Balloon angioplasty of the A_1 segment of the anterior cerebral artery narrowed by vasospasm

Technical note

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✔ The authors describe a new endovascular technique that improves catheterization and balloon angioplasty of the A_1 segment of the anterior cerebral artery after it has been narrowed by vasospasm. The technical results of using this method in seven patients are presented.

KEY WORDS • aneurysm • angioplasty • anterior cerebral artery • subarachnoid hemorrhage • vasospasm

SUBARACHNOID hemorrhage after aneurysm rupture often leads to cerebral vasospasm. Despite standard medical treatment with calcium channel blockers and hypertensive, hypervolemic, hemodilution therapy, up to one third of patients with vasospasm develop an ischemic neurological deficit.[13,15,17,22] When maximum medical therapy for vasospasm fails, early and aggressive endovascular intervention with balloon angioplasty can improve clinical outcome.[1,2,7,14,20,26] However, one disadvantage of balloon angioplasty is its limited ability to enter sharply angled vessels.

Based on our experience and confirmed by others, balloon angioplasty of the A_1 segment of the anterior cerebral artery (ACA) has been achievable in less than 10% of patients.[2,7,14] We report a new endovascular technique that improves access to and facilitates balloon angioplasty of A_1 segments narrowed by vasospasm in selected patients. The method involves over-the-wire navigation and microguidewire support of a low-profile high-pressure balloon microcatheter system.

Endovascular Technique

The technique of performing balloon angioplasty by using the standard 4-mm low-pressure nondetachable silicone balloon microcatheter (model ITC NDSB/8502 with 0.2-ml maximum volume, 0.85-mm diameter/4.1-mm length deflated, 4.2-mm diameter/11-mm length inflated [standard ITC balloon]; Target Therapeutics/Boston Scientific, Watertown, MA) for symptomatic vasospasm has been previously described.[10,23] If the initial diagnostic cerebral angiogram reveals normal caliber prevasospastic

A_1 segments, instead of using the standard ITC balloon, a low-profile high-pressure balloon microcatheter (Stealth Balloon Dilation System model 120502; inflated 2.5-mm diameter, 10-mm length; Target Therapeutic/Boston Scientific) is advanced across the narrowed A_1 segment with the aid of steerable hydrophilic microguidewires (Terumo 46–230, 0.016-in, 70°-angled, radiopaque gold tip tapered hydrophilic glidewire [Terumo gold tip] or Transend EX 46–801, 0.014-in, steerable microguidewire with ICE hydrophilic coating and shapeable tip [Transend EX]; Target Therapeutics/Boston Scientific) (Fig. 1).

With the assistance of biplane digital fluoroscopy and roadmapping, attempts are initially made to cross the narrowed A_1 segment with the Terumo gold tip. If successful, the microguidewire is carefully advanced to the distal pericallosal or callosomarginal artery (Fig. 2). Once the microcatheter is positioned across the A_1 segment with the aid of real-time fluoroscopic monitoring, the Stealth balloon microcatheter is dilated several times. The balloon is inflated with contrast agent that is injected using a Luer–Loc syringe attached to the Stealth balloon microcatheter via a rotating hemostatic valve.

If attempts to cross A_1-segment vasospasm with the Terumo gold tip are unsuccessful, the Transend EX can be advanced through the Stealth balloon microcatheter after shaping a tight 3- to 4-mm curve at its tip. This aids navigation of the acute bend of the terminal internal carotid artery (ICA) and the A_1 junction. Once the A_1 segment is crossed, the Transend EX is exchanged for the stiffer Terumo gold tip, which is carefully advanced to position its tip in the distal ACA. If the initial tight curve is not helpful in navigating across the A_1 segment, other curves can
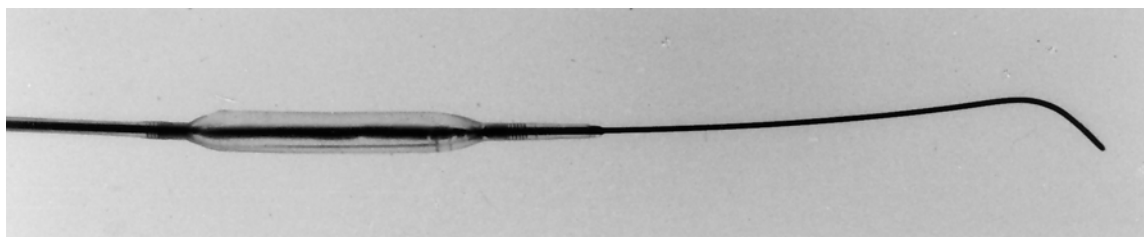
FIG. 1. Photograph showing the Stealth balloon microcatheter and steerable hydrophilic microguidewire system. The Stealth Balloon Dilation System model 120502 (inflated 2.5-mm diameter, 10-mm length) is pictured with a Terumo 46–230, 0.016-in, 70°-angled, radiopaque gold tip, tapered hydrophilic microguidewire (Terumo gold tip).

be shaped at the tip of the Transend EX and the process can be repeated.

We have used this technique with good results in treating 10 A_1 segments narrowed by vasospasm in seven patients (Table 1).

Discussion

For patients who survive the initial event of aneurysmal rupture, after the aneurysm has been excluded by surgical clipping or endovascular coil placement, vasospasm remains the most important cause of treatable disability.[17] Various strategies to prevent or treat vasospasm and its ischemic sequelae are under investigation, including intracisternal thrombolytic therapy, a course of 21-amino-steroids (tirilazad), intraarterial papaverine infusion, and balloon angioplasty.[16,25] Balloon angioplasty performed shortly after symptom onset appears to improve short-term and long-term clinical outcomes in patients suffering
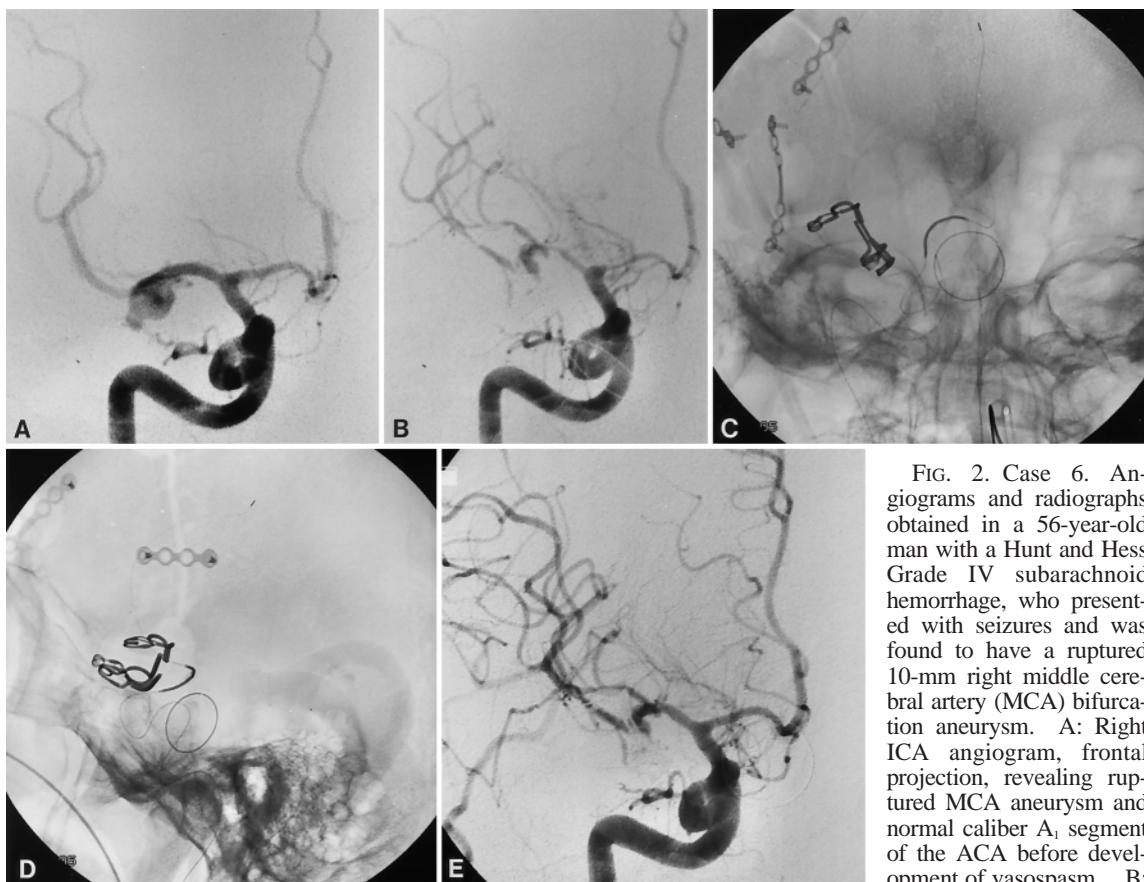

FIG. 2. Case 6. Angiograms and radiographs obtained in a 56-year-old man with a Hunt and Hess Grade IV subarachnoid hemorrhage, who presented with seizures and was found to have a ruptured 10-mm right middle cerebral artery (MCA) bifurcation aneurysm. A: Right ICA angiogram, frontal projection, revealing ruptured MCA aneurysm and normal caliber A_1 segment of the ACA before development of vasospasm. B: After surgical clipping of the aneurysm, the patient developed vasospasm with involvement of the M_1 segment of the MCA and A_1 segment of the ACA. C and D: Frontal and lateral projection radiographs demonstrating the Stealth balloon catheter positioned and inflated across the narrowed A_1 segment with the Terumo gold tip positioned in the distal pericallosal artery. E: Following balloon inflation, repeated right ICA angiogram, frontal projection, revealing normal caliber A_1 and M_1 segments. The Stealth balloon catheter was also used to dilate the M_1 segment mechanically by using a similar technique after A_1 segment balloon angioplasty.

from symptomatic vasospasm[1,2,7,14,20,26] Moreover, the dilation produced by balloon angioplasty appears durable, with rare vasospasm recurrence. With growing experience, enthusiasm for balloon angioplasty has increased as more neurosurgeons now use this treatment modality for symptomatic vasospasm.[4–12,18,19,21,23,24]

The importance of A_1 segment vasospasm as a contributor to incidences of morbidity and mortality related to vasospasm is underappreciated. The endovascular treatment of ACA vasospasm has been challenging. One disadvantage of balloon angioplasty is its limited ability to reach sharply angled vessels such as the A_1 segment. Balloon angioplasty of the A_1 segment is desirable because vasospasm in this location is common. Moreover, especially when the contralateral A_1 is hypoplastic or absent, A_1 segment vasospasm can lead to significant neurological deficits, including hemiparesis, hemihypesthesia, behavioral disturbances, transcortical motor aphasia, and mental deficits.[3]

In our experience of treating more than 150 patients with balloon angioplasty for symptomatic vasospasm during the past decade, we have found that the standard 4-mm nondetachable low-pressure ITC silicone balloon can be used to dilate the A_1 segment in less than 10% of patients. The Stealth balloon microcatheter/steerable hydrophilic microguidewire technique, however, has considerably improved our ability to access and perform balloon angioplasty on vasospastic A_1 segments.

The Stealth is stiffer than the standard ITC balloon and is, therefore, more difficult to advance through the numerous genua of the ICA. Moreover, because it is a higher-pressure balloon, the use of the Stealth carries a higher risk of vessel rupture. However, our technique modification of inflating the Stealth over a hydrophilic microguidewire addresses both of these disadvantages. In contrast to the occlusive wire supplied with the Stealth, the hydrophilic microguidewire is nonocclusive because it has no ball to close the valve. Therefore, inflations are "leaky," thereby limiting the high pressure applied by the balloon to the vessel, which probably decreases the risk of vessel rupture. Moreover, because the microguidewires are steerable and hydrophilic, they can be advanced quite distally into the ACA. Advancing the Stealth over a hydrophilic microguidewire improves balloon navigation across a stenotic A_1 segment. The distally positioned microguidewire also provides support for the balloon across the acute bend of the A_1 segment during balloon inflation. Hand-inflation pressures for the Stealth balloon are typically higher (2–3 atm) than those used for the ITC (0.5 atm). In in vitro experiments performed using this modified Stealth system, hand-inflation pressures greater than 25 atm have been achieved without balloon rupture while maintaining balloon shape and caliber. Therefore, the risk of balloon rupture by using this technique appears to be low. However, overly aggressive dilation can potentially rupture the vessel segment or cause occlusive dissection. We have observed one case of transient occlusive balloon microcatheter–induced spasm following A_1 segment angioplasty in a woman who was a long-time user of tobacco (Case 7).

The Stealth balloon microcatheter/steerable hydrophilic microguidewire system can also be used to perform balloon angioplasty in the M_2 and P_1 segments in selected

TABLE 1

Technical results of A_1 segment balloon angioplasty performed using the Stealth balloon microcatheter/steerable hydrophilic microguidewire system*

| Case No. | Age (yrs), Sex | Aneurysm Location | A_1 Vasospasm | | Complications |
			Before Angioplasty	After Angioplasty	
1	34, M	ACoA	lt severe	none	none
2	39, F	basilar tip	lt mild	none	VA dissection†
			rt moderate	mild	
3	12, M	ACoA	lt severe	mild	
			rt severe	none	none
4	33, F	lt MCA & PA	lt severe	moderate	increased ICP preangioplasty‡
5	50, F	basilar tip	lt moderate	none	
			rt severe	moderate	none
6	56, M	rt MCA	rt severe	none	none
7	37, F	ACoA & lt SCA	rt severe	mild	rt A_1 & M_2 microcatheter spasm§

* ACoA = anterior communicating artery; ICP = intracranial pressure; PA = pericallosal artery; SCA = superior cerebellar artery; VA = vertebral artery.

† Not directly related to A_1 segment balloon angioplasty.

‡ Stealth balloon positioned across left A_1 segment when ICP abruptly increased. Balloon never inflated. Emergency head computerized tomography scanning revealed no new hemorrhage or infarction. Patient was treated with intraarterial papaverine infusion.

§ Immediately postangioplasty cerebral angiogram revealed occlusion of the right A_1 segment. A 24-hour follow-up cerebral angiogram revealed almost normal caliber of the A_1 (see Fig. 3).

patients. When planning multiple-vessel-segment balloon angioplasty by using the Stealth balloon microcatheter/steerable hydrophilic microguidewire system, A_1 segment balloon angioplasty should be attempted first because, once the Stealth is inflated, it never completely returns to its baseline low profile. This endovascular technique can also be used to perform balloon angioplasty in cases of intracranial atherosclerotic stenoses. On the horizon are new microguidewire-directed low-pressure silicone balloon microcatheters that should be capable of reaching the A_1 segment. Theoretically, these newer angioplasty balloon catheters should be safer and more maneuverable.

Conclusions

Vasospasm of the A_1 segment is common and can lead to significant morbidity. When balloon angioplasty for symptomatic vasospasm is pursued, all stenotic proximal vessel segments should be mechanically dilated, including narrowed A_1 segments, if technically achievable. We have found that the low-profile high-pressure Stealth balloon microcatheter/steerable hydrophilic microguidewire over-the-wire technique improves access to and balloon angioplasty in vasospastic A_1 segments. Use of the high-pressure Stealth balloon carries a higher risk of vessel rupture compared with the use of the standard low-pressure ITC balloon. Balloon angioplasty in a vasospastic A_1 segment should not be performed if the prevasospasm caliber of the A_1 segment is not known, hypoplastic, or atretic.

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