Interventional neuroradiology continues to expand as an endovascular specialty, offering exciting new and effective treatment for a wide range of complex vascular disorders of the brain, spine, head, and neck. The vessels of the central nervous system are smaller, delicate, and less forgiving than their peripheral counterparts. Complications may lead to permanent disability, stroke, and death. Appropriately trained staff, clinical back-up, and good fluoroscopy equipment are prerequisites for all interventional procedures. We have provided a guide to the equipment we use at our institution. This list is by no means fully comprehensive in relation to all of the catheters, wires, and devices available; it is what we use every day. Familiarity with your equipment is critical for good outcomes in all patients.

CEREBRAL ANGIOGRAPHY

Sheaths
- 5-F short sheath
- Use a 5-F long sheath for tortuous or stenotic iliac anatomy.
- Use a 4-F short sheath for pediatric cases.

Catheters
- 5-F pigtail
- 5-F JB1 (Cook Medical, Bloomington, IN): first-choice catheter for cerebral angiography; it is soft and safe.
- 5-F Sim 2 (Cook Medical): ideal for the difficult left carotid.
- 5-F H1 (Cook Medical): nonhydrophilic is a little stiffer to hold position.
- 4-F Sim 1 (Cook Medical): nonhydrophilic catheter is easy and atraumatic to form.

Diagnostic Wires
- A .035-inch hydrophilic wire is the first choice for cerebral angiography.
- Use a .038-inch hydrophilic wire, which is a little stiffer, for tortuous anatomy.
- A .035-inch shapeable hydrophilic wire is ideal for tortuous right subclavian.
- .035-inch Bentson wire (Cook Medical) is safe for the diseased iliac and aorta.

INTRACRANIAL INTERVENTIONS

Sheaths
- 6-F short sheath
- Use a 6-F long sheath for tortuous or stenotic iliac anatomy.
- 6-F Shuttle sheath (Cook Medical) stabilizes access when the anatomy is challenging.

Catheters
- 6-F MPC (Cordis Corporation, Warren, NJ): first-choice guiding catheter; the workhorse of neurointervention procedures.
- 6-F Sim 2: guide catheters for bovine left carotid arteries.
- 5-F Vitek (Cook Medical): used in combination with a shuttle sheath.

Microcatheters
- Excelsior SI-10 (Boston Scientific Corporation, Natick, MA)
- Echelon 10 and 14 (ev3 Inc., Plymouth, MN)
- Prowler (Cordis)
- Renegade 18 (Boston Scientific)

Microwires
- Transend .014- and .01-inch (Boston Scientific)
- Agility .01-inch (Cordis)
- Mirage .008-inch (Micro Therapeutics, Inc., Irvine, CA) is used for flow-directed microcatheters.
- Luge .014-inch (Boston Scientific) is stiffer with an atraumatic tip, ideal for stenting.
**STENTS**
- Wingspan (Boston Scientific): for intracranial stenting.
- iCast (Atrium Medical Corporation, Hudson, NH): covered stent for carotid blowouts.
- Neuroform (Boston Scientific): stent-assisted aneurysm coiling.
- Enterprise (Cordis): stent-assisted aneurysm coiling.

**EMBOLIZATION**
- Polyvinyl alcohol
- Gelfoam
- Triacryl gelatin microspheres
- N-butyl cyanoacrylate

**THROMBOLYSIS AND ACUTE STROKE TREATMENT**
- 6-F MPC guiding catheter, microcatheter, and microwire.
- Merci retriever (Concentric Medical, Mountain View, CA)
- Microlysis EKOS catheter (EKOS Corporation, Bothell, WA)
- Balloon angioplasty

**POSTPROCEDURE CARE**
Patient management after neurointerventional procedures is as critical as the procedures themselves. Patients should be managed in an intensive care unit capable of performing frequent neurological examinations and with immediate access to CT scanning. Intracranial pressure, glucose, and blood pressure management are critical for good outcomes. Pharmaceutical management with antiplatelet agents should be used where appropriate. Long-term follow-up should be planned before discharge and is essential for the patient’s continued well-being.

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**Tips & tricks**

Interventional Neuroradiology

Critical considerations for complication avoidance and successful outcomes.

**CEREBRAL ANGIOGRAPHY**
1. The procedure begins by examining the patient and reviewing all imaging and laboratory data.
2. Always obtain a femoral/iliac angiogram immediately after you place the sheath. Arterial injury or dissection will be immediately discovered. Heparinize after the sheath is inserted.
3. Obtain an arch angiogram. Visualizing the anatomy will save you time and unnecessary catheter selections.
4. Use the double-flush and meniscus-to-meniscus technique. Keep the tip of your syringe pointing down.
5. Do not do an incomplete cerebral angiogram; you will miss something. The angiogram should include at least two views of the carotid bifurcations, intracranial circulation via each carotid artery, the origins of the vertebral arteries, and the posterior circulation.
6. Use compression of the carotid arteries if required to opacify the communicating arteries (Figure 1).
7. Do not inject anything pink or that looks like soda. Bubbles, clot, and physicians pushing catheters against the walls of vessels cause stroke.

**INTRACRANIAL INTERVENTIONS**
1. Carefully review the arch aortogram to help select the appropriate catheter.
2. Make sure everything fits (wires, coils, etc.). Dry table test if necessary.
3. The smaller, softer, and safer principle applies.
4. Do not let slack build up in the system; remove it.
5. Working at suboptimal obliquity can be disastrous, so get the best projection.
6. Do not just push harder; understand why something is not advancing.

**STENTS**
1. Always perform a control angiography of the brain before and after the procedure because absence of an anterior or middle cerebral branch can be subtle and easily missed.
2. A three-dimensional angiogram may predict the perfect view rather than performing multiple angiographies at different projections, increasing the dose of contrast.
3. Obtain an angiogram after every step of an intervention, and use the most recent roadmap and not the one from the beginning of the procedure.
4. In stent-assisted aneurysm coiling, avoid the proximal stent projecting into the vessel wall, which will make reaccess or retreatment difficult or impossible.
5. In stent-assisted aneurysm coiling, leave a safety wire across the stent to avoid reaccessing between the
stent and the vessel wall.
6. Stents foreshorten easily in the carotid siphon. Where is a good position for the proximal and distal ends of a stent? Using a longer stent may avoid having to place a second one.
7. In stenotic lesions, do not predilate if you can get your device across the stenosis, and only postdilate when necessary. Treatment is about hemodynamics, not a perfect angiographic result.
8. Think balloon: angioplasty alone can often achieve as much as a stent intracranially.

EMBOLIZATION
1. Inadvertent embolization can lead to blindness, stroke, or even death. Know your anatomy, and look for dangerous collateral pathways. If you do not know the name of a vessel, you should not be treating it.
2. Use a separate table/area for embolic material. Avoid contamination of the field with embolic material.
3. Slowly and carefully inject embolic material. A negative road map (fluoroscopy on top of a road map) helps to visualize reflux.
4. Particle size is critical; microspheres ranging from 40 to 120 µm are too small and can pass through the capillary bed, leading to irreversible hypoxemia and death. For epoxides, glomus tumors, and head and neck cancers, particles ranging from 500 to 700 µm are ideal.
5. Choose a microcatheter that is big enough for anything you might need, such as extra coils, etc.
6. Flush the microcatheter regularly to avoid blockage. If you have spent 20 minutes getting into a vessel, you do not want to have to recannulate it after one syringe full of embolic material. Flush the hub with a small needle and syringe if particles accumulate.
7. Do not overembolize. Mucosal and skin necrosis can occur with excessive embolization.

THROMBOLYSIS AND ACUTE STROKE TREATMENT
1. Form a pigtail loop on your microwire, then pass it back and front through the clot. This exposes greater surface area for the thrombolytic drugs to work.
2. Discuss an endpoint with your stroke neurologist before you start. It is easy to be too aggressive in the heat of the moment and prolong or complicate a procedure without benefit to the patient.
3. Beware of an underlying stenosis. Passing a larger retriever device through a tight narrowing is unlikely to be successful and is dangerous.
4. Beware of vasospasm. Pulling a guiding catheter into the common carotid once your microcatheter is in stable position may relieve internal carotid artery spasm in a hypoxic brain.

Figure 1. The Huber maneuver. Injection into the vertebral artery with temporary compression of the ipsilateral carotid shows the posterior communicating artery.

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