: a scientific statement from the American Heart Association. Circ Cardiovasc Interv. 2018;11:e000035. https://doi.org/10.1161/HCV.0000000000000035.