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Partially thrombosed giant basilar artery aneurysm with attenuated contrast enhancement of the intraluminal thrombus on vessel wall MRI after flow diversion treatment: illustrative case

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BACKGROUND The effect of vessel wall magnetic resonance imaging (VW-MRI) enhancement in partially thrombosed aneurysms has previously indicated aneurysmal instability and a rupture risk. However, whether the contrast effect of the wall changes before or after flow diversion treatment is still under investigation.

OBSERVATIONS The authors report a case of a partially thrombosed basilar artery aneurysm that increased in size over a short period, worsened brainstem compression symptoms, and was treated with a flow diverter stent with good results. In this case, VW-MRI after surgery showed a reduced contrast effect on the intraluminal thrombus within the aneurysm. The aneurysm thrombosed and markedly regressed over the next 5 months, with remarkable improvement in the brainstem compression symptoms.

LESSONS This finding on VW-MRI may indicate an attenuation of neovascularization in the thrombus wall and be a sign of aneurysm stabilization.

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KEYWORDS giant basilar artery aneurysm; partially thrombosed aneurysm; flow diversion; vessel wall MRI; DANTE; intraluminal thrombus

In partially thrombosed aneurysms, high-resolution vessel wall magnetic resonance imaging (VW-MRI) has been used to evaluate the aneurysm wall, and the wall contrast effect is known to indicate aneurysmal instability and rupture risk.[1] However, VW-MRI findings before and after flow diversion treatment are still under investigation.[2] Here, using the delay alternating with nutation for tailored excitation (DANTE) T1-SPACE (sampling perfection with application-optimized contrasts using different flip angle evolutions), a VW-MRI method, we confirmed that the wall contrast effect in a partially thrombosed aneurysm was attenuated after flow diverter (FD) stent implantation.

Illustrative Case

A 71-year-old male presented with ataxic gait disturbance as the chief complaint. Head magnetic resonance imaging (MRI) revealed a mass compressing the brainstem with surrounding edema (Fig. 1A). VW-MRI (DANTE T1-SPACE) showed continuity with the basilar artery (BA), leading to the diagnosis of a partially thrombosed giant BA aneurysm. Blood flow within the aneurysm was minimal, and most of the aneurysm was considered thrombosed (Fig. 1B and C). In addition, contrast enhancement of the intraluminal thrombus within the aneurysm was observed (Fig. 2A–C). Cerebral angiography showed the same findings as the MRI, with only a small portion of the BA aneurysm visualized (Fig. 1H and I).

Treatment with the placement of an FD stent was planned, and dual antiplatelet therapy (aspirin 100 mg/day and clopidogrel 75 mg/day) was started 2 weeks prior to the surgery. Four days before the scheduled surgery, the patient presented to the emergency department with left upper- and lower-extremity paralysis (Manual Muscle Test 2/5), dysarthria, and dysphagia. MRI showed worsening of the mass effect on

ABBREVIATIONS BA = basilar artery; DANTE = delay alternating with nutation for tailored excitation; FRED = flow-redirection endoluminal device; MRI = magnetic resonance imaging; PCA = posterior cerebral artery; POD = postoperative day; VA = vertebral artery; VW-MRI = vessel wall magnetic resonance imaging.

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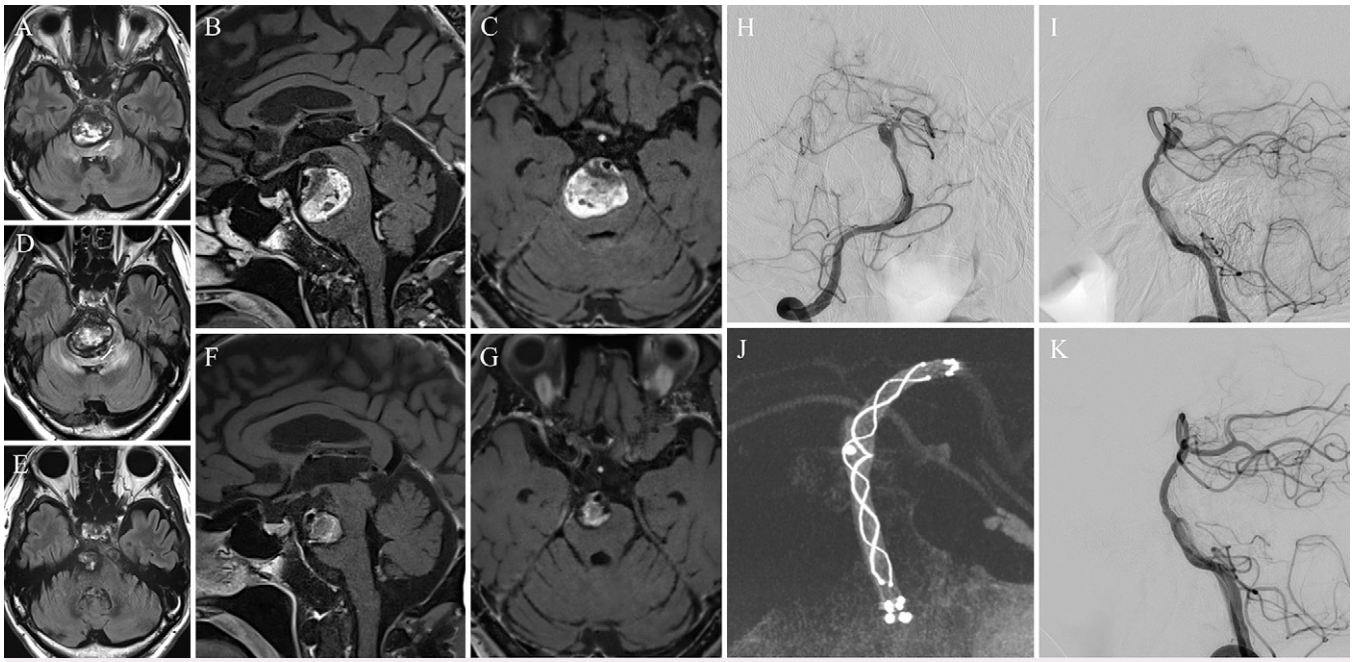

FIG. 1. Axial fluid-attenuated inversion recovery (FLAIR) magnetic resonance imaging (MRI) (**A**) at the initial examination showing a mass compressing the brainstem with surrounding edema. Sagittal (**B**) and axial (**C**) contrast-enhanced delay alternating with nutation for tailored excitation (DANTE) T1-SPACE (sampling perfection with application-optimized contrasts using different flip angle evolutions) at the initial examination showing a giant partially thrombosed basilar artery (BA) aneurysm compressing the brainstem. The blood-flow lumen of the aneurysm, which was contiguous with the BA, was very small, and most of it was thrombosed. Axial FLAIR MRI (**D**) 1 month after the initial visit showing increased mass effect on the brainstem and worsening edematous changes. Axial FLAIR MRI (**E**) 5 months after flow diversion treatment showing prominent shrinkage of the aneurysm and improvement in edematous changes. Sagittal (**F**) and axial (**G**) contrast-enhanced DANTE T1-SPACE 5 months after flow diversion treatment showing a prominent reduction in the thrombosed area within the aneurysm. Anteroposterior (**H**) and lateral (**I**) views of preoperative vertebral angiogram showing only a small portion of the thrombosed aneurysm as the intra-aneurysmal lumen. Three-dimensional rotational angiography (**J**) showing the flow-redirection endoluminal device (FRED) is placed from the left posterior cerebral artery (PCA) P1–2 junction to the BA and is fully open. Lateral vertebral angiogram (**K**) 5 months after flow diversion treatment showing complete occlusion of the aneurysm.

the brainstem (Fig. 1D). Steroids (prednisolone 30 mg/day) and glycerol were initiated to reduce edema. Endovascular treatment was performed as planned. With the patient under general anesthesia, an 8-Fr sheath was placed in the right common femoral artery. An 8-Fr guiding catheter was then placed at the origin of the right vertebral artery (VA) and advanced into the intracranial VA using a 6-Fr SOFIASELECT (MicroVention). A Headway27 microcatheter (MicroVention) and Traxcess guidewire (MicroVention) were used to guide to the left posterior cerebral artery (PCA) P2 segment. Additionally, a Headway Duo microcatheter (MicroVention) was guided into the aneurysm. A flow-redirection endoluminal device (FRED; 3.5 $\times$ 22 mm, MicroVention) was placed from the left PCA P1–2 junction to the BA through the Headway27 (Fig. 1J). No adjunctive coils were used after FRED implantation because the aneurysm had a small blood-flow lumen. Symptoms gradually improved from postoperative day (POD) 1, and steroids were tapered off and discontinued on POD20. Contrast-enhanced VW-MRI performed on POD1 (Fig. 2D–F) and 3 weeks postoperatively (Fig. 2G and H) showed reduced contrast enhancement of the intraluminal thrombus within the aneurysm. On POD30, the patient was transferred to a rehabilitation hospital with mild paralysis of the left upper extremity (modified Rankin scale score 2). Follow-up cerebral angiography 5 months after treatment showed complete occlusion of the aneurysm (Fig. 1K). Furthermore, MRI showed a significant reduction in the thrombus within the aneurysm and reduced mass effect on the brainstem (Fig. 1E–G). Clopidogrel was discontinued, and only aspirin was continued. The paralytic symptoms resolved almost completely, and the patient became an outpatient.

Patient Informed Consent

The necessary patient informed consent was obtained in this study.

Discussion

Observations

Giant ($\geq$25 mm) intracranial aneurysms are a unique subcategory of cerebral aneurysms with a poor natural history and technically demanding treatment options.[3,4] Direct surgery results for giant thrombosed aneurysms have been poor, and aneurysms in the posterior circulation region have been considered a poor prognostic factor.[5] Some giant aneurysms in the posterior circulation progressively and irreversibly enlarge, causing neurological deficits due to brainstem compression.[5] The treatment goal is not only to prevent future hemorrhagic events but also to alleviate the associated mass effect and compression symptoms.[4] Treatment strategies for these uncommon intracranial aneurysms remain a matter of substantial debate because evidence from large clinical trials is lacking.[4] Recent reports have demonstrated the flow diversion efficacy

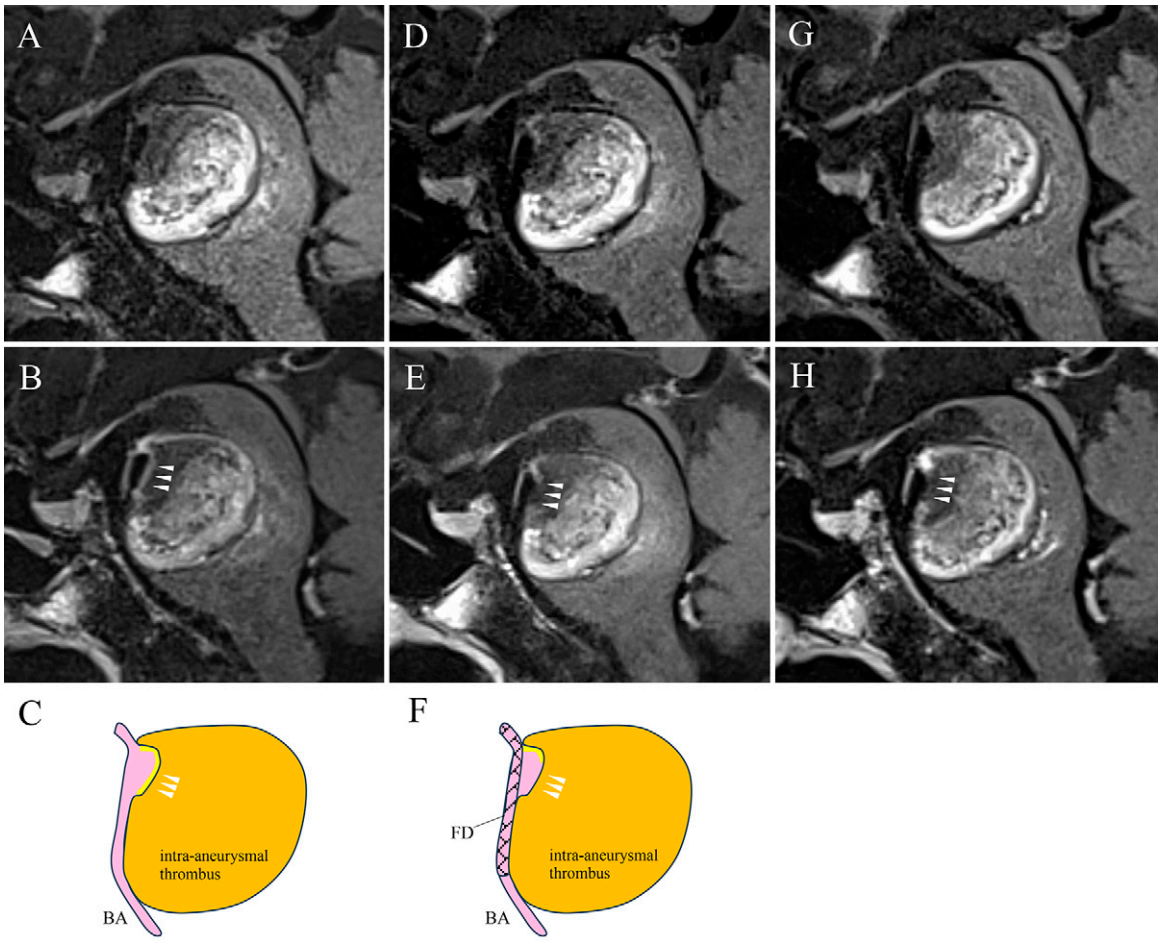

FIG. 2. Sagittal nonenhanced (**A**) and contrast-enhanced (**B**) DANTE T1-SPACE at the initial examination showing the contrast effect on the intraluminal thrombus within the aneurysm (*white arrowheads*). A schema (**C**) of the image is shown in panel B. The *white arrowheads* indicate an intra-aneurysmal thrombus in contact with the blood-flow cavity of the aneurysm, which is referred to as an "intraluminal thrombus." The *yellow marker* indicates the contrast effect of the intraluminal thrombus. Sagittal nonenhanced (**D**) and contrast-enhanced (**E**) DANTE T1-SPACE on postoperative day 1 showing attenuated wall enhancement of the intraluminal thrombus within the aneurysm (*white arrowheads*). A schema (**F**) of the image is shown in panel E. The contrast effect *(yellow marker)* of the intraluminal thrombus, indicated by the *white arrowheads*, has attenuated after FD implantation. Sagittal nonenhanced (**G**) and contrast-enhanced (**H**) DANTE T1-SPACE 3 weeks after surgery showing persistent wall enhancement attenuation of the intraluminal thrombus within the aneurysm (*white arrowheads*).

for giant cerebral aneurysms in the posterior circulation.[4,6] However, a significantly higher risk of perforating branch infarction compared with that in anterior circulation aneurysms has also been shown.[7]

Approximately 50% of giant cerebral aneurysms show thrombosis within the aneurysm.[8] The presence of a partial thrombosis has been identified as a clinical biomarker for aneurysm histological findings, suggesting instability and rupture risk.[1] Partially thrombosed aneurysms are related to subacute or chronic dissections, repeated intramural hematomas, proliferating vasa vasorum, and the triggering of inflammatory mechanisms.[9,10] Endoluminal implants that reduce and redirect blood flow away from the aneurysm sac can diminish the pulsation phenomenon and induce steady intrasaccular thrombosis.[4] Similar to the wound-healing mechanism, the biotransformation and organization of the intrasaccular thrombus into fibrous scar tissue allow the aneurysmal structure to be reduced and eventually resorbed to some extent.[11] In the present case, we decided to implant an FD stent to stabilize the growing thrombosed aneurysm. In fact, FD stent implantation stopped aneurysmal enlargement and further reduced the size of the giant thrombosed BA aneurysm, which showed a tendency to increase in a short period, suggesting that the decrease in flow within the thrombosed aneurysm itself may have triggered the healing mechanism.

Wall-enhancement patterns of thrombosed intracranial aneurysms on MRI are recognized as a clinical alert sign that indicates unstable behavior.[12] Partial or complete inner wall enhancement correlates with neovascularization of the inner wall layer and adjacent thrombus.[1]

Furthermore, it has been suggested that the change in contrast effect on VW-MRI before and after flow diversion treatment may indicate a potential biomarker of healing,[2] but the details are still under investigation, and the relationship with steroids is unknown.

In this case, preoperative contrast-enhanced VW-MRI confirmed the contrast effect on the intraluminal thrombus within the aneurysm. We observed a reduction in the contrast effect of the intraluminal thrombus within the aneurysm after FD stent implantation. The fact that such a finding was observed the day after the procedure is novel. This finding on VW-MRI may indicate that neovascularization of the thrombus wall, developed by repeated dissection of the intraaneurysmal lumen wall caused by hemodynamic injury, was attenuated. This may be a sign of stabilization of the intrasaccular thrombosis and may lead to negative remodeling of the aneurysm.

Because of its potential as a biomarker of healing, we routinely perform contrast-enhanced VW-MRI in patients after FD stent implantation, and we believe that its decreased invasiveness compared with cerebral angiography justifies its frequent examination. Whether the lack of contrast attenuation on posttreatment VW-MRI is an indicator of a poor prognosis or whether steroid use is a confounding factor needs to be further investigated in more cases.

Lessons

In partially thrombosed aneurysms, attenuated wall enhancement of the intraluminal thrombus on contrast-enhanced VW-MRI after flow diversion may be a sign of aneurysm stabilization.

Acknowledgments

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Disclosures

Dr. Ishii reports personal fees for educational lectures and advisory board from Terumo outside the submitted work.

Author Contributions

Conception and design: Ishii, Matsukawa, Sasaki. Acquisition of data: Matsukawa, Fushimi, Nagahori, Yamao, Sasaki, Tsuji. Analysis and interpretation of data: Matsukawa, Abekura, Kikuchi, Okawa. Drafting of the article: Matsukawa, Fushimi. Critically revising the article: Ishii, Matsukawa, Fushimi, Kikuchi, Okawa, Miyamoto. Reviewed submitted version of the manuscript: Ishii, Matsukawa, Kikuchi, Okawa, Yamao, Sasaki, Akiyama. Approved the final version of the manuscript on behalf of all authors: Ishii. Study supervision: Ishii, Miyamoto.

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