Vascular Access: Guide Catheter Selection, Usage, and Compatibility

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Abstract

Success in neurovascular interventions often depends upon achieving a stable position with an appropriately chosen guide catheter. Procedures can easily fail or be unnecessarily prolonged because of poor guide catheter selection or compromised catheter position. An ever-increasing array of products means the neurointerventionalist must have a clear understanding of the basic principles of the guide catheter properties, selection, and appropriate usage.

Keywords

Vascular access • Guide catheter • Selection • Usage • Compatibility • Neurovascular intervention • Adverse consequence • Vessel damage • Complications • Prolapse • Microcatheter position • Safety

Introduction

- Success in neurovascular interventions often depends upon achieving a stable position with an appropriately chosen guide catheter.
- Procedures can easily fail or be unnecessarily prolonged because of poor guide catheter selection or compromised catheter position.
- An ever-increasing array of products means the neurointerventionalist must have a clear understanding of the basic principles of the guide catheter properties, selection, and appropriate usage.

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Potential adverse consequences of poor guide catheter selection and placement include:

- Vessel damage, thromboembolic, and/or hemodynamic complications
- Inability to track microcatheters, balloons, stent delivery devices, etc.
- Prolapse of the guide lower into the neck or aortic arch at a crucial moments, often with the loss of a hard won microcatheter position.

General principle: the more distal the position that can be *safely* achieved with the guide catheter, the better.

Patient or technical factors contributing to choice of guide catheter include:

Patient Factors
- Size of vessel
- Vessel tortuosity: iliac/aortic/neck vessel
- Height of the patient
- Calcifications
- Patient morphology (short, fat hypertensive patients with no neck who used to be taller)

Technical Factors
- Access rigidity versus distal positioning
- Required internal lumen for planned procedure/potential rescue maneuvers
- Necessity for flow arrest (e.g., test-occlusion or mechanical clot retrieval)

More general factors relating to guide catheter selection often come down to personal choice or experience. Generally desirable properties in a guide catheter include:

- Soft atraumatic distal tip
- Stiff/sturdy proximal shaft for support
- Multiply graded transitions in rigidity from proximal to distal ends
- Large internal lumen relative to the outer diameter (thin wall profile), but without excessive compromise of wall weakness/tendency to kink

In reality, most guide catheters present a compromise between the above properties, and the selection of a guide catheter for any given case may depend on the most important properties required.

With the above factors taken into consideration, the following are questions to ask when selecting a guide catheter for a specific case:

- Can it be safely navigated into the vessel without occluding flow and without undue risk of causing dissection or severe spasm?
- Will it accommodate all of the equipment planned for use in the case?
- What case-specific complications might be anticipated, and will the guide catheter accommodate (separately or concurrently) any additional catheters/balloons/stents etc. that might be needed to deal with these complications?
- Can adequate angiographic runs be performed when single or multiple devices are inside it? i.e., to what degree will the inner lumen of the catheter be obturated?

Guide Catheter Types

Standard Guide Catheters (Guider, Envoy)

- Designed only to be positioned in the extracranial neck vessels
- Typically 5–8 F
- Angled or straight tip commonly used
- Delivered through an appropriately sized sheath in the groin
- Typically come in lengths of between 90 and 110 cm, with longer lengths for taller patients
- Common choice for simpler procedures (e.g., unassisted aneurysm coil embolization, embolization of intracranial AV shunt, or tumor)

Long Sheaths (e.g., Cook Shuttle)

- Designed only to be positioned in the extracranial neck vessels
- Typically 5–7 F (denotes internal capacity, not outer diameter)
- Straight tip – more complex to position using an exchange technique or as a single step using dedicated tip-shaped inner coaxial catheters sold as part of the system
- Kink resistant and very stable – can often be used to straighten tortuous proximal anatomy, providing greater stability with reduced chance of catheter prolapse
- Relatively large inner lumen – for simultaneous passage of multiple devices
- Common choice for complex procedures e.g., balloon-assisted aneurysm coil embolization or stent procedures requiring a large capacity guide

Intracranial Access (e.g., Neuron, Distal Access Catheters)

- Designed to be positioned more distally than standard guide catheters, e.g., in the petrous or cavernous portions of the internal carotid artery or around the C2 and C1 loops of the vertebral artery
- 6 F proximally and either 6 F distally or tapering to 5 F (relatively small lumen may be a weakness)
- Can be positioned using proprietary 3 or 5 F select catheters with a range of different shaped tips, or exchanged for a diagnostic catheter into the neck, then tracked more distally over a microcatheter/microwire
- Potential for greater stability in some circumstances, but only if truly positioned within the proximal intracranial vessels. Can be combined coaxially within long sheath devices when "extreme stability" is required
  - Useful for overcoming tortuous distal neck or proximal intracranial anatomy, particularly when trying to track balloons and stents to the intracranial circulation, e.g., around tonsillar loops in the cervical carotid artery
- Adopted by some operators first choice guide catheter for most intracranial embolizations, regardless of anatomy

Balloon Guide Catheters

- Designed to be positioned in the extracranial neck vessels (CCA/ICA).
- Typically 8 F.
- Straight tips.
- Reasonably small inner lumen relative to large outer diameter.
- The author reserves the use of these catheters for use in mechanical thrombectomy in acute stroke cases, where inflation of the balloon allows flow arrest/reversal and more effective aspiration.

Some Commonly Used Guide Catheters and Their Properties

Guider Softip (Boston Scientific)

- Typical sizes used: 6 and 7 F (5, 8, and 9 F also available).
- Respective internal diameters: 0.064 in and 0.073 in.
- Available lengths: 90 and 100 cm.
- Advantages: As the name suggests, it has a soft tip. Seven centimeter flexible distal segment. Relatively atraumatic and less likely to cause spasm. Easy to torque – good for direct selection of vessels from the arch (with or without a wire) in young patients.
- Disadvantages: 6 F version has a relatively small inner lumen compared to other 6 F guides. Less rigid/stable than some guide catheters, with a tendency to back out towards the aorta when negotiating inner microcatheters/devices etc. through tortuous distal anatomy.

5 F or 6 F Envoy (Codman Neurovascular)

- Typical sizes used: 5 and 6 F (only these sizes available).
- Respective internal diameters: 0.056 in (1.4 mm) and 0.070 in (1.8 mm).
- Available lengths: 90 and 100 cm.
- Advantages: Large inner lumen. Relatively rigid, often giving a stable position even in tortuous anatomy.
- Disadvantages: As in all cases, the trade-off for the rigidity is greater potential for trauma. The tip is also not as "vessel friendly" as the Guider Softip – it has quite a sharp lip. May "soften" during a procedure and lose its stability or rigidity.

5, 6, and 7 F Shuttle (Cook)

- Typical sizes used: 5, 6, and 7 F (8 F also available for carotid access).
- Respective internal diameters: 0.074, 0.087, and 0.100 in.
- Available lengths: 80 and 90 cm.
- Advantages: Very large inner lumen. Extremely stable. Track well over selective catheters. Straighten out tortuous aortoiliac anatomy. Good kink-resistance.

- Disadvantages: Large inner lumen can empty a flush bag in seconds if not closely monitored, with risk of gas embolus. Large lumen also forms large clots quickly –need to actively manage blood reflux. Again, stiff catheter is more spasm prone and has greater potential for dissection.
- Tip: if exchanging rather than using select catheters, be sure to use the inner obturator provided; this will help minimize vessel trauma.

Cello Balloon Guide (EV3 C3ovidien)

- Typical sizes used: 8 F only.
- Respective internal diameters: 0.075 in (1.9 mm).
- Available lengths: 95 cm effective length.
- Advantages: Soft atraumatic hydrophilic tip. Balloon inflation can achieve ICA flow arrest in mechanical thrombectomy cases and may allow for more effective aspiration during device/thrombus retrieval.
- Disadvantages: Relatively small inner lumen when compared to outer diameter. Like most balloons, need to carefully purge balloon of gas during preparation.
- Tip: a 125 cm 5.5 F SIM-2 Shuttle Select catheter inside this catheter provides a formidable access tool when used for mechanical thrombectomy in acute stroke patients (who often have challenging aortic arch and neck vessel anatomy).

Chaperon (Microvention)

- Typical sizes used: 5 and 6 F.
- Respective internal diameters: 0.059 and 0.071 in.
- Available lengths: 95 cm.
- Advantages: Thin wall profile, so 6 F version has slightly larger inner lumen than some of the other 6 F competitors. Good torque control. Comes with dedicated “inner” selective catheters for coaxial method.
- Disadvantages: While it offers a relatively stable position, it is not as stable as some of its competitors.

Neuron (Penumbra Inc.)

- Typical sizes used: 6 F.
- Respective internal diameters: 0.053 and 0.070 in (053 tapers to 5 F distally, both are 6 F proximally).
- Available lengths (working): 053 = 105 cm and 115 cm; 070 = 95 cm and 105 cm.
- Advantages: Can be positioned in petrous (070) and cavernous (053) ICA or the more distal vertebral arteries – assists in overcoming tortuous anatomy. Can allow for easier tracking of large/stiff kit such as balloons and stents. 5 F Select catheters for use in the 070 versions are useful for vessel selection.

- Disadvantages: Unless positioned distally as per the design intention, they can be less stable than ordinary guides – so either put it distally or choose another catheter. May require the additional support of a long sheath otherwise (but be careful to calculate the usable length of neuron at the distal end in advance).

Guide Catheter Positioning

Guide catheters can be positioned in the following ways:

- Direct selection of a vessel from the aorta, usually using a suitable guidewire
- Using a coaxial technique with a smaller and pre-shaped inner "select" catheter
- Exchanging over a wire having accessed the vessel using a smaller tip-shaped (diagnostic angiography) catheter

Direct Selection

- Direct selection of a vessel without a wire, but with intermittent "puffing" of contrast upon catheter advancement, should probably be reserved for relatively young patients in whom diseased neck vessels is not anticipated.
- Using this method in tortuous or grossly diseased vessels is likely to result in a higher incidence of vessel dissection and vasospasm.
- Puffing of contrast helps keep the catheter tip away from the vessel wall, allowing for prompt identification of any impediments to passage and dissections.
- If wire is used, an RHV and flush bag should always be attached to the guide catheter to prevent blood reflux around the wire and intraluminal thrombus formation, leading to subsequent thromboembolic complications.

Coaxial Technique

- Smaller catheter with a shaped tip.
- Loaded into the inner lumen of the guide catheter to select the desired vessel.
- Once the smaller inner catheter is advanced into the vessel over a wire, the external guide catheter can be advanced smoothly over the inner catheter.
- Helps minimize trauma to the vessel wall and likely reduces embolic events arising from an atheromatous aortic arch.
- Some guide catheters have accompanying proprietary inner catheters in a range of different shapes for the express purpose of coaxial catheter placement. *Examples*:
  - Shuttle long sheath (Cook)
  - Chaperon (Microvention)
  - Neuron (Penumbra Inc)
- Advantages: forming a snug fit within the guide catheter minimizing blood reflux and presenting a much smoother transition profile to the vessel on advancing.

Exchange Technique

- Inherently more dangerous than direct selection techniques
- Higher thromboembolic risk
- Exchange technique reserved (by authors) for tortuous or otherwise difficult anatomy and when either of the above two methods fail.
- If unavoidable, it is generally advisable to employ systemic heparinization prior to exchanging wherever possible.

Managing Guide Catheter Related Problems

Spasm and Flow Limitation

- Failure to observe and promptly correct limited or absent flow caused by a guide catheter can lead:
  - Thromboembolic
  - Hemodynamic ischemic stroke
- If flow is borderline, reduce the risk of thrombus formation by:
  - Higher flush rates.
  - Judicious use of systemic heparinization (to achieve an ACT of 2–3× baseline).
  - Does not eliminate the risk completely.
- With evidence of limited washout of contrast, but no obvious spasm or dissection:
  - Selected guide catheter may simply be too large for the vessel.
  - Downsizing the catheter or selecting a more proximal guide catheter position may be the only safe solution.
- Where spasm is seen at the tip of the guide catheter immediately after placement, with unacceptable impediment to distal flow:
  - Incrementally pulling the guide catheter back, short distances will usually restore acceptable flow.
  - Guide catheter can often be repositioned more distally later in the procedure (often over the microcatheter) once initial vasospasm has settled.
- Antispasmodic agents such a nimodipine and GTN may help relieve spasm and allow for a distal catheter placement with preserved flow.
- Some interventionists use GTN for catheter-induced spasm, reserving nimodipine for the treatment of spasm related to subarachnoid hemorrhage. Others use nimodipine for both causes of spasm.
- Nimodipine 1–2 mg boluses can be given slowly through the guide catheter until the desired effect is achieved.
- Caution: Inform the anesthetist before injecting, as there may be profound effects on systemic blood pressure.
- Nimodipine can also be added to flush bags, and some operators do this for every case. GTN may be given in small 30 μg aliquots – *again warn the anesthetist first*.

Arterial Dissection

- Much-feared problem in neurointervention, whether in the extra- or intracranial vessels.
- Potential complications: vessel occlusion or distal thromboembolism.
- Clinical situation will often determine the appropriate course of remedial action, if any.
- Limited flow but patent vessel lumen:
  - Consider balloon angioplasty or stent placement across the dissected segment.
  - Stent placement will usually require dual antiplatelet therapy: risk/benefit should be carefully considered. (Discussion with a colleague often helps.)
- No flow limitation:
  - Case is elective.
  - In its early phases, may be appropriate to defer the procedure and place the patient on anticoagulants/antiaggregants.
  - Decision making becomes more challenging in the emergency setting (e.g., acute subarachnoid hemorrhage) where it is necessary to cross the dissected segment to protect a lesion downstream.

The "Bouncing" Guide Catheter

- In patients with hypertension and/or tortuous access, guide catheter may "see-saw" back and forth along the axis of the vessel with each cardiac pulsation.
- The bouncing motion is often then transmitted to microcatheters, and this can be very disconcerting (and dangerous), particularly while trying to access fragile structures such as recently ruptured intracranial aneurysms.
- Allowing for anatomy, advancing the guide catheter to a more distal position (almost invariably, a more proximal position will only worsen the problem) may be attempted.
- Alternative strategies include:
  - Place a stiff "buddy" microwire alongside the microcatheter with its tip in the guide catheter to provide additional support without traumatizing the vessel (e.g., Platinum plus 014, Boston Scientific).
  - Change to a stiffer guide catheter or a long sheath.

Arterial Embolus

- Guide catheter related embolus is always avoidable by:
  - Meticulous catheter techniques
  - Judicious use of pressurized heparinized saline flush bags
  - Systematic organization of the angiography environment
  - Careful training of angiography staff
- One must be on high alert for embolic complications at all times and be prepared to act swiftly once recognized.

Emboli can occur in a number of ways:

Atherosclerotic Plaque Disruption: From Aortic Arch/Extracranial Arteries

- Appearance: Varying size emboli – often calcified/fatty fragments on CT.
- Prevention: These are predictable and can be avoided by vigilance in recognition of plaque on access imaging and appropriate modification of technique.
- Treatment: Difficult to treat as often small, distal, and unresponsive to drug therapies.

Fresh Thrombus: Stationary Blood-Forming Clot in Guide Catheter Lumen and Then Being Flushed Out or Clot Forming on Exposed Wires During Exchange Technique

- Appearance: long strings of clot or casts of the catheter lumen on angiography (red thrombus)
- Prevention: Scrupulous guide catheter flush management and avoidance of exchange techniques. Recognizing patient factors predisposing to thrombosis, e.g., sepsis, malignancy, clotting disorders. Early heparin administration
- Treatment: Consider thrombus retrieval for large proximal emboli or drug therapies such as IV tPA or antiplatelet therapies: abciximab > clopidogrel > aspirin

Arterial Gas Embolus: Gas Bubbles Entering via Flush Line or Directly Injected with Contrast

- Appearance: Showers of small distal emboli – gas locules often visible on post-procedure CT.
- Prevention: There are many potential initiatives including sealed contrast systems// meticulous handling of contrast syringes. Low volume alarms on flush bags etc.
- Treatment: anecdotal experience has found increasing patient's inspired oxygen concentration to maximum for duration of case promotes resorption of intravascular gas bubbles and minimizing deficit (no cost in doing this even if it doesn't work!).

Device Compatibility: French, Gauge and Inches Made Easy

- No single standardized method for communicating sizes of the wide range of equipment used in neurointervention.
- The following outlines the commonly used sizing systems in neurointervention, with an easy guide to conversion between these systems.
- Two reference tables are provided for everyday use.

French (Charrière) Gauge System

- Named after Joseph-Frédéric-BenoÎt Charrière, a nineteenth century Parisian cutler.
- Symbols: F, Ch, and CH.
- 1 F = 0.33 mm.

Table 1 Examples of size compatibility[a]

Procedure	Example equipment	Individual OD sizes (F/in)	Minimum inner guide lumen (F/in)	Usable guide catheters
Stent-assisted aneurysm coiling (jailing technique)	4 mm Solitaire stent delivery catheter (021 class)	2.8/0.037	5.2/0.069	6 F Envoy
	014 class microcatheter	2.4/0.032		6 F Chaperon
	Enterprise stent delivery catheter (021 class)	2.8/0.037	5.2/0.069	7 F Guider Softip
	014 class microcatheter	2.4/0.032		6 F Neuron
				5 F Shuttle
Balloon-assisted aneurysm coiling	Hyperglide/Hyperform balloon	2.8/0.037	5.2/0.069	
	014 class microcatheter	2.4/0.032		
Extracranial carotid stenting	Carotid Wallstent (8 mm)	5/0.066	6.1/0.080	6 F Shuttle
	Platinum Plus 014 "buddy" wire	1.1/0.014		8 F Guider Softip

[a]This type of table is easily modified and extended for individual practice and can prove to be an invaluable reference on the wall of a lab/angiography suite

F/3 = external diameter of a catheter in mm.

- Usage: Commonly used to refer to the OUTER DIAMETER (OD) of a catheter.
- However, confusingly, when describing a sheath size, it refers to the largest-sized catheter that will fit inside the sheath, i e., the INNER DIAMETER (ID) not the OD of the sheath itself. Example: a 6 F Shuttle (Cook) long sheath will accept a 6 F catheter inside it, and itself has an OD of 7.8 F (0.104 in).
- Unfortunately, catheter size in F does not reliably define the internal diameter of the catheter; this is also determined by catheter wall thickness. However, most catheters of a given F will have inner lumen that falls within a fairly narrow range (see Table 1).

Stubs Iron Wire Gauge System

- Developed by the Stubs Iron Works in the mid nineteenth century.
- Symbols: G, Ga, Gg, and g.
- Usage: needles and venous/arterial access catheters.
- Designated as the number of a particular device that can fit inside a circular orifice of standard diameter.

Table 2 Converting units

F	in	mm	G[a]
0.6	0.008	0.20	33
0.8	0.010	0.25	31
0.9	0.012	0.30	30
1.1	0.014	0.36	28
1.2	0.016	0.41	27
1.4	0.018	0.46	26
2.6	0.035	0.89	20
2.9	0.038	0.96	19
4	0.053	1.35	17
5	0.066	1.67	16
6	0.079	2.0	14
7	0.092	2.3	13
8	0.105	2.7	12
9	0.118	3.0	11

[a]The gauge sizing listed is an approximation to the nearest measurement in inches. Where a given G size is roughly equidistant between two sizes in inches, the larger G size has been listed

- Inverse and nonlinear scale: the larger the number, the smaller the caliber.
- It is sometimes useful to be able to convert F (Ch) to gauge e.g., when choosing an appropriately sized (same size or slightly larger) arterial or venous access catheter for exchange with the sheath at the end of a procedure.

Inch

- Imperial system unit of length.
- Symbol: in.
- 1 in = 25.4 mm.
- Usage: the internal diameter of a guide catheter is commonly measured in inches and class of microcatheter commonly referred to in terms of fractions of inches. In the latter case, this is not the true internal diameter of the microcatheter, but rather the maximum external diameter microwire that can be accommodated within it. Microwire diameters are entirely referred to in fractions of inches.
- To convert F to inches: F/76.2 = in (Table 2).

Key Points

- The neurointerventionalist requires a clear understanding of the following:
  - Principles of guide catheter design, selection, and usage
  - Guide catheter related complications – minimizing incidence and mitigating their effects
  - Complexities of device sizing and conversion between sizing systems
- Give careful thought to guide catheter selection in every case. Ask yourself in advance: what could go wrong, what equipment might be needed to fix the problem, and will the guide catheter be up to the task?
- Guide catheters can be navigated into the neck vessels in a number of ways. Choice of method depends on a number of factors including personal experience, patient age, and vessel tortuosity/disease. Avoid the exchange technique where possible, but if necessary, ensure the patient is heparinized.
- For catheter-induced spasm, first try slowly withdrawing the catheter until adequate flow is restored. Either GTN or nimodipine can be given slowly in small aliquots via the guide catheter. Warn the anesthetist regarding potential drops in blood pressure before giving either of these drugs.
- Keeping a chart of size-compatible equipment on the wall of the lab/angio suite is useful as an aide memoir and can prevent procedural delays and wastage by helping to choose the appropriate kit first time.

Suggested Reading

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