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Preliminary Results of Intracranial Angioplasty for Vascular Stenosis Caused by Atherosclerosis and Vasculitis

John D. McKenzie, Robert C. Wallace, Bruce L. Dean, Richard A. Flom, and Mazen H. Khayata

PURPOSE: To evaluate the results of balloon angioplasty of 17 stenoses resulting from intracranial atherosclerosis and vasculitis. **METHODS:** Seventeen skull-base and intracranial lesions were dilated with a microballoon angioplasty catheter. **RESULTS:** Initially, 16 of the 17 stenoses showed improvement at angiography. Moderate residual stenosis was found in 2 of 12 atherosclerotic lesions, both in the distal vertebral artery. Angioplasty in 1 of 12 atherosclerotic lesions caused worsening of the stenotic site, also in the distal V4 region of the vertebral artery. All but one of the patients improved clinically. However, all five lesions caused by acute vasculitis progressed to occlusion after initial improvement. **CONCLUSION:** Intracranial percutaneous transluminal angioplasty is a viable nonsurgical option for the treatment of atherosclerotic vascular insufficiency, but it may not be as successful in treating lesions caused by vasculitis in the acute phase.

Index terms: Arteries, transluminal angioplasty; Atherosclerosis; Vasculitis

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In the early 1980s, the EC/IC Bypass Study Group began enrolling patients in an international randomized trial to compare the results of superficial temporal artery–to–middle cerebral artery bypass surgery with those of the best-available medical therapy. The trial was designed to evaluate the option of surgical bypass to treat patients with otherwise inoperable but symptomatic vascular stenoses or occlusions. In 1985, the EC/IC Study Group concluded that patients who had bypass surgery did no better than those receiving medical therapy (1). Currently, no proved techniques exist for treating intracranial stenoses that fail to respond to conservative treatment; and surgically inaccessible lesions continue to daunt those who practice medical stroke management.

With technical improvements in catheter and balloon technology, percutaneous transluminal angioplasty (PTA) may provide a viable approach to previously unreachable lesions. Dotter and Judkins described PTA in 1964 (2), and Gruntzig performed the first balloon catheter angioplasty (3). The knowledge gained from PTA in peripheral vascular disease has been applied to the coronary circulation (4–10) and, since the 1980s, to brachiocephalic vessels (11). There have been reports of successful treatment by extracranial dilatation in the common (12–14) and internal (12–15) carotid arteries, as well as in the vertebral and basilar arteries (16–18). The most common diseases amenable to this treatment are atherosclerosis, fibromuscular dysplasia, intimal hyperplasia, and arteritis. Intracranial angioplasty with nondetachable latex and silicone balloons has been used successfully to treat vasospasm (19–21).

In 1993, Higashida et al (17) reported the results of the use of PTA in the treatment of 274 lesions in the cerebrovascular circulation. The majority of these lesions were in extracranial vessels. Their complication rate was less than 5% for cerebrovascular angioplasty, and there were no mortalities; but these authors pointed out that the morbidity and mortality of intracranial angioplasty were higher because of perforating arteries. The North American Cerebrovascular Percutaneous Angioplasty Registry

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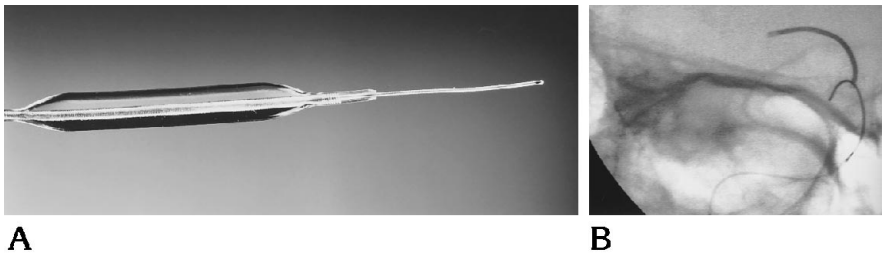

Fig 1. *A*, Stealth balloon (Target Therapeutics, Fremont, Calif).

B, Stealth balloon is seen in the distal internal carotid artery and extending into the horizontal middle cerebral artery.

has reported favorable results from the use of brachiocephalic and intracranial angioplasty (22).

We report our experience in treating 17 intracranial stenoses caused by atherosclerosis and vasculitis.

Materials and Methods

Seventeen intracranial and skull-base angioplasty procedures were performed in 11 patients. Symptomatology was referable to the vascular territory supplied by the stenosed artery. Maximum medical therapy, which included anticoagulation and the optimization of hemodynamic parameters (volume expansion and blood pressure management), failed in all cases. Stenoses were treated if the diameter of the vessel was reduced more than 70%. Extracranial stenoses were not included in the study.

All procedures were performed from the femoral route using a Stealth angioplasty balloon microcatheter (Target Therapeutics, Fremont, Calif). A guiding catheter with an inner diameter of 0.132 cm (0.052 in) or larger was used for Stealth balloons that were 2.0 to 3.5 mm in diameter, and a guiding catheter with an inner diameter of at least 0.150 cm (0.059 in) was used for the 4.0-mm Stealth balloons. High-quality diagnostic cerebral angiography was performed to evaluate collateral circulation and to measure the target vessel. Markers (washers or beads) of known size were placed on opposing sides of the head for calibrating and sizing the artery. The balloon size closest to the measured diameter of the normal segment of the target artery was used to avoid oversizing. Patients were anticoagulated with a 5000-U bolus of heparin followed by a continuous drip of 1000 U per hour. The angioplasty balloon was navigated into position across the stenosis by using a 0.036 cm (0.014 in) or 0.041 cm (0.016 in) guidewire. The guidewire was quickly exchanged for the occlusive balloon wire, and the balloon was inflated and deflated rapidly with a hand-held inflation device. Pressure was monitored with a gauge to prevent overinflation. The balloon deflated immediately when the occlusive wire was pulled back. Complete deflation was obtained by means of a hand-held syringe. The balloon was withdrawn to a position just proximal to the lesion, where a superselective angiographic run was obtained through the balloon. If inadequate results were obtained, the balloon was then repositioned and the angioplasty was repeated two to three times, if necessary. Three patients with atherosclerotic stenoses were pretreated with infusion of urokinase, ranging from 200 000 U to 1 000 000 U to lyse any clot at the

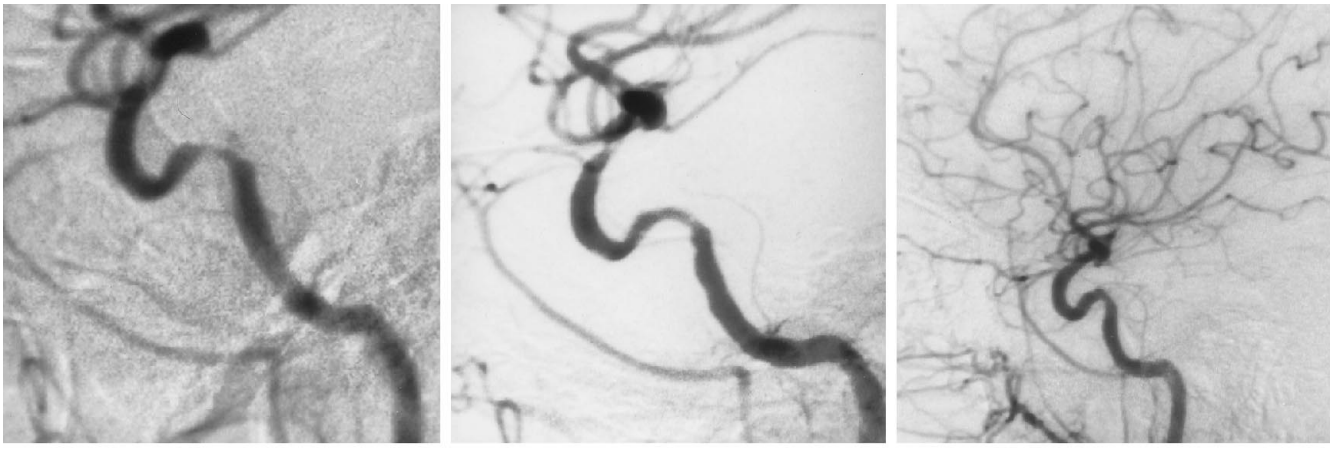

Fig 2. Elderly woman with recurrent transient hemiparesis.

A, Arteriogram shows stenotic lesion in the C4–5 segment of the cavernous internal carotid artery.

B, Postangioplasty angiogram shows mild residual stenosis of that segment.

C, Follow-up angiogram at 2½ years reveals a patent carotid artery.

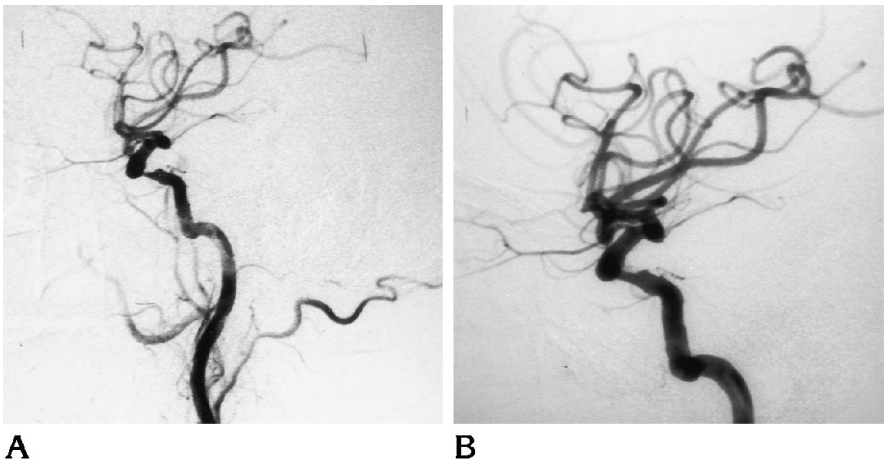

Fig 3. Elderly man with recurrent arm hemiparesis and amaurosis fugax.

A, Preangioplasty arteriogram in right common carotid artery shows a high-grade stenosis in the C-4 segment.

B, Postangioplasty arteriogram shows moderate residual stenosis. Patient was asymptomic at 12 months.

site before balloon inflation. This technique modification was added to the protocol when obvious fresh thrombus was encountered. Urokinase was not used in most cases.

After angioplasty, the patient was transferred to the neurosurgical intensive care unit for monitoring. Heparin was continued for a minimum of 24 hours and, in most cases, patients were discharged on oral aspirin. One patient who had a dramatic decrease in transient ischemic attacks was continued on warfarin for 6 months. Clinical follow-up was done at 3 months, 6 months, and 12 months, and patients were examined with magnetic resonance (MR) angiography or conventional angiography.

Results

Treated lesions included eight in the distal internal carotid artery (three supraclinoid, two petrous, and three cavernous), one in the A1 segment of the anterior cerebral artery, and two in the M1 segment of the horizontal middle cerebral artery. There were four in the intradural/intracranial portion of the vertebral artery (posterior inferior cerebellar artery region), and two in the basilar artery (one diffuse basilar involvement and one midbasilar).

Twelve lesions were clearly atherosclerotic, four were related to vasculitis, and one basilar artery lesion (in a young drug abuser) was of unknown origin (probably inflammatory). Three angioplasty procedures resulted in small dissections, which were seen angiographically. Two of these were asymptomatic, and the vessels remained patent on subsequent angiograms. One dissection resulted in more severe narrowing. Sixteen of 17 lesions improved angiographically. Six (35%) of the 17 lesions had moderate or severe residual stenosis after dilatation. These included 3 (25%) of 12 atherosclerotic lesions, which were all in the vertebral artery. One lesion in a patient with herpes vasculitis went on to occlusion despite two dilatations over a 48-hour period. All of the patients but one, who had atherosclerotic disease,

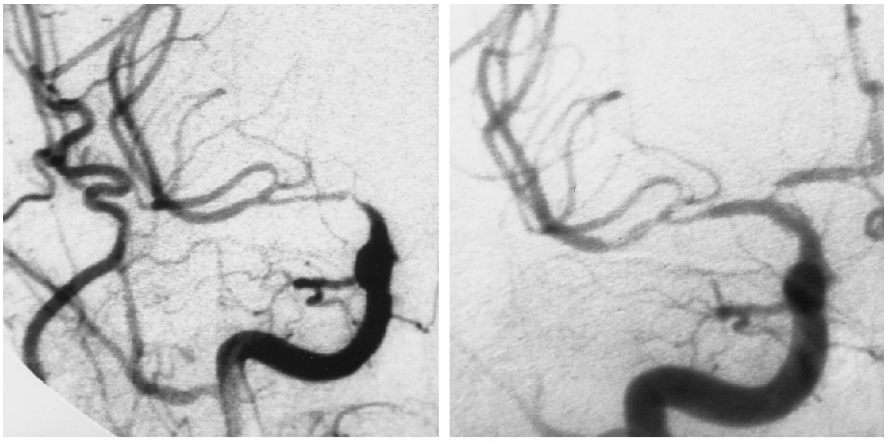

Fig 4. Elderly woman with herpes encephalitis with vascular involvement and progressing left hemiparesis.

A, Preangioplasty arteriogram shows high-grade stenosis of the distal carotid and middle cerebral arteries. The anterior cerebral artery is not seen.

B, Postangioplasty arteriogram shows moderate residual stenosis in the distal horizontal middle cerebral artery and the proximal anterior cerebral artery. Flow to the anterior cerebral artery is significantly improved. Angiographic result was not long-lasting.

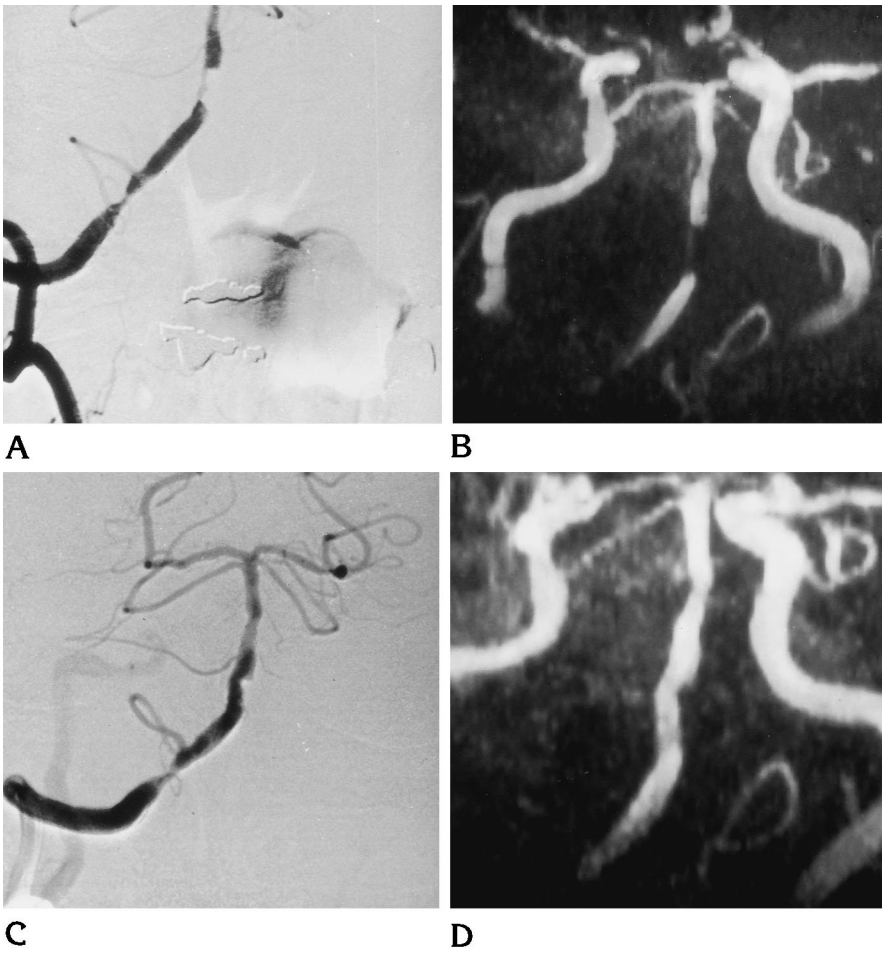

Fig 5. Elderly man with recurrent transient ischemic attacks of the posterior circulation.

A, Arteriogram shows a stenosis in the distal right vertebral artery and a second high-grade stenosis in the proximal basilar artery.

B, MR angiogram shows a flow gap in the proximal basilar artery, confirming high-grade stenosis.

C, Follow-up arteriogram after angioplasty of the proximal basilar lesion and distal vertebral artery lesion.

D, Follow-up MR angiogram confirms improvement of the stenotic lesion with resolution of flow gap. MR angiography offers a noninvasive method for follow-up examination of asymptomatic patients.

were clinically improved at 12 months. Patency was confirmed at follow-up by MR angiography or conventional angiography.

Discussion

PTA has been used successfully to reduce stenoses in the peripheral vascular system, furnishing subsequent relief from pain in the affected extremity. Angioplasty has also been effective in the treatment of coronary artery disease, providing improvement in cardiac function (6) and reduction in angina, and it is now a primary treatment technique for atherosclerotic coronary vascular disease. Coronary PTA has an 80% to 90% initial success rate for stenoses greater than 70%, with a 25% to 30% restenosis rate at 1 year (7–9).

We performed 17 intracranial angioplasty procedures in patients with a severe focal stenosis that was refractory to maximum medical therapy. Successful angiographic results were achieved in most patients with atherosclerotic stenoses. Moderate or severe residual stenoses occurred in 25% of the lesions. Experience with peripheral angioplasty would suggest that slight overdilatation may improve these results, but because of the potential catastrophic results of intradural vessel rupture, we did not pursue improved results by means of overdilatation. We did not dilate vessels distal to the first portion (ie, beyond first-order branches) for the same reason. In our series, patients in whom the vessel diameter improved but who had moderate residual stenosis still improved clinically, as has also been observed for stenoses in the basilar artery (23). Future technology may enable hardened plaques to be managed by the pressure of higher balloon inflation, and elastic recoil may be managed by flexible stents that can

be maneuvered into position (A. K. Wakhloo, F. O. Tio, F. Schellhammer et al, "Nitinol Stents in Canine Vertebral Arteries: Hemodynamics and Tissue Response," presented at the annual meeting of the American Society of Neuroradiology, Nashville, Tenn, May 1994). This methodology may be particularly important in treating vertebral artery lesions.

Three vessel dissections occurred in the group of patients with atherosclerotic stenoses. Two of the three patients had no clinical complications. Although thrombotic occlusions occurring within minutes to hours after angioplasty in the intracranial circulation have been described (R. Ferguson and L. Lee, unpublished data, May 1995), no immediate thrombotic or embolic complications were evident in our series. Our procedure protocol did not include delayed angiography unless clinical deterioration warranted it.

Angioplasty was attempted in five vascular territories in three patients with vasculitis. Satisfactory dilatation in patients with vasculitis could be achieved transiently but two patients required a repeat procedure 48 hours later because of restenosis. The natural course of the disease process could not be reversed, and vessel occlusion ensued in all cases. Nonatherosclerotic lesions related to inflammation may be at increased risk of dissection or subsequent occlusion because of inflammatory weakening of the vessel wall. Since these lesions progressed despite angioplasty, dilatation may be contraindicated when vasculitis is in the acute phase.

Intracranial PTA for atherosclerosis appears to be a viable nonsurgical option for treatment of vascular insufficiency. It may also be a useful adjunct intraoperatively in patients undergoing carotid endarterectomy. An understanding of the biochemical and pharmacological basis for smooth muscle proliferation resulting in restenosis will further aid in understanding this process (9, 24, 25). More experience with a longer clinical follow-up period is needed and a prospective multicenter trial is necessary to confirm efficacy of intracranial angioplasty.

Acknowledgments

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