Radial Access in Neurointervention: Innovations, Challenges, and Future Horizons

An update on the adoption of radial access in neuroendovascular procedures, including advantages in safety and patient comfort, managing complications, and where we're going next.

By Basel Musmar, MD, and Pascal M. Jabbour, MD

In the context of neurointervention, Matsumoto and colleagues introduced radial access in 2000, with subsequent large studies confirming the safety and practicality of transradial cerebral angiography.[1-5] Despite the use of devices originally designed for femoral access, radial access has been successfully employed in complex procedures for both ischemic and hemorrhagic conditions in the posterior and anterior circulation.[6-12] Although the adoption of radial access in neuroendovascular procedures has been gradual, interest has been steadily growing in recent years.

The shift from femoral to radial access is not just a matter of procedural preference but one that is supported by strong clinical evidence.[13] Radial access has been associated with a significant reduction in vascular complications, particularly in patients with complex vascular anatomies or those at high risk of bleeding.[13] Furthermore, the technique is linked with improved patient satisfaction, as it generally requires less postprocedural immobilization, which is a critical factor in patient-centric care.[13]

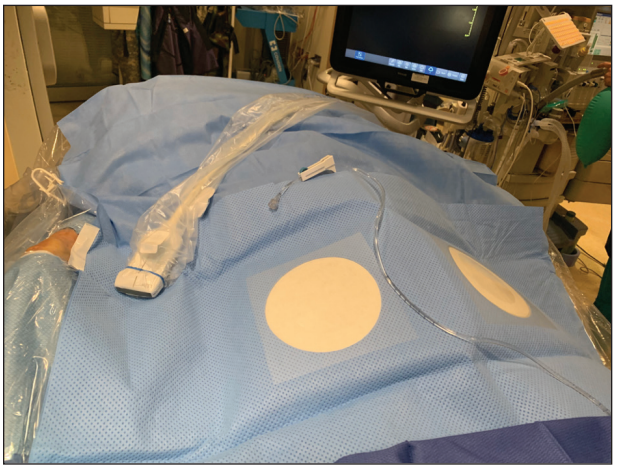

Figure 1. All procedures are performed with ultrasound-guided arterial puncture.

ADVANTAGES, SAFETY, AND CURRENT INNOVATIONS

Safety

Radial access in neurovascular procedures has gained attention due to its favorable safety profile, particularly regarding access site complications, major bleeding, and other adverse outcomes.[13] Although randomized control trials in the neurovascular field are lacking, there is a growing body of evidence from single-center studies that demonstrate positive outcomes using radial access for both diagnostic and interventional neurovascular procedures (Figures 1 and 2).[1,4,14-21] There is plenty of cardiology literature establishing safety and a better morbidity and mortality profile, to the point that three of the largest societies for interventional cardiology in Europe issued a joint guideline formally recommending radial access as the first choice for cardiac procedures.[13,22] Despite concerns from some femoral operators about the risk of hand ischemia due to the radial artery's smaller size, the forearm's extensive collateral circulation through the radial, ulnar, and interosseous arteries generally mitigates this risk.[13] Hand ischemia resulting from procedure-related compromise of the radial artery is exceedingly rare and usually limited to case reports.[13] Most distal complications tend to be embolic in nature, often secondary to inadvertent injection of air or particles through the sheath.[13]

Figure 2. Setup for a radial access approach, with the wrist positioned at the same level as the groin. A custom-built platform elevates the wrist, ensuring it remains aligned with the groin area to be able to comfortably manipulate microcatheters and wires.

Patient and Operator Benefits

Patients benefit from radial access in several ways, including shorter preprocedural preparation times, reduced procedure room times, less postprocedural discomfort, and earlier mobilization and discharge.[13,23] Patients report less stress and embarrassment due to the nonexposure of the groin and generally prefer radial access over femoral access.[13]

The advantages of radial access extend beyond patient comfort to cost savings as well.[24] Radial access for outpatient cerebral angiography is associated with shorter preparation times, shorter room times due to rapid hemostasis with radial closure devices, and quicker recovery and discharge, ultimately reducing the length of hospital stay.[13,24] Although the cost difference between uncomplicated radial and femoral diagnostic procedures is minimal, the financial benefits of radial access become more evident in interventional procedures and when access site complications arise.[24]

High-risk patient populations, such as the elderly, patients on blood thinners, pregnant patients, those with high body mass index, and patients with iliofemoral atherosclerotic disease, may also benefit from radial access due to reduced radiation exposure and fewer access site complications.[25,26] Importantly, anticoagulants do not need to be withdrawn when using radial access in patients already receiving these medications.[13]

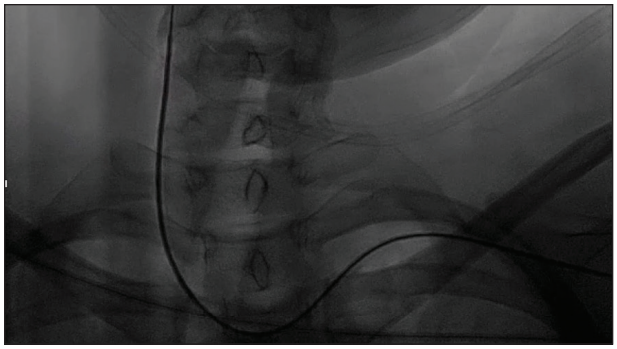

Figure 3. Left radial approach with catheterization of the right internal carotid artery.

Innovation and Refinement

The left radial access and distal radial access techniques represent additional refinements that expand the armamentarium for overcoming unique anatomic limitations (Figure 3).[27,28] The left vertebral artery is dominant in most patients, and subclavian tortuosity is more common on the right side, making the left radial approach more advantageous in these cases.[29-31] Distal radial access has been associated with lower rates of radial artery occlusion (RAO) and hand ischemia, and because hand supination is not required, left-sided access becomes more comfortable with the hand draped across the body in a neutral position.[5,32-34] These refinements further enhance the safety, feasibility, and patient satisfaction associated with radial access in neurovascular procedures.

In addition, radial access has shown its efficacy not only for elective procedures but also for acute and complex treatments such as aneurysm treatments in both anterior and posterior circulations, arteriovenous malformations, arteriovenous fistulas, stroke treatment, and carotid stenting.[13]

DISADVANTAGES AND PERSISTENT CHALLENGES

Radial Artery Spasm

Radial access in neurovascular procedures offers numerous advantages, but it is crucial to anticipate and manage potential complications effectively. Radial artery spasm (RAS) is the most common complication, occurring in 15% to 30% of cases. However, this can be reduced to 6% to 10% with intra-arterial administration of vasodilators such as nitroglycerin and calcium channel blockers.[35,36] RAS is often triggered by factors such as anxiety, small radial artery diameter, guidewire

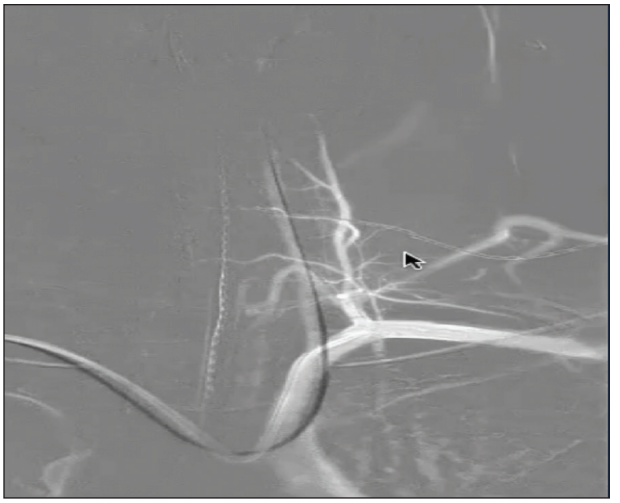

Figure 4. Catheterization of the left vertebral artery from the right radial approach.

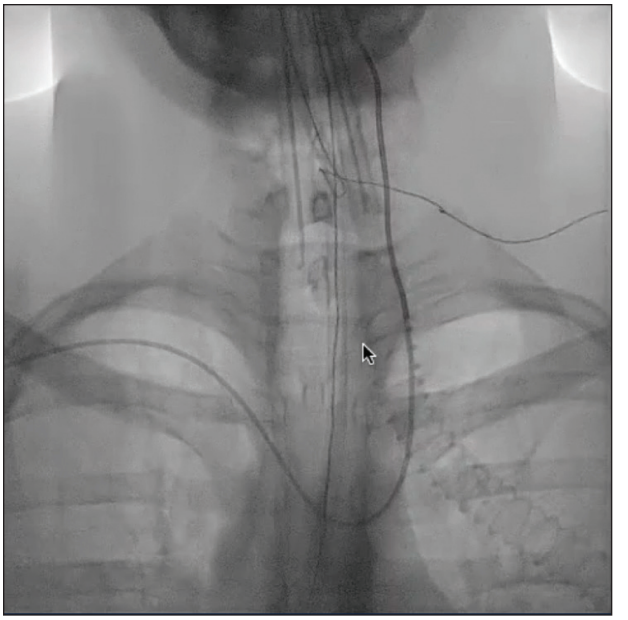

Figure 5. Catheterization of the left internal carotid artery from the right radial approach.

manipulation, and increase in size of the sheath/catheter.[13] To mitigate RAS, adequate sedation, warmth to the forearm, and regular administration of a radial cocktail are essential.[13] In the event of a spasm, the operator should avoid forceful catheter maneuvers and consider additional doses of vasodilators, including subcutaneous nitroglycerin, which has been shown to reduce spasm without significant systemic effects.[13] Inflating a blood pressure cuff at the arm to compress the brachial artery and cause reflex vasodilation in response to the ischemia resolves the spasm in the majority of cases. In severe cases, monitored anesthesia care may be employed to fully relax the patient and relieve the spasm.[13]

Operators must be familiar with anatomic variants of the radial artery, such as radial loops and high radial origin from the brachial or axillary arteries. These variants can usually be navigated safely if recognized early (Figures 4 and 5).[13] If wire perforation of the radial artery is suspected, immediate radial angiography should be performed. Advancing a catheter across the perforation or applying temporary balloon tamponade can control bleeding.[13,20] In cases of expanding forearm hematoma, applying and inflating a blood pressure cuff 20 mm Hg above the systolic pressure for 10 minutes, combined with anticoagulation reversal, may be effective.[13,20] If these measures fail, there is risk of compartment syndrome, indicated by loss of strength, sensation, and pulse in the distal digits and necessitating urgent vascular surgery consultation for potential fasciotomy.[37]

Radial Artery Occlusion

RAO is another significant complication, with incidence rates ranging from 0.8% to 33%.[38,39] However, the majority of RAO cases are clinically silent due to collateral circulation via the palmar arch. A meta-analysis of 66 studies reported RAO rates of 11% with a 6-F sheath and just 2% with a 5-F sheath, thus emphasizing the importance of using the smallest-caliber sheath necessary for the procedure.[40] Pancholy et al found that overall RAO rates at 30 days ranged from 1% to 3%.[41] The main concern with RAO is the potential loss of the radial artery as an access route for future procedures. To minimize the risk of RAO, meticulous attention to detail is essential; this includes minimizing access attempts, using radial-specific sheaths and guides, administering systemic heparinization, and appropriately sizing devices.[40,42] It is important in those cases to caution against using the ulnar route due to increased risk of hand ischemia. The PROPHET-II trial demonstrated that combining ulnar counter compression with patent radial hemostasis can further reduce RAO rates.[41] If RAO is detected early (ie, before discharge for outpatient procedures), a 1-month course of oral anticoagulation has been shown to improve recanalization rates.[13]

Rare and Minor Complications

Although less common, radial artery pseudoaneurysm can also occur. It is managed conservatively if small or with prolonged radial compression, ultrasound-guided compression, thrombin injection, or surgical repair in more severe cases.[13] Other minor complications include extended access site pain, hematoma, and bruising.[43]

Gaining Proficiency

The learning curve for radial access involves approximately 30 to 50 cerebral angiograms to gain proficiency, during which there is a reduction in crossover rates and fluoroscopy times and improved success in catheterizing all intended supra-aortic arteries.[2,44] In a systematic review of 1,342 neurointerventional procedures performed via radial access, the crossover rate to transfemoral access was 4.77%, with 10.93% of crossovers due to failure to obtain radial artery access and 89.06% due to inability to catheterize the target vessel.[45] Recently, these numbers have been decreasing significantly with the introduction of radial-specific catheters such as Armadillo (Q'Apel Medical) and Rist (Medtronic).

FUTURE HORIZONS

As the field of neurointervention continues to evolve, the role of radial access is becoming increasingly prominent, with ongoing publications highlighting the experiences and outcomes of "radialist" neurointerventionalists. The growing body of literature includes articles and book chapters ranging from basic techniques to advanced and procedure-specific protocols for radial access.[13] This wealth of information is complemented by a variety of online and live training courses, initially developed for cardiology and other interventional procedures and now making its way into neurointerventional meetings.[13] Additionally, industry has supported this educational effort by providing radial access simulators for centers that are committed to dedicated training in this approach.[13] Many medical centers across the United States have introduced radial access training into their fellowship programs to ensure that the next generation of neurosurgeons is well-versed in both radial and femoral techniques. Also, more radial-specific sheaths are being developed to help navigate the difficult anatomy, especially for tortuous left carotid arteries.

CONCLUSION

With adequate training, the radial access approach can be effectively utilized across the entire spectrum of neurointerventional procedures. The advantages of radial access observed in cardiology and body interventional literature—such as reduced bleeding, vascular complications, mortality, lower costs, and improved patient satisfaction—are now being recognized in the neurovascular field. As these benefits become increasingly apparent, radial access is poised to become an essential approach in neurointerventional procedures, keeping in mind that it is always important to evaluate the vascular anatomy before the procedure to be able to choose the best approach for the best patient. ■

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Basel Musmar, MD
Department of Neurological Surgery
Thomas Jefferson University Hospital
Philadelphia, Pennsylvania
Disclosures: None.

Pascal M. Jabbour, MD
The Angela and Richard T. Clark Distinguished Professor of Neurological Surgery
Division Chief of Neurovascular Surgery and Endovascular Neurosurgery
Thomas Jefferson University Hospital
Philadelphia, Pennsylvania
pascal.jabbour@jefferson.edu
Disclosures: Consultant to Medtronic, MicroVention, Balt, and Cerus Endovascular.