CASE REPORT

Disappearance of a small intracranial aneurysm as a result of vessel straightening and in-stent stenosis following use of an Enterprise vascular reconstruction device

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SUMMARY

In-stent stenosis after stent-assisted coil embolization is a rare but well-known complication. A 32-year-old woman with an unruptured wide-necked left internal carotid artery (ICA) terminus aneurysm and an ipsilateral very small anterior choroidal artery aneurysm underwent stent-assisted coil embolization for the ICA terminus aneurysm. The 4-month follow-up angiography revealed diffuse in-stent stenosis and disappearance of the untreated anterior choroidal artery aneurysm, retaining the patency of the anterior choroidal artery. To our knowledge, this is the first report to demonstrate the course of in-stent stenosis and disappearance of an untreated small intracranial aneurysm as a result. We report this unique case and discuss the interesting mechanism underlying this phenomenon, and also provide a review of the relevant literature.

BACKGROUND

To our knowledge, this is the first report to demonstrate the course of in-stent stenosis and disappearance of an untreated small intracranial aneurysm as a result.

CASE PRESENTATION

A 32-year-old woman was incidentally found to have a left internal carotid artery (ICA) terminus aneurysm during an investigation for headaches.

CT angiography was undertaken to characterize the lesion further. The left ICA terminus aneurysm had a small bleb on the dome measuring 7.3 mm in the largest dimension with a neck size of 5.0 mm. The segment of the parent artery that gave rise to the aneurysm was ectatic, suggesting a circumference extension of the disease. A decision was therefore made to perform stent-assisted coil embolization of the aneurysm. In addition, a very small left anterior choroidal artery aneurysm with a 2.2 mm neck and 1.1 mm depth was noted just proximal to the ICA terminus aneurysm. The origin of the anterior choroidal artery was incorporated into the proximal neck of the aneurysm (figure 1A,B). The parent artery proximal to the two aneurysms measured 3.9 mm in the largest diameter.

Stent-assisted coil embolization was performed using an Enterprise vascular reconstruction device 4.5 mm×22 mm stent (Codman Neurovascular, Miami, Florida, USA) and six Axium 3D coils

(Covidien/ev3 Neurovascular, Irvine, California, USA). The stent was deployed from the proximal left M1 segment down to the ophthalmic artery segment. The final post-embolization angiogram showed tight packing of the aneurysm with stagnation of contrast within the coil interstices. There was no evidence of complications such as vessel dissection or in-stent thrombosis. However, some straightening of the natural ICA curvature was noted, presumably due to the placement of the closed-cell stent (figure 1C). Perioperative aspirin 325 mg and clopidogrel 75 mg per day were administered beginning 3 days before the procedure and were continued for 3 months. Clopidogrel was discontinued after 3 months and the patient was maintained on aspirin at the same dose. Follow-up angiography was performed at 4 months due to a new headache behind her left eye, which started to increase in intensity 2 months after the stent-assisted embolization.

The follow-up angiogram showed complete obliteration of the ICA terminus aneurysm and also diffuse in-stent stenosis with further straightening of the stented segment. The stenosis involved the entire length of the stent from the supraclinoid portion extending into the proximal M1 segment (figure 2B). This stenosis was approximately 50%, but was not a flow-limiting lesion. The anterior choroidal artery was patent but the small anterior choroidal artery aneurysm was no longer visualised (figure 2B). Given the presence of the significant in-stent stenosis, the patient was newly started on cilostazol 50 mg twice a day and the aspirin dose was reduced to 81 mg daily.

The patient was otherwise healthy without any neurological deficits and the headache disappeared over the course of the next 3 months. Another follow-up angiography was performed 8 months later, which showed complete resolution of the in-stent stenosis. The left anterior choroidal artery aneurysm was still completely obliterated with good patency of the anterior choroidal artery (figure 2C).

DISCUSSION

In-stent restenosis is a well-known complication encountered 3–6 months after coronary stenting (rate range 10–50%).^{1 2} Pathologically, it has been attributed primarily to neointimal hyperplasia. In particular, the endothelial cells play a crucial role in regulating smooth muscle cell growth and, when

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Figure 1 Preoperative angiography. (A,B) Left internal carotid artery (ICA) angiograms (A: lateral view, B: anteroposterior view) showing a wide-necked ICA terminus aneurysm (white arrow) and a very small anterior choroidal artery aneurysm (small white arrow). (C) Postoperative angiography: left ICA angiogram immediately after stent-assisted coil embolization indicating some straightening of the angle between the supraclinoid ICA and the left M1 segment (white arrowheads).

the endothelium is disrupted by a therapeutic angioplasty and the regulation is interrupted, neointimal (ie, smooth muscle cells and extracellular matrix) proliferation results in stenosis.^{3–6} Thus, the degree of neointimal proliferation seems to be defined by the endothelial injury due to either the balloon angioplasty or the persistent radial force of the stent.

Neointimal hyperplasia and resultant in-stent stenosis is relatively rare with intracranial stenting for the treatment of aneurysms using low radial force stents such as Neuroform EZ (Stryker Neurovascular, Fremont, California, USA) and Enterprise, but the timing of it is similar to that of coronary stenting.⁷ The rates of in-stent stenosis and symptomatic stenosis are reported to be 2.3–7.8% and 0–1.3%, respectively.^{8–12} Spontaneous resolution of the stenosis has also been observed in several case reports with a rate of 12.5–44.4%.^{8–10–11} This phenomenon is unique to aneurysm stenting and is not shared by other vascular interventions.⁸ On the other hand, in cases of stenting for atherosclerosis, the rates of both restenosis and symptomatic stenosis are much higher (7.5–32.4% and 0–9.5%, respectively).^{13–16} Although several factors (such as preceding balloon angioplasty, high radial force stent, background of atherosclerosis) might be implicated in this difference, based on the rate of adverse events and the spontaneous resolution, aneurysmal stenting seems to have a more benign course than atherosclerosis.^{17–18}

The most interesting point in this case was the mechanism of the disappearance of the small aneurysm with preservation of the anterior choroidal artery. Small ruptured aneurysms have been successfully treated by flow-diverting stents.¹⁹ It is considered quite unlikely that our Enterprise stent would produce such a strong flow diversion effect in the small saccular

aneurysm. The actual mechanism of the spontaneous disappearance of the small aneurysm remains undetermined without histological evaluation. Nevertheless, we consider there are two possibilities. The first is that the intimal hyperplasia and resultant in-stent stenosis may have extended to the small aneurysm. It is very uncommon for intimal hyperplasia to obliterate the adjacent small branches with antegrade blood flow.^{8–11} However, the extension of intimal hyperplasia into such a small aneurysm could have a significant impact on its patency. The second theory is that the straightening of the ICA itself induced a significant flow diversion effect. The Enterprise vascular reconstruction device is a relatively stiff stent among currently available self-expandable intracranial stents.²⁰ Zenteno *et al* reported straightening of the parent artery with the use of stiff balloon-expandable stents, and the resultant flow change induced thrombus formation in the intracranial aneurysm and achieved long-term obliteration of those lesions.^{21–22} Thus, a combination of intimal hyperplasia and vessel straightening may have led to the permanent obliteration of the aneurysm even after the resolution of the intimal hyperplasia. Given that the aneurysm remained occluded after spontaneous resolution of the in-stent stenosis, the straightening may be more likely to be the cause than the in-stent stenosis.

One case of spontaneous aneurysm obliteration after placement of an Enterprise vascular reconstruction device does not produce a firm conclusion, but it is sufficient to make us aware how little we know about the mechanism of aneurysm obliteration after stent placement. The process of aneurysm obliteration after stenting may involve multiple mechanisms rather than a simple flow diversion effect from the stent mesh.

Figure 2 Left ICA angiograms (A) immediately after stent-assisted coil embolization (white arrow indicates the aneurysm and the anterior choroidal artery, respectively), (B) 4 months later and (C) 12 months later. The 4-month angiogram shows diffuse in-stent stenosis and disappearance of the untreated anterior choroidal artery aneurysm, retaining the patency of the anterior choroidal artery (B). The 12-month angiogram shows moderate resolution of the previous in-stent stenosis and continued obliteration of the anterior choroidal artery aneurysm, retaining the patency of the anterior choroidal artery (C).

Learning points

- We report a unique case that showed the spontaneous obliteration of the small aneurysm retaining the patency of the perforating artery as a result of both post Enterprise VRD in-stent stenosis and vessel straightening.
- Various mechanisms other than mere thrombotic formation may be responsible for the process of aneurysm obliteration after stenting.

Competing interests None.

Patient consent Obtained.

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