An Algorithmic Approach to Carotid Access

A review of the techniques and possible complications associated with accessing this difficult anatomy.

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Safe carotid access with a guide catheter or sheath is the first step (and one of the most important) in successful embolism-free carotid stenting. Knowledge of anatomy and arch type, awareness of pitfalls posed by tortuosity, and the ability to modify the technique in special situations are essential cognitive and technical skills with a steep learning curve. Proper mentoring techniques are necessary to help disseminate these procedural skills to the community at large.

DIAGNOSTIC VERSUS INTERVENTIONAL CAROTID ACCESS

An interesting paradigm is the necessity of basic diagnostic carotid angiography skills as a stepping stone for safe interventional access (Table 1). Although diagnostic catheters are soft, low-profile 4- to 5-F flexible devices, the interventional access devices are typically stiffer, higher-profile 6- to 10-F devices that need deep common carotid placement. The starting point for these diagnostic carotid angiography skills is cognitive awareness of the type of aortic arch and the presence or absence of arch disease.

NONINVASIVE EVALUATION OF AORTIC ARCH

Computed tomographic and magnetic resonance angiography may help provide a road map of the aortic arch, defining the type and identifying the extent of ostial bifurcation external carotid artery (ECA) disease as well as tortuosity. Significant arch disease may dictate switching to a brachial or radial technique, avoiding the femoral route. Tortuosity alone may render device transit more difficult, along with the development of distal kinks and spasm. Aggressive manipulation may lead to scraping the vessel walls, dissection, embolization, and even vessel perforation. Knowledge of the anatomical layout even before angiography may assist the operator in technique and equipment selection (Figure 1).

Figure 1. Magnetic resonance angiogram of arch vessels.

AORTIC ARCH ANALYSIS

We originally described aortic arch classification in 1996 based on aortic arch curvature in relation to common carotid diameters and the extent of deep seating;[1,2] we have modified this technique by simplifying the measurements. Typical arch anatomy is seen in 70% of cases. Minor variations in the origin of the great vessels are common, but major variations are rare. Shared origin of the brachiocephalic trunk (BCT) and left common carotid artery (CCA) is seen in 15% of cases; bovine arch is seen in 8% to 10% of cases. With increasing age, hypertension, and disease of the aortic valve, the arch sinks deeper and elongates into the thoracic cavity while pulling the origins of the great vessels along with it. This creates difficulties in not only cannulating the great vessels but also in directing coaxial transfer of energy during catheter exchanges. Using the origin of the left subclavian artery as a landmark, the arch curvature can be classified into three levels of difficulty (Figure 2).

Aortic Arch Types

In a type I arch, the origins of the great vessels are at or near the superior arch line drawn at the origin of the left subclavian artery. In a type II arch, the great vessels arise between the superior arch line and inferior arch line drawn at the fulcrum point of the junction of the lower border of the arch and descending thoracic aorta. The fulcrum point provides a crucial landmark for the femoral approach, because all femorally advanced catheters hinge on this point, and if they had to bend into the arch below this level, it sets the stage for catheter prolapse.

In a type III arch, the great vessels arise below the inferior arch line, thereby making access very difficult. Refer to *Carotid Anatomical Analysis* sidebar for additional factors for determining access.

CAROTID ACCESS TECHNIQUES

Basic Technique/Telescopic Method

Applicable for type I and II arches; assumes the ECA is patent. After achieving groin access, the 7- to 9-F guide sheath is advanced over the 0.035-inch wire into the descending thoracic aorta (Tables 2 and 3). The 5-F diagnostic catheter is loaded into the sheath after the dilator is removed. After angiography of the target vessel is performed, the angled Glidewire (Terumo Interventional Systems, Somerset, NJ) is advanced through the diagnostic catheter into the ECA, and the catheter is advanced over the angled Glidewire into the ECA. Using the wire and diagnostic catheter as coaxial rails, the guide sheath is advanced into the CCA over the diagnostic catheter. If excessive tortuosity is present in the proximal CCA or if abnormal and deep angulation takeoff of the CCA is present, the sheath is advanced over an Amplatz super stiff guidewire (Boston Scientific Corporation, Natick,

TABLE 1. COMPARISON OF DIAGNOSTIC CAROTID ACCESS CATHETERS

Features	Catheter Shapes			
	Headhunter	Simmons	VTK	Judkins Right
Size	5–7 F	5–7 F	5 F	5–7 F
Ease of use	Easy	Difficult	Moderate ease	Easy
Success in cannulation	50%–70%	90%	70%–90%	50%
Type of arch	Type I	Type I, II, III	Type I, II	Type I
Risk of emboli	Minimal	Moderate	Minimal	Minimal
Anomalous left CCA	Not useful	Highly useful	Somewhat useful	Not useful
Ease of advancement into CCA after cannulation	Very easy	Somewhat difficult (need to bury the shoulder into the CCA before it can be advanced further)	Moderately easy	Easy in type I arch
Potential for catheter prolapse into arch during advancement	Minimal except in type II, III arch	Moderate unless the shoulder is advanced into the CCA	Minimal	Minimal
Amount of expertise needed	Minimal	Significant skill level needed, need ability to shape the reverse curve	Minimal to moderate	Minimal

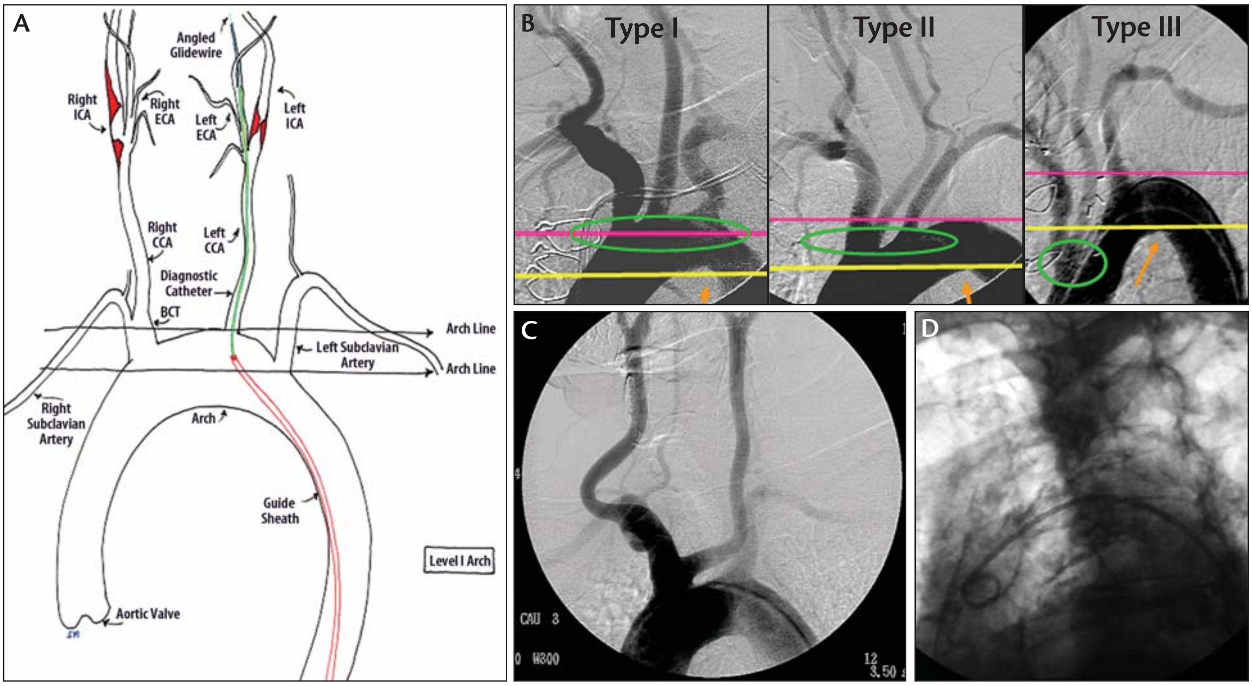

Figure 2. Original aortic arch classification (A). Modified aortic arch classification type I (telescopic access using a simple-curve HN1 catheter), type II (serial stiffening using a reverse-curve Simmons 2 [SM2] catheter), and type III (using a reverse-curve SM2 catheter) based on the subclavian arch line (purple line) and the inferior arch line (yellow line) at the fulcrum point (green oval) (B). Bovine arch (C). Porcelain arch (D).

MA) or Supra Core wire (Abbott Vascular, Santa Clara, CA), or a Nitrex wire (ev3 Inc., Plymouth, MN) and is placed in the diagnostic catheter instead of the Glidewire. Occasionally, the sheath dilator may have to be used inside the sheath over the super stiff wire for better tracking in extremely tortuous vessels. The dilator (Arrow International, Inc., Reading, PA) can be shaped for better tracking over the super stiff wire.[3,4]

Intermediate Technique/Serial Stiffening Method

Applicable for type II and III arches; assumes that the ECA is patent and that the carotids are not too tortuous. An angled 0.035-inch Glidewire is advanced into the diagnostic catheter, and using a road map, the ECA is cannulated with the Glidewire. The diagnostic catheter is advanced into the ECA over the wire. The Glidewire is exchanged for a 0.035-inch super stiff Amplatz/Nitrex or Supra Core wire. The diagnostic catheter is removed, keeping the position of the super stiff wire constant in the distal branch of the ECA (ie, the superficial temporal branch). Over the stiff wire, we backload a preflushed 7- to 8-F vascular sheath (Arrow International systems or Flexor Tuohy-Borst sidearm introducers [Cook Medical, Bloomington, IN]). Because the dilators do not have radiopaque markers, caution should be exercised in advancing the dilator into the ECA. The wire and dilator are then removed slowly, leaving the sheath in a secure position in the mid-CCA.[5,6]

Advanced Technique/Remote Guide Catheter Access Method

Best for the experienced operator in a type III arch; assumes no significant arch disease. A 5-F VTK catheter (Cook Medical) is loaded inside an 8-F JCL guide catheter (Cordis Corporation, Bridgewater, NJ) and placed inside aortic arch. As the angled Glidewire (0.035-inch) is advanced, the curvature of the guide catheter straightens out. As the entire system is positioned with the tip of the catheter just below the great

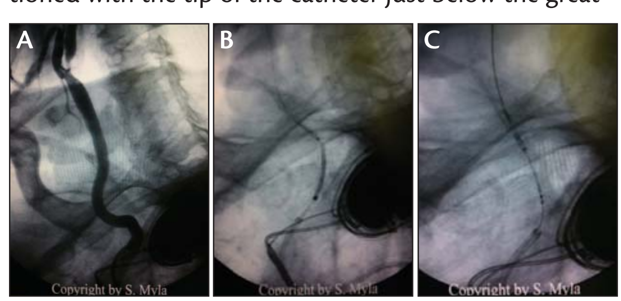

Figure 3. Remote carotid access, (A) remote access stent delivery (B), and remote access filter retrieval (C).

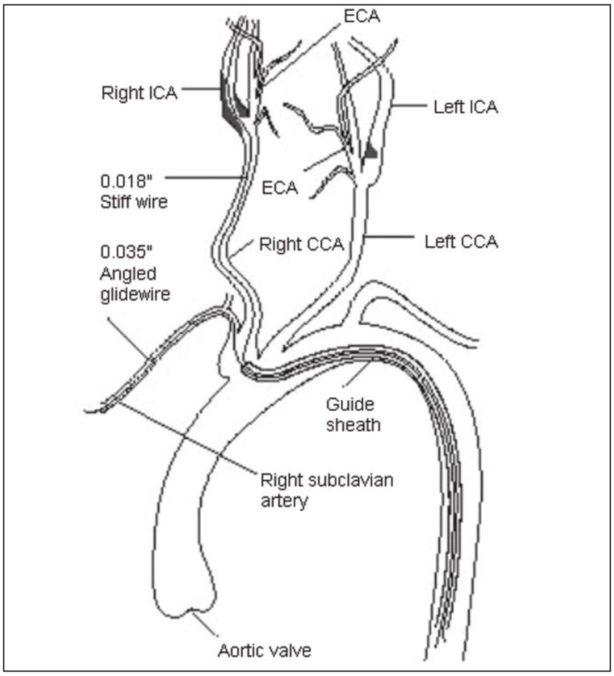

Figure 4. Subclavian arch method.

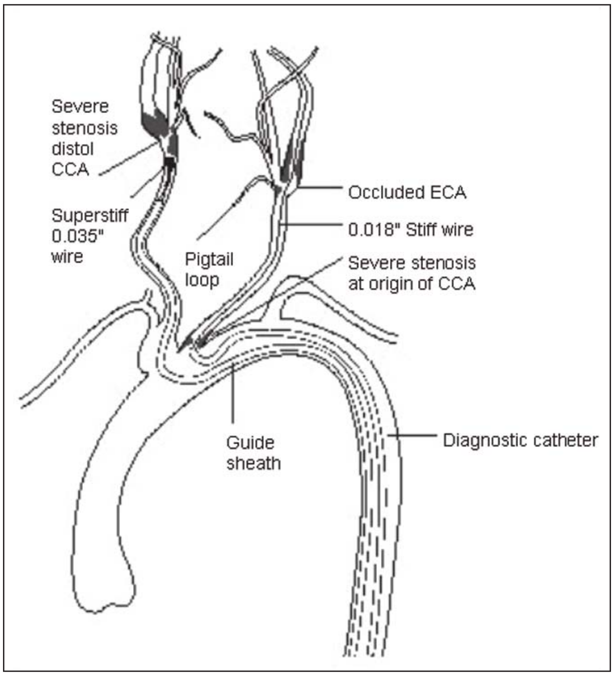

Figure 5. Carotid access during special situations.

vessel needing to be cannulated, the guidewire is pulled back, reshaping the diagnostic catheter first. After engaging the great vessel, the guidewire is advanced, and the guide catheter is slowly advanced to the ostium; once this is reached, the wire is left in place, and the diagnostic catheter is withdrawn, allowing the guide catheter to resume its curve, hooking the ostium. The wire is left behind, removing the diagnostic catheter. If this is chosen, we recommend leaving the wire until an over-the-wire filter is placed in the high distal ICA to provide anchorage and to leave the guide opening without scraping the vessel wall (Figure 3).

SPECIAL SITUATIONS

Subclavian Anchor

For type III arch situations (although type II strategies can be used), serial stiffening methods are more likely to be associated with prolapse of the guide sheath/catheter into the ascending aorta. Although operators have used the bare-wire method of stenting across a bare guidewire (abandoning the guide sheath/catheter), more often, this was not successful either due to lack of support or lack of landmarks for precise placement of nitinol stents (Figure 4).[5,6] We have developed a method by using the subclavian artery as an anchor for right CCA access. This involves placing a 6-F sheath in the right brachial artery.

After the diagnostic catheter, usually a SM2 catheter is placed in the BCT, an angled Glidewire is advanced

CAROTID ANATOMICAL ANALYSIS

Factors determining carotid access extend beyond the arch type and involve carotid arteries and iliac vessels as well.

Arch angiogram:
- Is there normal shape and curvature?
- Bovine arch
- Deep origin of the BCT
- Calcification and disease in the arch

Great vessels:
- Disease at the origin of the great vessels
- Deep origin of the BCT
- Deep origin of the left CCA
- Anomalous origin of the left CCA from BCT

Carotid arteries:
- Tortuous CCA
- Disease at distal CCA
- Occluded ECA
- Stenosis at bifurcation involving both the ICA and ECA
- Tortuous internal carotid artery (ICA) at the lesion
- Severe calcification of the lesion

Iliac vessels:
- Stenotic and occluded iliac arteries
- Tortuous iliac arteries

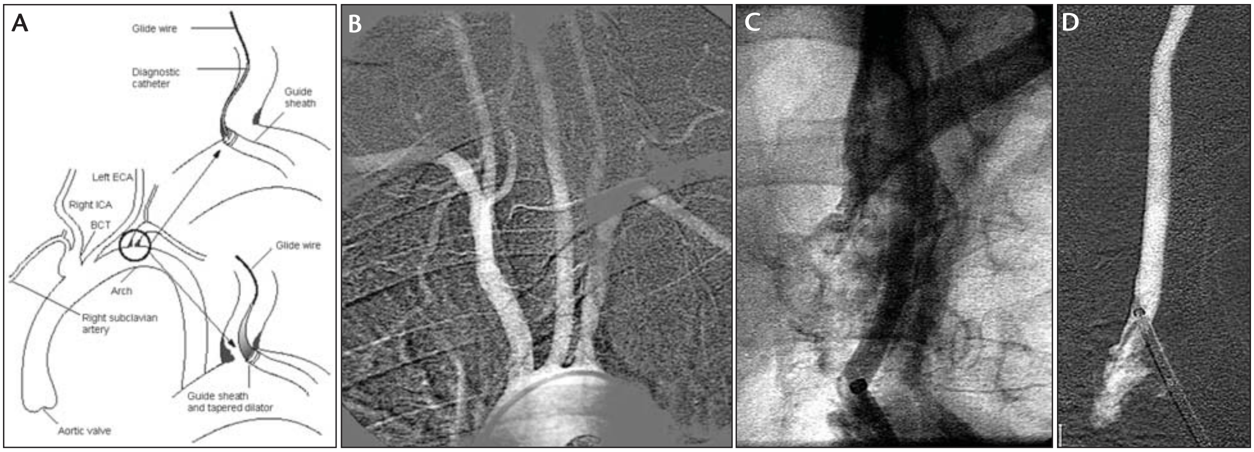

Figure 6. Ledge effect leading to carotid dissection (A). Gap between guide catheter and wire can be eliminated by the guide sheath and dilator (B). Arch with left CCA origin pointed to the right CCA (C). Successful repair with Smart stents (Cordis Corporation) (D).

into the right subclavian artery through the SM2 catheter. The angled Glidecath (Terumo Interventional Systems) is then advanced through the right brachial sheath and brought outside. By now, we have firm control of the wire from the brachial and femoral routes. The 8-F Arrow sheath is then advanced over this wire into the right BCT using traction control of the Glidewire from both ends. It is important to remember that the sheath cannot be advanced into the CCA without giving up the anchor wire in the subclavian artery. After the guide sheath with its dilator is advanced into the BCT, the dilator is removed. A 0.018-inch Steelcore wire (Abbott Vascular) is advanced into the ICA through the guide sheath placed in the BCT. Carotid predilatation and stent deployment are then carried out from this position. Due to the ability to leave the Glidewire through the guide sheath and anchoring it at both ends, there is enough wire purchase and support to complete the case. Excessive tension on the Glidewire is avoided to minimize trauma to the subclavian artery.

Ostial Stenosis of the CCA and BCT

Cannulate the involved artery with a diagnostic catheter and advance the 0.018-inch Steelcore wire into the ECA. A 4-mm coronary balloon is advanced across the ostial lesion and predilated to approximately 10 atm. The coronary balloon is removed, and a 6- to 8-mm balloon is advanced and dilated across the stenosis over the Steelcore wire. The Steelcore wire is removed, and a 0.035-inch wire is advanced into the ECA through the larger peripheral balloon placed across the ostial lesion. The peripheral balloon is then removed, and the guide sheath is backloaded with its dilator. The sheath and dila-

TABLE 2. COMPARISON OF GUIDE CATHETER AND GUIDE SHEATH

Technique	Advantages	Disadvantages
Guide sheath	• 6- to 7-F hole in the groin • Integrated dilator permits smoother transition and advancement into the CCA • Allows placement of the diagnostic catheter inside the sheath for one-step access	• No torque option • Potential for kink in angulated vessel take-off (anomalous left CCA) • Larger volume of contrast, slightly greater risk of air embolism
Guide catheter	• Better torque control • Least chance for kink • Allows retrieval of filters by advancement into the stent; the torque control allows orientation of the guide catheter toward the ICA; better in tortuous anatomy	• 9- to 10-F hole in the groin • During advancement over 0.035-inch guidewire into the CCA, the abrupt transition at the tip may predispose to scraping and emboli • Difficult to place the diagnostic catheter inside the guide catheter for one-step access; the relative stiffness and size mismatch do not allow smooth transition

TABLE 3. CAROTID ACCESS GUIDEWIRES			
Type	Size	Manufacturer	Description
Amplatz super stiff	0.035 inch, 260/450 cm	Boston Scientific Corporation	Excellent wire for tortuous vessels; allows advancement of diagnostic and guide catheters and sheaths; floppy tip has no torque.
Angled Glidewire	0.035 inch, 260/300 cm	Terumo Interventional Systems	Great wire to cannulate external carotid artery; allows advancement of diagnostic catheter in type III arch; can kick Simmons out of CCA; tip can easily dissect if forced into curves.
Bentson	0.035 inch, 300 cm	Cook Medical	Atraumatic; easy to advance wire into the vessel; no support for catheter advancement; doesn't force catheter out of the vessel; good for initial placement of catheter; SM2 shape.
Hi-Torque Spartacore 14	0.014 inch, 300 cm	Abbott Vascular	Workhorse wire for carotid stenting; excellent floppy tip with torque control, and the shaft provides enough support for stent advancement; great as a buddy wire for distal protection in tortuous vessels.
Hi-Torque Supra Core	0.035 inch, 190/300 cm	Abbott Vascular	Excellent alternative to Amplatz super stiff; the two distal markers allow easy catheter exchanges without having to keep the tip in the field of view.
Hydronol	0.035 inch, 300 cm	Cordis Corporation	Good alternative to angled Glidewire in type I and II arches.
Ironman	0.014 inch, 300 cm	Abbott Vascular	Workhorse for carotid stenting; similar but inferior to Spartacore.
Stabilizer Plus	0.014 inch, 300 cm	Cordis Corporation	Good workhorse wire for type I arch.
Steelcore	0.018 inch, 300 cm	Abbott Vascular	Great wire for initial access in distal common carotid lesions or when ECA is occluded precluding its use as anchor in carotid access; provides good support for coronary balloon predilatation without guide sheath placement.
Storq	0.035 inch	Cordis Corporation	Superb wire for torque control in tortuous vessels but doesn't provide support for catheter advancement.
TAD 1, 2	0.018–0.035 inch	Covidien (Mansfield, MA)	Great wire for distal common carotid disease or when ECA is occluded; the 0.018-inch tip gives safety in crossing the lesion with great torque control; the 0.035-inch portion provides support for catheter advancement.

tor are then advanced through the ostium as one seamless unit. The dilator is removed after positioning the sheath in the CCA. The ICA lesion is treated in the standard fashion by reintroducing the Steelcore wire, this time through the ICA lesion. On the way out, the CCA is stented by withdrawing the guide sheath, baring the stent. The guide sheath at the ostium can be used to take final images without removing the Steelcore wire (Figure 5).

Total Occlusion of the ECA

After placing the diagnostic catheter and recording images, make a tight pigtail loop to the Amplatz super stiff guidewire and advance it into the distal CCA without reaching the origin of the ICA. The super stiff wire can be used to advance the guide sheath assembly into the CCA after removing the diagnostic catheter.

The alternative approach is to advance a 0.018-inch Steelcore wire or tapered attenuation diameter wire (TAD) (0.018–0.035 inch) through the diagnostic catheter and into the lesion, placing it distally in the ICA. The diagnostic catheter is exchanged for the guide sheath assembly and coaxially advanced into the CCA. The TAD wire provides decent (but not superb) wire support that works well for type I and II arches. For a type III arch and total occlusion of the ECA, a 0.038-inch-diameter Amplatz super stiff wire is needed.

Distal Common Carotid Stenosis

Similar to the situation with total occlusion of the ECA, this situation also entails modifying the standard technique. Because the diagnostic catheter could not be dottered into the ECA through the stenosis at the distal CCA, we suggest the following alternative: After the proximal CCA is cannulated with the diagnostic catheter, advance an Amplatz super stiff wire with its tip tightly wound up as a pigtail through the diagnostic catheter into the distal CCA just below the stenosis. This usually gives sufficient traction and support for the guide sheath assembly to be advanced into the mid-CCA. Alternatively, a TAD wire can be used with its 0.018-inch tip advanced through the lesion in the distal ICA, while the 0.035-inch wire shaft provides adequate support for guide sheath advancement.

Anomalous Origin of the Left CCA (Bovine Arch)

We find a 5-F VTK catheter is best suited for this anomaly. If the angle of origin is not too steep, we can apply the level 2 techniques of backloading the sheath. If the origin has a steep right angle, we recommend an 8- to 9-F Amplatz left[2,3] coronary guiding catheter to be placed over a 6-F multipurpose diagnostic catheter as a dilator into the origin of the left CCA. The multipurpose catheter is removed, and the procedure is completed in its entirety from the CCA origin without advancing the guiding catheter into the mid-CCA (Figure 2C).

COMPLICATIONS

Besides embolism, several complications can occur during carotid access, including dissection of the carotid arteries caused by the ledge effect due to unopposed space between a larger guide catheter (7–9 F) and a smaller diagnostic catheter and guidewire-related ECA branch arterial perforations (Figure 6). The small branch perforations can be deadly, with rapid development of retropharyngeal bleeding and airway compromise in an anticoagulated patient. Rapid diagnosis, prompt coil embolization, external pressure, and securing the airway are mandatory. The most dreaded complication to look for during the remote guide catheter access method is guide catheter prolapse, with the carotid filter getting entangled in the stent and detaching or embolizing. Keeping a vigil on the guide catheter position is extremely crucial. Choosing an over-the-wire filter also provides a long wire purchase and an increase in guide catheter stability. Cerebral embolism during carotid access is a stark reminder that not all parts of carotid stenting can be protected.[7-10]

CONCLUSION

Carotid anatomical analysis and an algorithm-based approach to carotid access can streamline a procedure and help achieve safe and embolism-free access in most situations. Aborting a progressively difficult and challenging access is far better than dealing with atheromatous embolism for which there is no effective recourse. Future technology should address an unmet need by developing a morphing catheter suitable for carotid access. ■

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