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Coronary Artery Disease (D Feldman and V Voudris, Section Editors)

Radial Percutaneous Coronary Intervention in Complex Arm and Chest Vasculature: Tips and Tricks

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Abstract

Purpose of review The purpose of this review is to identify the anatomical difficulties an operator may encounter during the transradial approach for cardiac catheterization and to offer tips and tricks to overcome those challenges.
Recent findings With increasing implementation of the transradial approach for cardiac catheterization, many new techniques have been utilized to overcome anatomical challenges. This article also discusses the difficulties faced during transradial approach in patients with prior coronary artery bypass grafting (CABG).
Summary Numerous large randomized trials have demonstrated the value of the transradial approach over the transfemoral approach during cardiac catheterization. However, this technique is routinely avoided or aborted due to anatomical variations in the upper arm and chest. These obstacles have delayed adoption of transradial access by operators despite the apparent benefits. This article reviews some of the available tips and tricks described in the literature to overcome anatomical obstacles. By implementing some of these tools into practice, an operator may realize improved procedural success, decreased procedure time, and improved patient comfort with the transradial approach.

Introduction

Since its first description by Campeau, Kiemeneij, and Laarman, the transradial access approach has led to a decrease in vascular complications, shorter hospital stay, improved patient preference, and an overall decrease in all-cause mortality.[1–4] As with all access strategies, operators must be aware of common vascular anomalies encountered during the procedure. This article reviews the various arm and chest vascular variations encountered and the tips to manage them.

We have divided this review into three sections: (1) Anatomical challenges in the upper extremity; (2) Challenges in the chest; (3) Challenges in patients with prior coronary artery bypass graft (CABG) surgery.

Upper extremity anomalies

Radial spasm

Radial artery spasm should be suspected in a patient complaining of pain during the passage of the catheter or guidewire. Difficulty with advancement or a "tugging" feeling on the catheter should suggest spasm. Management can be performed by injecting a spasmolytic cocktail containing agents such as verapamil and nitroglycerin. Sedative and anxiolytic agents such as midazolam and fentanyl can also be administered to relieve the sympathetic tone in the artery due to patient's anxiety and improve patient comfort (see Table 1). The spastic artery can often be traversed with lower profile guidewires or smaller caliber catheters. Attempts should be made to minimize repeated radial artery puncture as well as repetitive catheter exchanges. Hydrophilic sheaths and catheters can also be utilized to improve efficacy. Anomalous vasculature such as a high take-off radial artery or the recurrent radial artery is more prone to spasm. Defining the anatomy can be helpful if initial attempts to treat spasm with vasodilators is not successful.

Radial tortuosity

Similar to radial artery spasm, radial tortuosity often presents with difficulty in passing the guidewire or guide catheter. Risk factors for radial tortuosity include

Table 1. Spasmolytic medications

	Medications	Common dosage
Calcium channel blockers	Diltiazem	1–5 mg
	Verapamil	1–5 mg
Nitrates	Nitroprusside	100 μg
	Nitroglycerin	0.1–0.4 mg
	Nicorandil	2 mg
Phosphodiesterase inhibitors	Papaverine	30 mg
Anesthetics	Lidocaine 1%	Administer locally as needed
Sedatives	Midazolam	0.5–2 mg
	Fentanyl	25–100 μg

older age, female gender, and hypertension. If the operator encounters resistance in passing the guidewire, an angiogram is warranted. If the radial artery is tortuous, it can be addressed with smaller caliber guide wires such as 0.025″ hydrophilic wire or 0.014″ soft-tipped coronary wire. The guide wire should be advanced as far as possible and then the catheter should be slowly passed over it. If the patient experiences discomfort during delivery of the catheter, the operator should suspect vasospasm and repeated spasmolytic cocktail administration can be delivered through the guide catheter. Finally, "balloon-assisted tracking" (BAT) may also be utilized in the most difficult situations [5]. In the BAT technique, an inflated PTCA balloon is partially protruded through the distal end of the guide catheter and deployed at low pressure. Then the whole assembly is advanced over the 0.014″ coronary wire, thus allowing for the non-traumatic advancement through the anatomical obstruction.

Radial artery loop

The reported incidence of a radial artery loop is 0.8 to 2.3%.[6] However, it is the most common anatomical variation causing transradial approach failure [7]. When the operator feels resistance to catheter or guide wire advancement, early angiography is recommended. In case of a simple/partial loop, one can use fluoroscopic guidance to cross the loop.

If a complex loop is identified and one wishes to cross it, using a few angiographic views may identify the exact anatomy of the loop. Some common strategies include using a smaller catheter, a hydrophilic wire or a lower profile guidewire (0.025″ or 0.014″). The tip of the wire can be shaped according to the angle of the loop to further facilitate the passage. If one guidewire is inadequate to provide the support to cross the loop, additional one or two buddy guidewires can also be utilized. In most cases, the anatomy of the loop is not disturbed. However, if the operator feels the resistance to cross the loop, straightening of the loop can be of alternative help. This can be done by placing the guide wire tip as far as possible (high radial, brachial, or subclavian) and then passing the catheter as far as possible. Thereafter, the whole assembly (including the guide wire and catheter) should be pulled back and rotated slightly. This method straightens the loop. The patient should be warned of possible discomfort in the arm during this maneuver and appropriate sedation should be administered. If the patient experiences discomfort during this process, it is this author's opinion that the approach should be abandoned. In case of complex 360-degree loops, either exchanging the standard guide wire with 0.025″ hydrophilic guidewire or BAT, as described above, is recommended. In case of reactive spasm or failure of passage through the loop, switching to the left radial or right ulnar is recommended. It should be noted that even many experienced radial operators, upon identifying a complex loop, will abandon the access site and choose either the ipsilateral ulnar or contralateral radial artery.

Another important observation with radial artery loops is that they are often associated with a recurrent radial artery that originates at the apex of the loop. It is relatively common for many wires to enter that recurrent radial and allow for passage of a diagnostic catheter. This anatomy becomes apparent when spasm develops, or the catheter is unable to be advanced beyond the upper arm (Fig. 1).

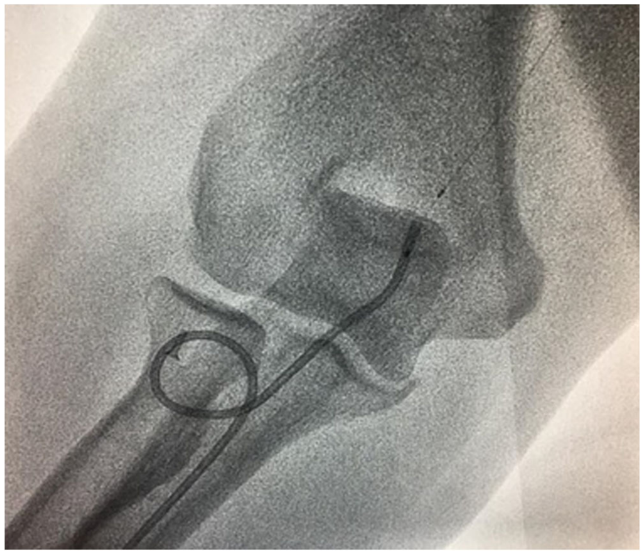

Fig. 1. Radial artery loop.

Anomalous radial artery

High radial artery origins can be frequently encountered during procedures with a reported incidence of up to 8%.[8] Resistance to advancement of guide wire or guide catheter can occasionally be misinterpreted as spasm given the small caliber diameter of the radial artery. Under fluoroscopy, it may be noted that the arterial course through the antecubital fossa has a more lateral approach than expected. As mentioned previously, obtaining an angiogram near the site of encountered resistance will help. Next, downsize the catheter and administer a repeat dose of the anti-spasmolytic cocktail to enable reduction in resistance. In most circumstances, the high origin can be traversed with most diagnostic catheters and a hydrophilic wire. Lastly, BAT again proves a useful technique to navigate the small radial artery should there be continued difficulty advancing the guide catheter. Operators should be aware that these vessels are more prone to spasm and pay attention to catheter exchanges and manipulation. It is also important to distinguish a high-origin radial artery from a recurrent radial artery (Fig. 2).

Chest vasculature anomalies

Subclavian tortuosity

Approximately 6–10% of patients undergoing TRA (see Fig. 3) demonstrate severe subclavian tortuosity.[9, 10] Clinical predictors include female gender, older age, systemic hypertension, short stature, nonsmoker, and high body mass index. Tortuosity should be initially managed by asking the patient to take deep breaths which moves the thorax downwards and improves the passage of assembly through the tortuous vessel. At times, despite having the guidewire positioned appropriately in the ascending aorta, the operator may notice resistance while passing the catheter through the tortuous vessel. In this case, the whole assembly should be pulled back slightly which helps straighten the

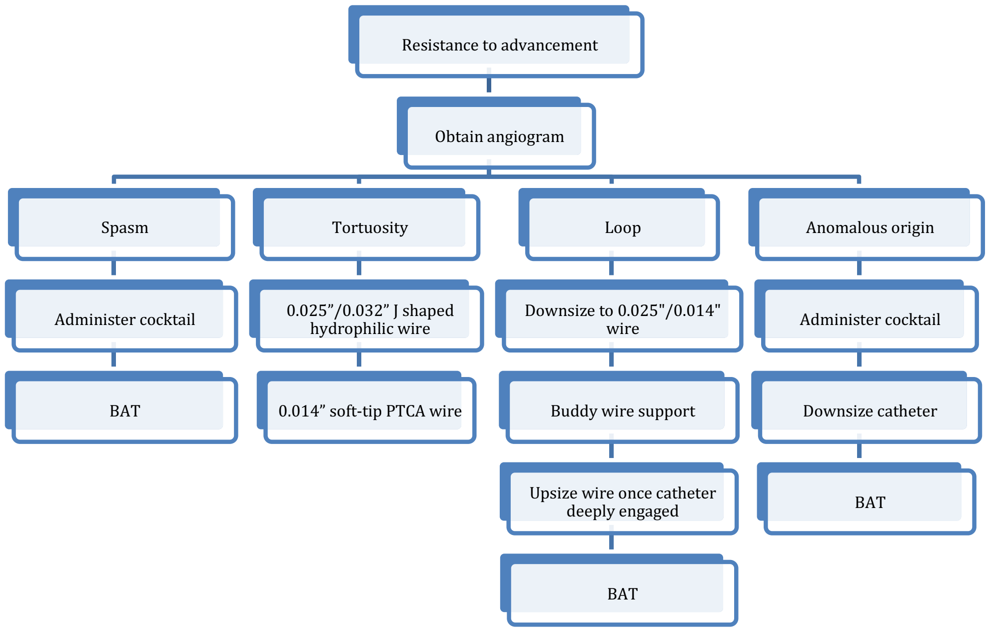

Fig. 2. Navigating frequently encountered upper extremity obstacles.

tortuosity. If a standard guidewire fails to enter the ascending aorta, the 0.025″ hydrophilic wire may pass the tortuous segment. Studies have shown a twofold higher incidence of operator-reported subclavian tortuosity through right radial approach compared to left radial approach [11]. Also, a relative decrease in the fluoroscopic time and radiation exposure via left radial approach should provide incentive to the operator to consider left radial approach [12]. Many groups have taken these observations into account when developing their transradial primary PCI program. Patients with increased risk of subclavian tortuosity are

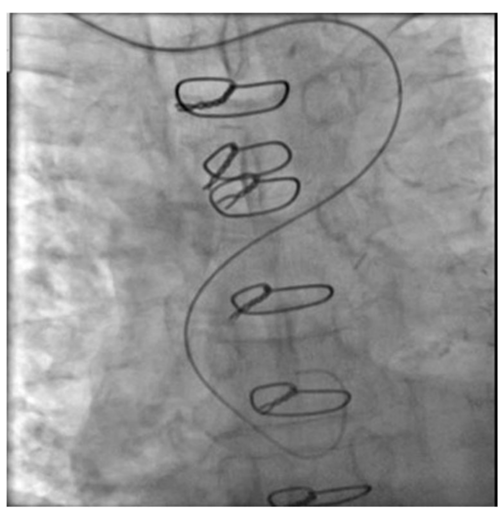

Fig. 3. Subclavian tortuosity.

preferentially approached with the left radial artery to decrease door to reperfusion time [13].

Subclavian loop

Simple loops are commonly encountered in the subclavian-innominate region. If the standard guidewire is unable to pass the simple loop, 0.032″ or 0.025″ hydrophilic guidewire can be used. If the hydrophilic wire also fails, consider a soft-tipped 0.014″ wire to enter the ascending aorta. Finally, for more complex loops, the BAT technique can be used to surpass the loop.

Congenital aberrancy - arteria lusoria

Arteria lusoria is a congenital aberrancy of right subclavian artery where the right subclavian artery originates from the ascending aorta as a fourth branch and turns right behind the esophagus and in front of the vertebral column. The incidence of retro-esophageal subclavian artery varies from 0.3–1.7%. [14] Repeated entry of the guidewire and the catheter in the descending aorta should raise the suspicion for the presence of arteria lusoria. If a standard 0.035″ guidewire repeatedly enters the descending aorta, a 0.032″ or 0.025″ hydrophilic guidewire can help facilitate the entry of the guidewire into the ascending aorta. If the guidewire and catheter still enter the descending aorta, pull the assembly slightly back and ask the patient to take a deep breath. This can facilitate the movement of the assembly into the ascending aorta. If this fails, replace the previous catheter with an IMA, Simmons, or AL diagnostic catheter and ask the patient to take a deep breath to facilitate entry into the ascending aorta. Switching to a left radial access approach will also solve this problem, as the left subclavian will enter the aorta in its usual location.

Challenges in patients with prior CABG surgery

All patients with prior coronary artery bypass grafts (CABG) must undergo a pre-procedural evaluation to assess for the number and type of grafts to help select the best vascular access site. Operators need to direct their attention to the presence of an IMA graft (functional side) and use of radial conduits for the bypass. The role of routine pre-procedure testing for the presence of dual hand circulation is of unclear clinical benefit in terms of reducing the rate of hand ischemia (RADAR Trial). [15] However, this testing is still useful in guiding post procedure management. Studies have shown that time for internal mammary artery (IMA) cannulation and IMA assessment using transradial approach is less than the transfemoral approach [16]. For patients with a patent LIMA, the left radial approach should be preferred as failure in 27% cases in cannulation has been reported via the right radial approach [17]. Similarly, right radial approach is preferred for RIMA. For bilateral IMA grafts, consider a right-sided approach as engaging the LIMA from the right is more straightforward than engaging the RIMA from the left side. The take-off angle between the subclavian artery and IMA is a major determining factor for catheter selection during ipsilateral transradial approach. Common catheters for this purpose include the Judkins right, internal mammary, and 3D Williams catheter. For crossover access of the LIMA from the right, the Bartorelli-Cozzi (BC) or IMA catheters are commonly used.

Crossing over to the left subclavian (LSC) from the right side: (1) bring your diagnostic catheter of choice (IMA or BC) in the aorta, (2) exchange for a non-stiff 0.035″ angled hydrophilic wire (180 cm) with a torque device, (3) extrude the wire from the catheter with the camera in an LAO projection (15–20 degrees), (4) advance the wire slowly into the LSC, continue to advance the wire as far as possible preferably past the shoulder joint, (5) while holding the wire as a rail, advance the catheter to several centimeters past the likely ostium of the LIMA (NOTE: if there is insufficient support to advance the catheter, a few options include the following: advance the wire further and use a bent elbow or an inflated BP cuff to secure the wire distally, exchange for a stiff wire), (6) remove the wire, flush, retract the catheter until it engages the ostium. This process can be repeated for a guiding catheter or if the diagnostic catheter is in place, use an exchange length wire (hydrophilic or standard).

In aorto-coronary saphenous venous grafts, for diagnostic angiography, a Judkins right catheter is a reasonable first choice for both left and right venous grafts. However, better engagement and support for PCI can be achieved with multipurpose catheters for right grafts and with Amplatz left catheters for left grafts. With careful catheter selection, prior CABG is not a contraindication for the diagnostic and interventional procedures via transradial approach. In fact, patients with CABG tend to be older and have more comorbidities than non-CABG patients; this observation makes CABG patients even more likely to experience the benefits of radial access.

Conclusion

Transradial access is an important advance in the evolution of cardiac catheterization and PCI. To achieve its full potential, operators must be able to identify and navigate common vascular anomalies and obstacles. In this manuscript, we describe many preventative steps as well as strategies to tackle specific anatomical challenges. However, as Julius Caesar suggested, "Experience is the teacher of all things."

Compliance with Ethical Standards

Conflict of Interest
The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

Publisher's Note

References and Recommended Reading

1. Jolly SS, Yusuf S, Cairns J, Niemelä K, Xavier D, Widimsky P, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. Lancet. 2011;377:1409–20.
2. Rao SV, Cohen MG, Kandzari DE, Bertrand OF, Gilchrist IC. The transradial approach to percutaneous coronary intervention. historical perspective, current concepts, and future directions. J Am Coll Cardiol. 2010;55:2187–95.
3. Singh S, Singh M, Grewal N, Khosla S. Transradial vs transfemoral percutaneous coronary intervention in ST-segment elevation myocardial infarction: a systemic review and meta-analysis. Can J Cardiol. 2016;32:777–90.
4. Valgimigli M, Gagnor A, Calabró P, Frigoli E, Leonardi S, Zaro T, et al. Radial versus femoral access in patients with acute coronary syndromes undergoing invasive management: a randomised multicentre trial. Lancet. 2015;385:2465–76.
5. Patel T, Shah S, Pancholy S, Rao S, Bertrand OF, Kwan T. Balloon-assisted tracking: a must-know technique to overcome difficult anatomy during transradial approach. Catheter Cardiovasc Interv. 2014;83:211–20.
6. Dash D. Troubleshooting in transradial catheterization: the lessons learnt so far. Cit Dash D J Hear Heal. 2016;2:1–7.
7. Barbeau GR. Radial loop and extreme vessel tortuosity in the transradial approach: advantage of hydrophilic-coated guidewires and catheters. Catheter Cardiovasc Interv. 2003;59:442–50.
8. Lo TS, et al. Radial artery anomaly and its influence on transradial coronary procedural outcome. Heart. 2009;95:410–5.
9. Rigatelli G, et al. Strategies to overcome hostile subclavian anatomy during transradial coronary angiography and interventions: impact on fluoroscopy, procedural time, complications, and radial patency. J Interv Cardiol. 2014;27:428–34.
10. Cha KS, Kim MH, Kim HJ. Prevalence and clinical predictors of severe tortuosity of right subclavian artery in patients undergoing transradial coronary angiography. Am J Cardiol. 2003;92:1220–2.
11. Sciahbasi A, Romagnoli E, Burzotta F, Trani C, Sarandrea A, Summaria F, et al. Transradial approach (left vs right) and procedural times during percutaneous coronary procedures: TALENT study. Am Heart J. 2011;161:172–9.
12. Shah RM, Patel D, Abbate A, Cowley MJ, Jovin IS. Comparison of transradial coronary procedures via right radial versus left radial artery approach: a meta-analysis. Catheter Cardiovasc Interv. 2016;88:1027–33.
13. Larsen P, Shah S, Waxman S, Freilich M, Riskalla N, Piemonte T, et al. Comparison of procedural times, success rates, and safety between left versus right radial arterial access in primary percutaneous coronary intervention for acute ST-segment elevation myocardial infarction. Catheter Cardiovasc Interv. 2011;78:38–44.
14. Patel TM, Shah S, Pancholy SB. Strategies to traverse the arm and chest vasculature. Interv Cardiol Clin. 2015;4:127–44.
15. Valgimigli M, Campo G, Penzo C, Tebaldi M, Biscaglia S, Ferrari R. Transradial coronary catheterization and intervention across the whole spectrum of Allen test results. J Am Coll Cardiol. 2014;63:1833–41.
16. Burzotta F, Trani C, Hamon M, Amaroso G, Kiemeneij F. Transradial approach for coronary angiography and interventions in patients with coronary bypass grafts: tips and tricks. Catheter Cardiovasc Interv. 2008;72:263–72.
17. Sandhu K, Butler R, Nolan J. Expert opinion: transradial coronary artery procedures: tips for success. Interv Cardiol (London, England). 2017;12:18–24.