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ABSTRACT

BACKGROUND AND PURPOSE: VBD can trigger various clinical symptoms, especially ischemic stroke in the posterior circulation, but there is no effective treatment for their prevention. We aimed to validate the feasibility of coil-assisted stent reconstruction in the vascular lumen for the treatment of VBD and to evaluate its long-term effectiveness in preventing ischemic events.

MATERIALS AND METHODS: Clinical and imaging data of 9 patients with unruptured VBD were reviewed retrospectively. Depending on the length and diameter of the diseased target vessel, multiple LEO and/or Solitaire stents were implanted, assisted by coils.

RESULTS: Stent reconstruction in the vascular lumen was successful in all patients. Procedure-related complications occurred in 1 patient who developed brain stem and cerebellar infarction 8 days after endovascular treatment and died in 4 months. Coil embolization of the nondominant side of the vertebral artery was performed 1 month after the operation in 1 patient who developed partial brain stem and cerebellar infarction leading to hemiplegia. The mean follow-up time of the 8 surviving patients was 20.75 ± 6.90 months. Of the 4 patients with dolichoectasia in the anterior circulation, 2 experienced ischemic events in the anterior circulation. Another patient had sudden death at home 26 months after the operation. The conditions of the remaining 5 patients were stable without deterioration, and in 4, DSA/CTA/MRA suggested improved morphology of the vertebral artery compared with that before the operation.

CONCLUSIONS: Endovascular reconstruction with coil-assisted stent placement or stent placement alone in the vascular lumen for the treatment of VBD is technically feasible and can prevent ischemic events in the territory of stented vessels compared with the natural course, though further studies in larger samples are needed.

ABBREVIATIONS: IADE = intracranial arterial dolichoectasia; mRS = modified Rankin Scale; PCA = posterior cerebral artery; VA = vertebral artery; VBD = vertebrobasilar dolichoectasia

IADDE is a dilative arteriopathy characterized by local dolichoectasia of the intracranial arteries. The incidence of IADDE is approximately 0.06%–5.8%,1,6 of which VBD accounts for approximately 78%.7 Although the incidence of VBD is not high, it may trigger various clinical symptoms, especially ischemic stroke in the posterior circulation.6,8 A long-term follow-up study in 156 VBD cases showed that 39.7% (62/156) of patients died during the follow-up period.6 However, there is still a lack of an effective treatment for VBD.9 This study retrospectively reviewed the clinical and imaging data of 9 patients with VBD who were treated with coil-assisted stent reconstruction in the vascular lumen, in an attempt to explore the feasibility and long-term effectiveness of this technique in preventing ischemic events in stented vessels.

MATERIALS AND METHODS

This retrospective review included the clinical and imaging data of patients whose diagnosis was consistent with the CT and MR imaging diagnostic criteria for VBD10,11 and was confirmed by 2 specialists in cerebrovascular diseases. All patients received multiple overlapping stents alone or coil-assisted stent reconstruction in the vascular lumen for VBD in our center between January 31, 2004, and August 31, 2011. Informed consent was obtained from all patients and their relatives. The research protocol was ap-

proved by the institutional review board of Changhai Hospital (Shanghai, China). In our center, stent reconstruction for VBD was indicated for: 1) patients whose primary symptom was stroke; 2) patients whose condition deteriorated gradually as indicated by clinical or imaging follow-up; and 3) patients with VBD-complicated acute dissection, aneurysmal arterial wall vesicles, or aneurysms.

The patients with IADE involving the carotid and vertebrobasilar arteries were separated into a subgroup. The natural course of IADE was further followed up after endovascular reconstruction for VBD.

Treatment

Anticoagulation and Antiplatelet Protocols. Dual antiplatelet agents (75 mg/day of clopidogrel and 300 mg/day of aspirin) were administered for 3 days before the procedure. All patients were maintained on aspirin and clopidogrel for 6 weeks, followed by indefinite continuation of aspirin, 100 mg/day, alone.

Strategies and Endovascular Treatment. All patients underwent endovascular procedures under general anesthesia and received systemic heparinization after placement of the sheath. The activated clotting time was maintained at 2–3 times the baseline throughout the procedure. A 6F Envoy guide catheter (Cordis, Miami Lakes, Florida) was navigated to the C1–2 level of the dominant side of the VA, as defined by Jeng and Yip. Depending on the length and diameter of the diseased target artery, multiple LEO self-expanding stents (Balt Extrusion, Montmorency, France) and Solitaire stents (ev3, Irvine, California) were implanted, and we ensured that the distal portion of the stent was placed in the normal portion of the distal target vessel. The lumen of the diseased artery was reconstructed by the overlapping technique, and we ensured that the proximal portion of the stent covered the proximal normal portion of the target artery. All stents and coils were delivered and released according to the standard procedures as described in the instructions of the manufacturer.

In patients in whom the luminal diameter of VBD is ≥8 mm, the diameter of the stent may not be large enough. As a result, the proximal end of the stent might swing under the blood flow, and it would be difficult to deploy the distal end of the next stent at the optimal position within the first stent. To avoid this awkward situation, before the deployment of the proximal end of the first stent at the distal normal segment of the VBD, we loosely packed a bare coil or coils in the lumen of the VBD with a double-catheter technique to support and fix the proximal end of the first stent before it was completely released; then we fully deployed the first stent. After that, the next stent was deployed with a telescoping technique. When the following stents were successfully deployed and steady apposition to the vascular wall was secured, the coil would be withdrawn to avoid occlusion of the perforating vessels from the basilar artery, as shown in our case (Fig 1B, C). However, if the VBD was longer than the 2 stents, more coil packing was needed to fix the stents, and these could not be retrieved.

In cases in which the VBD involved bilateral vertebral arteries, we reconstructed the basilar artery and the dominant vertebral artery with stents. One month later, after confirmation that the balloon occlusion test result was negative, the nondominant vertebral artery was occluded between the basilar artery and PICA with bare coils, to reduce the blood flow into the space between the stents and the vascular wall.

Imaging and Clinical Follow-Up. With informed consent obtained from the patients, imaging follow-up including MRA at 3, 24, and 36 months and DSA at 6 and 12 months after the operation. The follow-up MRA and DSA images were compared with the immediate postembolization angiograms. Clinical follow-up by using the mRS was performed immediately after the operation; before discharge; and 1, 6, 12, 18, and 24 months after the operation.
RESULTS

Nine patients were included in this study, consisting of 7 men and 2 women with a mean age of 59.56 ± 11.45 years (range, 39–75 years). Four of the 9 patients had anterior circulation dolichoectasia (Table). Cerebrovascular risk factors included the following: hypertension in 8 patients, hyperlipidemia in 1 patient, hyperuricemia in 1 patient, smoking history in 2 patients, alcohol consumption in 2 patients, and polycystic kidney disease with a family history in 1 patient. No diabetes mellitus, hypercysteinemia, or family history of cerebrovascular disease was elicited in these patients. The onset of disease was headache in 4 patients, and the remaining 5 patients displayed symptoms of posterior circulation ischemia, which deteriorated gradually (Table).

Of the 9 patients who underwent preoperative imaging examinations, intraluminal thrombosis or wall thrombus was found on MR imaging in 5 patients, and vertebrobasilar dolichoectasia with high-intensity shadows was found on head CT scans in 2 patients, which indicated intraluminal thrombosis or wall thrombus (Table).

Angiography showed that VBD was mainly supplied by the dominant vertebral artery in 6 of the 9 patients (4 by the left-dominant side). Fenestration in the basilar artery trunk was confirmed in 1 patient. One patient had subarachnoid hemorrhage due to rupture of a left posterior cerebral artery aneurysm in the P2 segment. The PCA aneurysm was embolized with sacrifice of the PCA, and the VBD was treated by multiple stent deployment 1 month after the first session (Table).

Clinical and Angiographic Follow-Up

The 8 surviving patients were followed up by telephone interviews, imaging examinations, and clinical visits for a mean of 20.75 ± 6.90 months. One patient died suddenly at home 26 months after the operation, though no ischemic event occurred after VBD stent reconstruction during clinical follow-up. The cause of death was unknown because the family refused a post-mortem examination. In 4 patients who received imaging re-examination, DSA, MRA, or CTA suggested that the vertebrobasilar artery was improved to nearly normal morphology, and vesicle-like protrusions on the arterial wall disappeared.

All patients had taken medicine according to our protocol. No patient had posterior circulation ischemic symptoms. However, 2 of 4 patients with anterior circulation dolichoectasia presented with recurrent anterior circulation cerebral infarctions. No sign or symptom of recurrence was observed in the remaining 5 patients during the 10–25-month follow-up period.

Case Illustration

Case One. A 48-year-old male patient with a 5-year history of well-controlled hypertension and a history of excessive smoking was admitted due to a sudden onset of headache. DSA suggested VBD with hemorrhage from a ruptured aneurysm in the P2 segment of the cerebral posterior circulation and vesicle-like protrusions on the VBD arterial wall (Fig 2A). The aneurysm was tightly occluded with 6 coils (Fig 2A). Two months later, the vertebrobasilar artery was reconstructed with 5 LEO stents (Fig 2B, −C). No procedure-related complication occurred, stroke did not occur during the 14-month clinical and imaging follow-up, and the vesicle-like protrusions on the arterial wall disappeared (Fig 2D).
Case Two. A 63-year-old male patient with a >10-year history of well-controlled hypertension was admitted because of symptoms of chronic headache and dizziness. DSA suggested a right predominant vertebral artery and VBD (Fig 1A). The vertebrobasilar artery was reconstructed with 2 LEO stents with the assistance of 1 coil, which was retrieved later (Fig 1B, C). Imaging follow-up with CTA 24 months after the operation demonstrated that the fusiform aneurysm of the basilar artery had disappeared (Fig 1D).

DISCUSSION

Compared with the posterior circulation, dolichoectasia involves the arteries in the anterior circulation at a lower frequency; involvement of both the vertebrobasilar and carotid systems is rare. In our series, 4 patients with asymptomatic dolichoectasia in the anterior circulation were followed up after endovascular reconstruction of vertebrobasilar vessels. Although the natural history of asymptomatic dolichoectasia in the anterior circulation is still unknown, clinical follow-up in this study revealed that 50% of the anterior circulation dolichoectasia could also lead to ischemic events in their territory with time, even with antiplatelet treatment after stent placement. All these findings suggest that more aggressive treatment might be needed for these patients.

The natural history of VBD usually progresses slowly, but with progression of the condition, the original symptoms may become continuously worse, posing a high risk of stroke and various adverse events. In addition, the death rate was significantly higher than that in patients with simple mass effect or asymptomatic VBD. It was found that the cumulative survival curve of patients with VBD was significantly worse than that in a control group. The severity of imaging presentations of patients with VBD was significantly correlated with prognosis. Follow-up observations on patients with VBD showed those patients with deteriorating imaging presentations had higher mortality and morbidity. In our opinion, patients with ischemic onset or physical dysfunctions or those who have deteriorating imaging presentations should be treated as soon as possible to halt disease progression.

The most common clinical manifestations of VBD are ischemia and infarction of the posterior circulation, but prevention of risk factors for stroke did not seem to have altered the occurrence of ischemic stroke significantly. Some researchers used anticoagulation or antiplatelet therapies to prevent infarction from occurring and achieved moderate results. However, other researchers argued that the effect is not ideal in patients with VBD and may even increase the risk of intracranial hemorrhage.

Mount and Taveras first reported occlusion of the vertebral artery for the treatment of VBD. Many researchers have made modifications on the basis of this method through their surgical or interventional practices for the treatment of VBD. However, VBD may continue to grow even though the proximal portions of the bilateral vertebral arteries have been occluded. This outcome suggests that the strength of the vascular wall and hemodynamics are both important factors affecting the progression of VBD. Simple reduction of blood flow may not warrant the long-term therapeutic effects.

There are cases of successful treatment of VBD by using microvascular decompression, Teflon (Dupont, Wilmington, Delaware) sling decompression, vascular clip grafting, synthetic vascular grafting, and surgical reduction of the basilar artery diameter; but the benefits of surgery are still controversial. Moreover, all the above methods can only resolve the VBD-induced mass effect, and there is no convincing evidence to indicate that these methods can improve blood supply in the posterior circulation to prevent ischemic stroke in this territory. Some authors reported their trials with different kinds of stents and coils to reconstruct the lumens of fusiform aneurysms of the basilar artery trunk, which may evolve from VBD or combine

FIG 2. A. Anteroposterior position angiogram of the left vertebrobasilar artery depicts the VBD (white arrow) and aneurysmal arterial wall vesicles (black arrows). B. Angiogram immediately after overlapping stent deployment. C. Stents after the procedure. D. Angiographic follow-up 14 months after the procedure shows that the lumen of the basilar artery is thinner than that in A (white arrow) and the vesicles have disappeared (black arrows).
with VBD. However, in those articles, reconstruction of the lumen might not have been long enough to cover the VBD because their targets were fusiform aneurysms and long-term follow-up evidence was not available, either, to support the effect of ischemic stroke prevention in the posterior circulation.

In our study, we were unable to confirm the real cause of death in the patient who died suddenly 26 months after the operation due to the lack of follow-up imaging clues and postmortem examination. However, a mean of 20.00 ± 7.09 months’ follow-up of the other 7 patients showed that multilevel reconstruction in the vascular lumen for VBD could lower the occurrence of ischemic stroke in the stented vessels (0/7) and the death rate (0/7) compared with the natural course. In all 4 patients who had follow-up imaging data, the dilated vascular lumen became smaller and the vesicle-like protrusions on the vascular wall disappeared (Fig 1D), suggesting that stent reconstruction in the vascular lumen was successful. In addition, a mean of 20.25 ± 8.02 months’ follow-up in the 4 patients with anterior circulation arterial dilation showed that 50% of ischemic strokes occurred in territories of untreated vessels, suggesting that stents or other more aggressive treatments are also needed for IADE involving the anterior circulation.

Some authors found that vertebral artery dominance contributes to basilar artery curvature and posterior circulation ischemic events, which is in line with our findings that 6 of 9 patients with VBD had a dominant VA. We suppose that modifications of hemodynamics play an important role in ischemic stroke prevention by stent deployment in patients with VBD. First, stent deployment and coil packing could change the hemodynamics and reduce the flow out of stents just like flow-diverter devices, which might recover the reduced axial flow. Second, the rigidity and elasticity of the stent can partially change the morphology of the diseased artery, thus normalizing the morphology of VBD and recovering the distortion of branches from VBD, and then increasing the flow of the branches. Third, the increased blood flow and the use of anticoagulants and antiplatelet agents after intravascular stent placement might reduce the formation of intraluminal thrombus, artery-to-artery embolism, and low-flow thrombosis in VBD. Stents might also reduce the risk of hemorrhage due to VBD rupture induced by the simple use of antiplatelet agents.

Vertebrobasilar artery stent placement is a safe treatment and has been widely used for the treatment of vertebrobasilar aneurysms, stenosis, and dissection owing to minimal invasiveness compared with craniotomy. In the present series of patients, we used LEO self-expanding stents and Solitaire stents. Both LEO and Solitaire stents are safe and effective devices for intravascular intervention treatment. The LEO stent can be retrieved after it and the vesicle-like protrusions on the vascular wall disappeared (Fig 1D), suggesting that stent reconstruction in the vascular lumen was successful. In addition, a mean of 20.25 ± 8.02 months’ follow-up in the 4 patients with anterior circulation arterial dilation showed that 50% of ischemic strokes occurred in territories of untreated vessels, suggesting that stents or other more aggressive treatments are also needed for IADE involving the anterior circulation.

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