AJNR

Transradial Cerebral Angiography: Technique and Outcomes

Alison M. Nohara and David F. Kallmes

Transradial Cerebral Angiography: Technique and Outcomes

Alison M. Nohara and David F. Kallmes

BACKGROUND AND PURPOSE: **The transradial approach is routinely used for coronary angiography, but only limited data exist regarding transradial cerebral angiography. The purpose of this report was to offer detailed procedural methods for transradial cerebral angiography to facilitate adoption of the technique.**

METHODS: **We reviewed 60 consecutive cases of transradial access used for neuroangiography and catalogued the indications for angiography, the sheath size, the catheter type, the length of the procedure, the number of cases in which radial artery access was unsuccessful, and the complications. We also noted procedural details regarding adjunctive medications, preprocedural patient assessment, and postprocedural care.**

RESULTS: **Transradial angiography was successfully applied in 57 of 60 cases (51 diagnostic, six interventional, three failed accesses). Sheaths were used in all cases and ranged in size from 4F to 6F. Mean procedural time for diagnostic cases was 40 minutes ± 19 [SD]. Access-site complications included one forearm hematoma.**

CONCLUSION: **Transradial angiography is a useful tool for diagnostic and interventional neuroangiographic procedures. All relevant vessels can be accessed from the radial artery for diagnostic studies. Interventions in the right vertebral and carotid systems are facilitated by the transradial approach.**

The radial artery approach to coronary angiography and intervention has been used since 1989 (1–6). Transradial access offers numerous benefits in comparison with conventional femoral or transbrachial approaches. These benefits include decreased rates of puncture site–related complications, improved patient comfort, and cost-effectiveness (1–9). If similar benefits could be realized in neuroangiographic applications, the transradial approach could serve as a valuable alternative to standard techniques. However, despite the widespread reporting of transradial angiography in the cardiology literature, use of the technique is rarely reported in diagnostic and interventional neuroangiography (10–14).

In this article, we present our experience with the use of transradial access in diagnostic and interventional neuroangiographic procedures. We offer details of our approach to radial angiography, specifically regarding 1) preprocedural assessment; 2) equipment used, including needles, wires, and size and type of sheaths and catheters; 3) postprocedural care; and 4) complications. Our study was intended for practitioners not yet experienced in the use of radial artery access for neuroangiography, and we hope that the details offered here will facilitate adoption of the technique.

Methods

A retrospective study was performed from October 2001 through February 2002 by using chart review to identify all patients in whom angiography via the radial artery was considered. This approach is particularly advantageous in patients requiring vertebral basilar interventions, in patients receiving anticoagulation, in patients undergoing gamma knife procedures (in which a stereotactic frame is placed, making lying flat burdensome), and in patients who were neurologically impaired in whom postprocedural care would be difficult. Patients with renal insufficiency or renal failure who were candidates for arteriovenous (AV) fistulas—as determined through discussion with the referring physician—were excluded, because patency of the radial artery is imperative for the success of the fistula procedure. We catalogued the following parameters: indication for angiography, sheath size, catheter type, length of procedure, number of cases in which radial artery access was unsuccessful, and complications.

Procedural Protocol

Before considering radial artery access, patients were examined to confirm patency of the palmar arch. We performed a visual Allen test, for which blanching of the palm was eradicated within 7 seconds after release of the ulnar artery, while still compressing the radial artery (15). In addition, a Doppler probe was placed over the expected region of the palmar arch to determine whether arterial signal intensity remained present during compression of the radial artery. Finally, in equivocal cases after visual Allen testing and Doppler insonation, a pulse oximeter was placed on the patient's thumb, and the radial artery compressed; patency of the palmar arch was considered present if a strong waveform remained and the percentage of oxygen saturation remained unchanged.

A modified armboard was used to support the extremity. Puncture of the radial artery was performed approximately 2 cm cephalic to the radial styloid. The right radial artery was used in preference to the left radial artery, except in rare instances, as detailed later. After subcutaneous infiltration with 1% lidocaine (Abbott Laboratories, North Chicago, IL) buffered with 8.4% sodium bicarbonate (Abbott Laboratories) a 21-gauge needle was used to enter the radial artery. After arterial entry was achieved, a 0.018-inch guidewire was inserted. (micropuncture set; Cook, Inc, Bloomington, IN). Although single-wall puncture was considered ideal, the needle frequently passed through both arterial walls before is was retracted and the wire inserted. The sheath (radial sheaths, 4F, 5F, and 6F; Cook) was then advanced over the wire. After sheath placement, verapamil 3 mg (American Pharmaceutical, Los Angeles, CA) was injected through the sheath sideport for spasm prophylaxis. Early in our experience, we noted that a pressurized sodium chloride infusion through the sheath, as routinely used in transfemoral cerebral angiography, was painful for some patients. We ascribed this finding to the fact that radial artery spasm at the sheath tip might have caused transluminal exudation of the infused solution. Therefore, we avoided continuous sodium chloride flushing of the sheath and instead simply filled the sideport of the sheath with 1000–2000 U of heparin (American Pharmaceutical) immediately after sheath placement.

After placement of the sheath, a straight 0.035-inch wire, either a Bentson (Cook) or Terumo (Boston Scientific/Meditech, Natick, MA) wire, was used to navigate the arm vasculature. Because our angiography table (Neurostar; Siemens, Essen, Germany) does not allow imaging lateral enough to include the arm, we gently advanced the wire without fluoroscopy to the level of the shoulder. Subsequently, we used fluoroscopic guidance to monitor all wire and catheter manipulations. The systemic administration of heparin (American Pharmaceutical) was used routinely, except when it was contraindicated because of medical or neurologic conditions, such as recent or ongoing hemorrhage.

Catheter and Guidewire Selection

For patients undergoing angiography for a workup of carotid stenosis, a pigtail catheter (Cook) was placed over a Bentson guidewire into the ascending aorta for arch aortography. In most cases, the wire and catheter was used to preferentially select the descending aorta. If difficulty was encountered in placing the pigtail into the ascending aorta rather than descending aorta, an angled 0.035-inch Terumo guidewire (Boston Scientific/Meditech) was used to select the ascending aorta. In cases in which angiography was limited to right vertebral or right carotid injections, a vertebral (Merit Medical, Angelton, TX) or hockey-stick curve (Angiodynamics, Inc, Queensbury, NY) was preferred. For selecting the right common carotid artery (CCA), which originates from the brachiocephalic artery in an acute angle via the transradial approach, catheters were custom steamed to exaggerate the distal curve. The right CCA could then be accessed by using an angled

guidewire (Terumo; Boston Scientific/Meditech). In cases requiring left carotid or left vertebral catheterization, a Simmons II catheter (Boston Scientific) was preferred. Simmons catheters were shaped either by tracking the catheter over a Bentson guidewire that had doubled back on itself after contacting the aortic valve or by allowing the curve of the catheter to elbow across the aortic arch. However, if the left CCA was known to originate from the brachiocephalic artery, a vertebral (Merit Medical) or hockey-stick (Angiodynamics) curve was used.

Postprocedural Care

At the termination of the angiographic study, the sheath was removed, and a wrist brace (RadStat, Merit Medical) was placed (10). If resistance was encountered during removal of the sheath, a second infusion of verapamil (American Pharmaceutical) was given. Anticoagulation was not reversed. The wrist brace was kept in place for 2–3 hours, depending on the amount of heparin administered during the procedure. If continued oozing or bleeding was noted at the time of initial brace removal, an additional 1 hour of bracing was used. Patients were allowed to sit up immediately after the procedure, if their medical condition allowed it. Close observation was maintained regarding the adequacy of distal tissue perfusion. Pulses were checked after adequate homeostasis was achieved; however, no further evaluation was performed to confirm the patency of the radial artery. Because patency of the palmar arch was determined before the onset of the study, candidates for AV fistulas were excluded, and the rate of long-term occlusion of the radial artery after catheterization (as determined at 1–6-month sonographic follow-up) is only 3.6% (16), it was believed that further postprocedural evaluation of patency was not necessary.

Results

We identified 60 patients who were considered for radial artery angiography, after patency of the palmar arch was confirmed. We did not keep track of cases in which results of the Allen test suggested inadequacy of the palmar arch, although we estimated that this occurred in approximately 10–20% of patients screened. The 60 cases included 50 diagnostic cases, seven interventional cases, and three failed attempts.

Sheath sizes were 4F (n = 3), 5F (n = 52), and 6F (n = 2). The catheters used included the following: pigtail (n = 26; Cook), Simmons II (n = 41; Boston Scientific), vertebral (n = 17; Merit Medical), hockey-stick 2 (n = 6; Angiodynamics), WA Hospital cerebral (n = 2; Cook), Berenstein Soft-Vu catheter (n = 1; Angiodynamics), Simmons hydrophilic catheter (n = 1; Boston Scientific), and Envoy (n = 2; Cordis, Miami, FL).

A total of 15 aortic arch injections were performed. In the diagnostic cases, selective injections involved the following: right CCA (n = 34), right internal carotid artery (ICA) (n = 16), left CCA (n = 31), left ICA (n = 14), right vertebral artery (n = 14), right subclavian artery (n = 5), left vertebral artery (n = 17), left subclavian artery (n = 11), and right innominate artery (n = 1). The seven interventional cases included coil occlusion of vertebrobasilar aneurysms (n = 2), coil occlusion of a left ophthalmic artery aneurysm, epistaxis embolization, spinal embolization, and dural AV malformation embolization.

We preferred using the right radial artery as our room is set up to accommodate this approach. In a

single case in which attempts to cannulate the right radial artery failed (presumably as a result of a previous arterial line), successful cannulation of the left radial artery was performed as described before. The patient rested his arm across his chest for the duration of the procedure, without discomfort.

A total of three failed attempts occurred, wherein transradial arterial access was unsuccessful and femoral angiography was performed. Minor bleeding from the puncture site was seen in seven (12%) of 57 cases. In these seven cases, bleeding stopped after 1 additional hour of compression with the RadStat device (Merit Medical). Complications included forearm hematoma (n = 1), dissection of the right CCA (n = 1), and transient reddening of the hand (n = 1). The single case of forearm hematoma occurred because of perforation of the radial artery due to the tip of the dilator, which was inadvertently advanced beyond the tip of the guidewire. The hematoma resolved without sequelae. None of the complications conveyed long-term morbidity or lengthened the patient's hospital stay. The mean duration of the diagnostic procedure was 40 minutes (range, 15–120 minutes ± 19 [SD]).

Discussion

The radial artery approach is a well-established practice in coronary artery intervention. A recent study described its potential usefulness in neuroangiography, but its scope was limited to a single 4F catheter type, and it offered few procedural details that could facilitate adoption of the technique by those inexperienced with the transradial approach (11). Another group (14) reported excellent results in a cohort of similar size and also offered some details regarding the technique. Reports of transradial angiography for interventional neuroradiology are limited (10, 13). Our study broadens the current literature about transradial angiography by providing procedural details regarding patient assessment, access techniques, and catheter selection.

Our study findings confirm the utility of transradial angiography in diagnostic and interventional neuroangiographic procedures. Compared with the standard femoral and brachial approaches, this approach offers equal access to all relevant brachiocephalic vessels, including both vertebral arteries and ICAs; it exhibits comparable or lower complication rates; it has less severe consequences due to occlusion; it does not require the termination of anticoagulation; and it potentially offers greater patient comfort.

The transradial approach is ideal for interventions in the right vertebral and right carotid systems. The right vertebral artery is often extremely difficult to catheterize from a transfemoral approach. From a transradial approach, the right vertebral artery is often the cerebral vessel most readily catheterized. Stability of guiding catheters in the right vertebral and carotid systems is outstanding from a transradial approach. Catheter stability is excellent because the catheter system is confined to vessels with relatively small diameters, whereas guiding-catheter instability from a transfemoral approach often results from the need to traverse ectatic and large-diameter aortic arches. In fact, in one diagnostic case, we were unable to obtain catheter stability in the left CCA to perform the procedure. Switching to the radial approach not only allowed diagnostic runs but also enabled us to perform interventional permanent balloon occlusion of the left ICA when the patient returned because the transfemoral approach fail for a second time.

The complication rates with the transradial approach are comparable to those of the femoral approach, if not slightly improved (6). In comparison, axillary and brachial artery access has a fivefold increase in the complication rate, compared with the rate with puncture of a femoral graft; overall risk for all minor and major complications is 8% (17–18). The rate of serious complications requiring further hospitalization or surgery is 3.3% for axillary-brachial access versus 1.7% for the transfemoral approach (19).

The higher rate of major complications encountered with the axillary-brachial approach is primarily due to occlusion leading to limb ischemia and clinically important hematoma leading to nerve impingement. These two complications are far less likely to occur with the transradial approach. Unlike the brachial or axillary arteries, the radial artery is not an end artery in cases in which Allen test results are normal. Patency of the palmar arch protects the vascular supply to the hand; therefore, the incidence of distal ischemia is low. Previous series have demonstrated that occlusion rates of the radial artery after transradial cardiac catheterization range from 0% to 5% (16, 20–21). However, to our knowledge, cases of clinically important ischemic complications due to radial artery occlusion have not been reported.

In the axillary-brachial approach, large hematomas can occur because maintaining adequate compression of the axillary or brachial artery is difficult and because of the anatomic location of the nerves. These hematomas can result in brachial plexus compression or injury. These risks are reduced in the transradial approach, because bleeding in the location is so readily apparent that hematomas of a size sufficient to cause vascular and neurologic symptoms are extremely rare.

Anticoagulation is a contraindication for axillary-brachial and femoral approaches secondary to the potential for neurologic compromise caused by a large hematoma. Anticoagulation does not have to be terminated for the transradial approach. Furthermore, anticoagulants can be administered without the need for reversal at the termination of the procedure.

Although we did not specifically quantify the response of patients and nursing staff to the use of transradial angiography, we noted outstanding satisfaction with the technique in both groups. The transradial approach facilitates outpatient angiography, and nursing care is straightforward. Patients who undergo immediate postangiographic procedures, such as radiosurgery, may benefit from transradial angiography.

This study was limited because it was retrospective in design. As noted earlier, we did not determine the frequency of inadequate palmar arch anatomy. Also, we did not perform systematic surveillance of our patients to determine the incidence of radial artery occlusion. Clinical complications caused by damage to the radial artery have rarely, if ever, been published in series detailing transradial coronary angiography because the vessel is so superficial that problems are readily apparent before they become serious.

Conclusion

Transradial angiography is a useful adjunct for diagnostic and interventional neuroangiographic procedures. All relevant vessels can be accessed from the radial artery for diagnostic studies. Interventions in the right vertebral and carotid systems are facilitated by the transradial approach.

Acknowledgments

References

1. Otaki M. Percutaneous transradial approach for coronary angiography. *Cardiology* 1992;81:330–333
2. Campeau L. **Percutaneous radial artery approach for coronary angiography.** *Cathet Cardiovasc Diagn* 1989;16:3–7
3. Lotan, C, et al. **Transradial approach for coronary angiography and angioplasty.** *Am J Cardiol* 1995;76:164–167
4. al-Kutoubi A, de Jode M, Gibson M. **Radial artery approach for outpatient peripheral arteriography.** *Clin Radiol* 1996;51:110–112
5. Rihal CS, Holmes DR Jr. **Transradial cardiac catheterization: is femoral access obsolete?** *Am Heart J* 1999;138:392–393
6. Louvard Y, et al. **Coronary angiography through the radial or the femoral approach: The CARAFE study.** *Catheter Cardiovasc Interv* 2001;52:181–187
7. Cooper CJ, et al. **Effect of transradial access on quality of life and cost of cardiac catheterization: A randomized comparison.** *Am Heart J* 1999;138:430–436
8. Louvard Y, Lefevre T, Morice MC. **Radial approach: what about the learning curve?** *Cathet Cardiovasc Diagn* 1997;42:467–468
9. Goldberg SL, et al. **Learning curve in the use of the radial artery as vascular access in the performance of percutaneous transluminal coronary angioplasty.** *Cathet Cardiovasc Diagn* 1998;44:147–152
10. Fessler RD, et al. **Transradial approach for vertebral artery stenting: technical case report.** *Neurosurgery* 2000;46:1524–1527
11. Matsumoto Y, et al. **Transradial approach for diagnostic selective cerebral angiography: results of a consecutive series of 166 cases.** *AJNR Am J Neuroradiol* 2001;22:704–708
12. Matsumoto Y, et al. **Transradial approach for selective cerebral angiography: technical note.** *Neurol Res* 2000;22:605–608
13. Yoo BS, et al. **A case of transradial carotid stenting in a patient with total occlusion of distal abdominal aorta.** *Catheter Cardiovasc Interv* 2002;56:243–245
14. Levy EIB, Fessler AS, Bendok RD, Ringer BR, Kim AJ, Qureshi SH, Guterman AI, Hopkins LR. **Transradial cerebral angiography: an alternate route.** *Neurosurgery* 2002;51:335–342
15. Benit E, et al. **Frequency of a positive modified Allen's test in 1, 000 consecutive patients undergoing cardiac catheterization.** *Cathet Cardiovasc Diagn* 1996;38:352–354
16. Nagai S, et al. **Ultrasonic assessment of vascular complications in coronary angiography and angioplasty after transradial approach.** *Am J Cardiol* 1999;83:180–186
17. Ansell J, Bettmann MA, Kaufman JA, Wilkins RA. *Complications in Diagnostic Imaging and Interventional Radiology.* 3rd ed. Cambridge: Blackwell Science; 1996:306–308
18. Bakal CW, Silberzweig JE, Cynamon J, Sprayregen S. *Vascular and Interventional Radiology: Principles and Practice.* New York: Thieme Medical Publishers; 2002:11
19. Hessel S, Adams DF, Abrams HL. **Complications of angiography.** *Radiology* 1981;138:273–281
20. Hall JJ, et al. **Ultrasound imaging of the radial artery following its use for cardiac catheterization.** *Am J Cardiol* 1996;77:108–109
21. Saito S, et al. **Transradial coronary intervention in Japanese patients.** *Catheter Cardiovasc Interv* 1999;46:37–41