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Long-Term Clinical and Radiological Results of Endovascular Internal Trapping in Vertebral Artery Dissection

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Abstract

Purpose

Previous reports have suggested that endovascular parent artery occlusion is an effective and safe procedure for the treatment of vertebral artery dissection (VAD). However, the results of long-term outcomes are still unclear. This study reviewed the clinical and imaging outcomes of patients with VAD treated by endovascular internal trapping.

Methods

A total of 73 patients were treated for VAD by endovascular internal trapping between March 1998 and March 2011. Patients were regularly followed up by magnetic resonance imaging, magnetic resonance angiography, and clinical examinations. Clinical outcomes were evaluated using the modified Rankin Scale.

Results

Forty-five patients had ruptured VADs, and 28 had unruptured VADs. Clinical follow-up of at least 6 months data were obtained for 61 patients (83.6%). The follow-up period ranged from 6 to 145 months (mean $\pm$ SD, 55.6 $\pm$ 8.9 months). Two patients with ruptured VADs had recurrence (2.74%). Cranial nerve paresis (CNP) was observed in 6 patients (8.21%), spinal cord infarction in 2 patients (2.74%) and a perforating artery ischemia was diagnosed in 7 patients (9.59%); all patients with CNP and 5 of the patients with partial Wallenberg syndrome experienced only temporary symptoms; 2 of the patients with partial Wallenberg syndrome had permanent neurological deficits. Despite their symptoms, most patients were in good general condition, as shown by their clinical scores.

Conclusions

The results of this study have proven that endovascular internal trapping is a stable and durable treatment for closure of VADs. Recanalization is rather rare and occurred only in ruptured cases, both within 3 months after initial treatment without rupture. CNP were observed in 8.21%, perforating ischemia in 9.59%, and spinal cord infarction in 2.74%. The former two are temporary, while the last can be a factor that affects mRS. Patients rated their quality of life as good, as corroborated by their posttreatment clinical score. Endovascular internal trapping for VAD is a therapy with a satisfactory long-term outcome.

Keywords:

Endovascular treatment, Internal trapping, Long-term follow-up, Vertebral artery dissection

Introduction

Treatment of vertebral artery dissection (VAD) poses a great technical challenge for neurosurgeons, but the advent of new endovascular techniques has made such treatments more feasible. Determining optimal therapy for patients with vertebral artery dissections is empirical because no randomized controlled trials have compared multiple treatments. Conventional surgical treatment includes trapping the aneurysm, proximal ligation of the vertebral artery (VA), or wrapping the aneurysm. Previous reports have suggested that endovascular parent artery occlusion is a safe and effective treatment for VAD [1-10]. Although some case series have reported on the feasibility of stent replacement, endovascular internal trapping has been performed in most of the cases. However, few reports have been published on this subject, leaving the status of long-term outcomes unclear [4, 5]. This study reviewed the long-term clinical and imaging outcomes of patients with VAD who were treated by endovascular parent artery internal trapping. This series represents the largest contemporary series of VAD treatments in the era of endovascular internal trapping.

Materials and Methods

Since 1998, clinical data regarding patients with ruptured or unruptured VADs who underwent endovascular treatment as a primary treatment were retrospectively obtained. All of the treatments, retreatments, and observations from follow-up visits were recorded for each patient.

In total, 73 patients with VADs, treated by endovascular internal trapping between March 1998 and March 2011, were retrospectively reviewed. The severity of the subarachnoid hemorrhages *was* clinically assessed at the time of admission by using the Hunt and Kosnik (H-K) grading scale for ruptured VADs[11] and clinical outcomes were evaluated using the modified Rankin Scale (mRS). All VADs were classified into 1 of 4 types according to their anatomical relationship to the posterior inferior cerebellar artery (PICA); the 4 classifications were as follows: PICA proximal type, PICA involved type, PICA distal type, and PICA absent type. However PICA involved type was excluded in this study. Clinical follow-up data were obtained for 61 patients (83.6%), with the follow-up period ranging from 6 to 145 months (mean $\pm$ SD, 55.6 $\pm$ 8.9 months). The follow-up evaluations were performed between March 1998 and December 2011. Clinical patient management was not affected by this study. All patients gave informed consent for their treatment.

Following treatment, each patient attended follow-up evaluations that occurred monthly for 3 months, quarterly for the next half year, and annually thereafter. During each of the follow-up visits, each patient was evaluated by magnetic resonance imaging (MRI) and magnetic resonance angiography (MRA), as well as by regular clinical examinations. The results of the imaging follow-ups were evaluated and compared with previous imaging results by 2 experienced clinicians. If recurrence was suspected, digital subtraction angiography was performed.

Treatment criteria

Inclusion and exclusion criteria

The indication for patient treatment was an H-K grade of 1–4; patients with an H-K grade of 5 were only observed initially. Patients with improvement in their clinical grade were candidates for endovascular treatment. In these patients, endovascular internal trapping, using a detachable coil, is preferred if the PICA can be preserved.

Patients with unruptured VADs met with their vascular surgeon before treatment, and the risks and objectives of their proposed endovascular treatment were explained. Conservative therapy and follow-up by MRI and MRA were the initial treatments. Endovascular internal trapping was supposed to be considered if the dissection site was shown to be enlarged or there were a mass sign close to the brainstem on MRI and MRA, though we had no such cases as a result in this study. . If the dissection demonstrated neither enlargement nor signs of a mass, conservation therapy was continued.

Exclusion criteria

Patients in whom it was difficult to preserve the PICA underwent surgical trapping with occipital artery–PICA anastomosis. Patients without improvement after initial observation in H-K grade of 5 were excluded. Insufficient flow within the contralateral VA, due to hypoplasia or aplasia, was an exclusion criterion. VADs presenting with ischemic onset was excluded.

VADs with irregular shapes or intraluminal thrombi without enlargement were observed without endovascular or surgical treatment.

Endovascular treatment

Endovascular treatments were performed by 3 qualified physicians. The endovascular management for each patient in this series was similar in technique, approach, and follow-up. All VADs were embolized with bare platinum coils while the patients were under general anesthesia; systematic heparinization of the patients was not performed. The endovascular internal trapping were performed in such a manner as to keep them as small as possible. The coil length ranged from 44 to 115 cm (mean $\pm$ SD, 76.7 ± 16.5 cm). All aneurysm embolizations were performed using detachable platinum coils, including Guglielmi detachable coils (Boston Scientific, Natick, MA, USA) and Deltapaq coils (Micrus Endovascular, San Jose, CA, USA). Patients with unruptured aneurysms received mono-antiplatelet medication before endovascular treatment and for 1 month following treatment to avoid thromboembolic events. Patients with ruptured aneurysms received mono-antiplatelet medication only after endovascular treatment. Intracranial stents and modified coils were not used during the course of this study. All procedural complications were recorded.

Results

There were 40 male and 33 female patients treated by endovascular internal trapping during the study period. The average age of the patients was 52.2 ± 8.5 years (mean $\pm$ SD). Forty-five of the treated VADs had ruptured, and 28 had not. The patients with ruptured VADs presented with subarachnoid hemorrhage. The patients were admitted with H-K clinical grades of 1 (8 patients), 2 (11 patients), 3 (3 patients), 4 (17 patients), and 5 (6 patients). The 28 patients with unruptured VADs were either asymptomatic or presented with minor headaches. None of the VADs had accompanying masses close to the brainstem or lower cranial nerve. There were 20 PICA proximal type VADs, 37 PICA distal types, and 16 PICA absent types. Clinical follow-up data were obtained for 61 patients (83.6%); the follow-up periods ranged from 6 to 145 months (mean $\pm$ SD, 55.6 ± 8.9 months).

Treatment complications and mortality

None of the VAD patients experienced treatment failure due to the shape of the dissection or instability of the coil. One patient developed rebleeding during the procedure and died the next day. Because of the severity of their subarachnoid hemorrhages, vasospasms, or associated hematomas, 3 patients died within the first 30 days after treatment. However, none of the patients with unruptured VADs died within the perioperative period. Two patients developed spinal cord infarctions: 1 patient had severe hemiparesis and died of pneumonia 30 days after treatment, and another had moderate hemiparesis that resulted in a permanent disability. Both cases were of the PICA distal type. In addition, cranial nerve paresis (CNP) was observed in 6 patients: 5 with unilateral abducens palsy and 1 with bilateral abducens palsy. All 6 cases were of the PICA distal type. These cases of CNP were observed within 30 days of the procedure and did not result in permanent complications. Cerebral infarctions in the region of the perforating artery were observed in 7 patients, presenting as partial Wallenberg syndrome. One of these cases was PICA proximal type, 4 were PICA distal type, and 2 were PICA absent type. All complications are presented in Table 1. Ischemic complications including ASA occlusion and perforating artery occlusion were occurred 13.33%(6/45) in ruptured VAD and 7.14%(2/28) in unruptured VAD. This result is not significant statistically (Fisher's exact test $P=0.34$). In this study, 11 patients had neurological complications. Of them, 8 patients were PICA distal type, 2 PICA absent type, and 1 PICA proximal type. All CNP and ASA occlusion were occurred in PICA distal type.

Besides the patients who succumbed within the first 30 days, 3 other patients died during the follow-up period: 1 died of severe pneumonia 39 months after treatment, and 2 died of cancer at 25 and 40 months after treatment.

Radiological follow-up

During the follow-up period, MRI evaluations did not demonstrate any ischemic lesions that were

related to the VAD or the treatment. Two patients with ruptured VADs showed antegrade recurrence on MRA and angiography performed during the follow-up period both within the first 3 months after treatment. Angiography performed at 2 and 3 months after the first endovascular treatment showed recanalization of the vertebral artery, dilatation of a portion the aneurysm through the dissected site, and almost normal configuration with an antegrade flow into the basilar artery (BA). Additional coil embolization was performed as a retreatment and further recurrences were not observed during the follow-up period.

Clinical follow-up

The 28 patients with unruptured VADs had a mRS score of 0 at the last follow-up (4 patients were lost to follow-up). Only two patients with unruptured VADs had a mRS score of 1 at 1 month after the procedure, but they had fully recovered by the time of the final follow-up. The 34 of 45 patients with ruptured VADs had mRS score of 0 at the last follow-up (3 patients were lost follow-up and 5 patients died before 6 months follow-up), one had mRS1, one had mRS2, and one had mRS5, and 3 had mRS6. The cause of mRS5 was severity of SAH and mRS6 were pneumonia and cancer.

Discussion

Endovascular internal trapping is believed to be a feasible treatment method for VAD. During the past 10 years, there have been a significant number of investigations into the feasibility of this technique [1-10]. Some articles have described the stability of occlusions treated with detachable coils and the efficacy of providing protection against VAD recurrence and consequent bleeding [4, 5]. Endovascular techniques are popular because they avoid the manipulation of the tissues adjacent to the target vessel, decreasing the risk of damage due to retraction or resection. However, the main disadvantage is that the tiny vessels involved are nearly invisible. This issue is unavoidable and strongly affects the results of internal trapping in VAD. With increasing experience in the use of these techniques, additional information about the results and long-term outcomes, including ischemic complications, is a valuable aid for physicians in assessing the value of the technique and determining whether the technique is appropriate for specific patients.

Radiological result and follow-up

According to the results of this study, endovascular internal trapping is a stable and durable treatment for the closure of VADs. Of the patients treated in this study, only 2 (2.73%) had recanalization of the vertebral artery within the first 3 months after treatment. Moreover, additional recanalizations were not observed after that time. This observation is supported by other published reports in which recurrence has been most commonly observed within a comparatively short time after the procedure [12-15]. In these

reports, including the current study, recanalizations have only been observed within the first 6 months after treatment. Sawada et al suggested coil embolization of false lumens resulted in inadequate occlusion in 2 cases they treated [15]. Although antegrade recanalization was observed in 2 patients with ruptured VAD in this study, reruptures have not been reported to occur as a result of recanalization. Thus, it is very important to follow all patients, especially ruptured cases, regularly to better assess the first year during which VADs are most susceptible to reopening, especially in cases of ruptured VADs.

Regular radiological follow-up may not be necessary after a few years.

Complications and follow-up

Hemodynamic complications due to the sacrifice of the vertebral artery were not observed over the length of the follow-up conducted in this study. CNP was observed in 6 patients (8.21%) and symptoms of a perforating artery were observed in 7 patients (9.59%). However, the CNPs observed in 6 patients and the partial Wallenberg syndrome observed in 5 patients were temporary. Unfortunately, one patient who showed partial Wallenberg syndrome developed permanent neurological deficits. The patient had mild numbness, dysphagia and mild trunk ataxia. CNP is known to be one of the symptoms of ruptured VAD may worsen the symptoms, temporarily. However, most patients with CNP recover within a short term. The cause of the abducens nerve palsy in cases of subarachnoid hemorrhage (SAH) was speculated to be vasospasms of the pontine branches or direct shock to the brainstem and decreased blood supply to the abducens nerve [16-17]. Because the abducens nerve palsy can be caused by SAH, particularly in posterior fossa SAH, we speculate this complication was not caused by endovascular treatment. Two patients demonstrated spinal cord infarctions due to anterior spinal artery occlusion. As a result, 1 patient had permanent mild hemiparesis and the other developed hemiparesis, but died of severe pneumonia 3 months after the internal trapping treatment. In these 2 patients, the spinal cord infarction had a significant impact on their quality of life. Despite their symptoms, the other patients were in good general condition, as shown by the results of their mRS scores; only the 2 patients with anterior spinal artery occlusion exhibited poor clinical outcomes. After the first 3 months of treatment, none of the patients experienced worsening symptoms, such as hemodynamic ischemia in the posterior circulation, cranial nerve palsy, or ischemia in the perforating artery.

The benefit of endovascular treatment is that it involves less trauma and fewer risks of damage to the brain and cranial nerves while also allowing for earlier antithrombotic therapy for any possible thromboses in trapping sites. The procedure's primary shortcoming is that longer segments were required to be sacrificed, compared to direct surgical trapping, in order to obtain complete occlusion. Longer segment sacrifices carry higher risks of ischemia in normal perforator or anterior spinal artery (ASA). Most complication due to ischemia in the ASA or perforating artery occurred in PICA distal or PICA absent types of VADs. Only in one case was a PICA proximal type VAD associated with perforating artery ischemia. This study, therefore, suggests that the PICA distal type may pose a higher risk of

ischemic complications.

Bilateral VAD or VAD with BA dissection remains challenging. Successful treatment has been reported as a result of the placement of a stent or other flow-diverting devices [18-23]. Although preservation of the parent artery is ideal, the durability of the perforating artery or the anterior spinal artery is not clear. With additional research and technical advancements, we hope that it will be possible to establish these methods without sacrificing the parent artery. Nevertheless, additional information about the risks and long-term outcomes of endovascular internal trapping procedures is important even if stents become the better alternative therapy in the future.

Clinical situations

In this study, 45 ruptured VAD and 28 unruptured VAD were contained. The clinical situation between ruptured VAD and unruptured VAD are totally different. All CNP were occurred in ruptured VADs.

Location analysis

We speculated PICA distal type VAD is more closer to abducens nerve or ASA than other type VAD. Perforating artery occlusion were observed in any type of VAD.

The main limitation of this study was in the inclusion and exclusion criteria. We excluded the cases with contralateral VA hypoplasia, aplasia and PICA involved type. Thus study group of this study does not represent whole type of VADs. The result of this study is that of specific type of VADs, which are suitable for endovascular internal trapping without hemodynamic risks. The second limitation of this study was the small number of patients, which prevented a definite statistical statement. This study is also limited by its retrospective nature. In this study, both ruptured and unruptured VADs were included, making a confounding bias possible, especially in the prognosis results, because ruptured cases are affected by initial damage by SAH.

Conclusions

In summary, endovascular internal trapping for VAD is a therapy with satisfactory long-term outcomes. Patients rated their quality of life as good, which was supported by their mRS scores. Recanalization is rather rare and occurred only in ruptured cases., both within 3months after tinitial treatment without rupture. CNP were observed in 8.21%, ,perforating ischemia in 9.59%, and spinal cord infarction in 2.74%. The former two are temporal, while the last can be a factor that affect mRS.

Acknowledgments

None

Conflict of Interest

We declare that we have no conflicts of interest.

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Table Legends:

Table 1. Complications and outcomes, including duration of symptoms.

Case	State	Follow-up time (months)	Spinal cord infarction Hemiparesis	Partial WS Dysphagia	Partial WS Horner syndrome	Partial WS Cerebellar dysfunction	CNP (VI)	One-month results (mRS)	Final results (mRS)	location
1	Unruptured	28			1 month	2 months		1	0	proximal
2	Ruptured	34		Permanent		2weeks		1	1	distal
3	Ruptured	113	Permanent		3 months		3 weeks	3	2	distal
4	Ruptured	3	Permanent					4	6	distal
5	Ruptured	181		3 weeks		3 weeks		1	0	absent
6	Unruptured	62		4 months	3 weeks	3 weeks		1	0	absent
7	Ruptured	28					3 weeks	0	0	distal
8	Ruptured	91		2weeks		4days	3 months	1	0	distal
9	Ruptured	82		3weeks			2 weeks	0	0	distal
10	Ruptured	141					2 days	0	0	distal
11	Ruptured	47					4 days	0	0	distal

Table 1. Ischemic complications and outcomes, including duration of symptoms

CNP (VI): Cranial nerve paresis

distal: PICA distal type, proximal: PICA proximal type, absent: PICA absent type

Partian WS: Partial wallenberg syndrome