In the wake of the SAPPHIRE trial\(^1\) and subsequent approval of carotid stenting (CAS) devices by the Food and Drug Administration (FDA) in the United States, CAS is poised to explode in the frequency of its application in North America. Although the results of the Carotid Revascularization Stenting versus Endarterectomy Trial (CREST), the largest randomized controlled trial comparing carotid endarterectomy to CAS, are years away, many practitioners in multiple disciplines have already entered the competition for patients and remuneration. Despite the absence of evidence to support CAS over carotid endarterectomy\(^2,3\) and the need to continue recruiting patients to CREST,\(^4\) cardiologists, vascular surgeons, neurologists, neurosurgeons, general interventional and neurointerventional radiologists are all vying to treat carotid stenoses, many of which are <70% in severity, and asymptomatic.\(^2,5,6\) Attempts are being made to establish training, competency and credentialing standards for performance of CAS, and they vary widely between specialties.\(^7,8,9\) Computer simulations are playing a larger role in this process\(^10\) and may help to address the mismatch between training opportunities and interested practitioners. There have been concerns about the SAPPHIRE trial\(^11\) and the incidence of restenosis in previous case series.\(^3,12\) The techniques of CAS are still variable, with some operators advocating the use of cerebral protection devices,\(^13\) whereas others found that distal emboli might be more common with their usage.\(^14\) Although abnormalities on diffusion-weighted MRI after CAS are not uncommon (up to 30% of patients), most of these are asymptomatic.\(^15\) Patient related risk factors might be important determinants of complication rates after CAS, with those presenting with hemispheric strokes at particularly high risk.\(^16\) There may be a role for preoperative ultrasound in the identification of friable plaque, which may be more likely to generate distal emboli during CAS procedures.\(^17\)

### Intracranial Angioplasty and Stenting for Atherosclerosis

As technology and experience evolve, this procedure is becoming increasingly effective and safe for the treatment of intracranial atherosclerotic disease, and guidelines are being developed for its use.\(^18,19\) Although still performed relatively infrequently,\(^20\) the risks of periprocedural stroke and death have been reported to be as low as 8.3%, with the annual risk of stroke in the territory of the treated vessel between 3% to 5%.\(^21\) Balloons and stents are considerably softer and more flexible than earlier cardiology devices, and a new self-expanding stent specifically designed for intracranial use has recently become available.\(^18,19\) This procedure, however, remains hazardous with up to 50% of patients showing new, ipsilateral ischemic lesions on diffusion-weighted MR images.\(^22\) Angioplasty alone may be safer than the combination with stenting,\(^23\) and drug-eluting stents, although showing promise in coronary and canine vessels for the prevention of restenosis,\(^18\) are still not ready for human cerebral arteries because of differing histology and questions of drug neurotoxicity.

### Acute Stroke Interventions

The limitations of intravenous (IV) and intra-arterial (IA) chemical thrombolysis for reperfusion in acute stroke are becoming more apparent. The MERCI (Mechanical Embolus Removal in Cerebral Ischemia) trial of a dedicated device for mechanical embolectomy in stroke has been updated to include 141 patients who presented within 8 hours of their acute event.\(^23\) A 48% recanalization rate was obtained using this device, with a trend toward improved neurological outcome at 90 days in these patients, although symptomatic hemorrhages occurred in almost 28% of patients and overall mortality in the series was 44%. The high mortality may have been attributable to the initial severity of the strokes, the large number of basilar and internal carotid terminus emboli, and the advanced age of the patients compared with other series. Another series\(^24\) reported an 80% recanalization rate in 10 patients treated with this device, although the mortality rate was still 50%. There is some evidence that a very aggressive, multimodality approach using IV or IA GP IIb/IIIa antagonists abiciximab or tirofibian, IA recombinant tissue plasminogen activator or urokinase, and percutaneous angioplasty and stenting may result in more favorable outcomes, with promising results in small numbers of patients.\(^25,26,27\) Preliminary results suggest that endovascular ultrasound probes can accelerate thrombolysis;\(^28\) however, externally applied ultrasound combined with IV recombinant tissue plasminogen activator may increase the risk of hemorrhage.\(^29\) There are at least 3 commercial devices in development for selective, endovascular, locally induced hypothermia to limit brain damage during...
A new self-expanding, closed-cell design nitinol stent, designed for the endovascular treatment of wide-necked cerebral aneurysms, was recently introduced, featuring less permeability to coil migration and the ability to recapture and reposition the stent if necessary. Current and emerging therapies continue to be analyzed, particularly regarding their durability. The International Subarachnoid Aneurysms Trial (ISAT) was updated to present clinical outcomes at 1 year posttreatment. The early survival advantage of endovascular related to surgical therapy was maintained up to 7 years, with an absolute risk reduction of 7.4%. The endovascular group also had a lower incidence of epilepsy, and a low incidence of rebleeding (0.2% per patient-year), but higher incidence of rebleeding than the surgical group. Another analysis of 160 consecutive patients undergoing coil treatment showed that 73% were independent at 18 months, with an annual delayed rebleed risk of 0.45%. Almost 50% of patients, however, experienced negative events, such as aneurysmal remnant increase, retreatment, rebleeding or death. Overall clinical outcome was related to the immediate postprocedural angiographic result, which in turn was related to microcatheter stability, aneurysm geometry and aneurysm neck diameter. Follow-up of complex and wide-necked aneurysms treated with stents and coils has shown good results with acceptable occlusion and complication rates.

Arteriovenous Malformations

The natural history of brain arteriovenous malformations (BAVMs) is still not well understood, and the decision to treat remains complicated. Important factors are patient age, associated aneurysms, deep location and prior hemorrhage; however, the risk of an unruptured BAVM may be lower than previously thought. A randomized controlled trial of treatment versus no treatment in this group may be of value. The results of embolization with Onyx continue to improve and in some centers are comparable to those of microsurgery for Spetzler-Martin grades 1 and 2 lesions. Advances in gene therapy may lead to innovative interventions in the future.

Vasospasm

Balloon angioplasty remains the mainstay of accepted treatment for postsubarachnoid hemorrhage vasospasm when medical therapy fails to reverse the deficits, and a combination of angioplasty with IA nicardipine may represent a promising protocol. There is still a need to develop a soft, flexible, dedicated balloon for angioplasty in vasospasm, as currently used balloons are designed for other applications, such as balloon remodeling during aneurysm coiling. Various IA drugs aside from papaverine are now being used more frequently, including nimodipine and verapamil.

Transcranial duplex sonography remains the most reliable imaging modality to identify middle cerebral artery vasospasm, and perfusion CT and MRI are being used more frequently to identify brain at risk for infarction from vasospasm.

Imaging

As noninvasive imaging and carotid stenting become more popular, the precise measurement of atherosclerotic carotid stenosis becomes more critical. Conventional digital subtraction angiography (DSA) is being replaced as the gold standard for carotid stenosis measurement by 3-dimensional computed rotational angiography. DSA has long been suspected of understimating the disease burden, and contrast-enhanced magnetic resonance angiography may actually correlate best with 3-dimensional computed rotational angiography. DSA remains the gold standard for target definition in radiosurgery of BAVMs.

References


