Int J Clin Exp Med 2016;9(1):140-147
www.ijcem.com /ISSN:1940-5901/IJCEM0014833

Original Article

Efficacy of endovascular occlusion treatment for ruptured dissecting vertebral artery aneurysms: a single center experience

Yuan Pan*, Zhaohu Yu*, Tao Xin, Xiliang He, Peilin Lu, Xutao Jiang, Botian Shao, Zaijin Zhang, Yu Wang

*Department of Neurosurgery, The People's Liberation Army 401 Hospital, China. *Equal contributors.*

Received August 21, 2015; Accepted November 17, 2015; Epub January 15, 2016; Published January 30, 2016

Abstract: For ruptured dissecting vertebral artery aneurysm, the reconstructive methods which mainly include stent application requiring the use of anticoagulation or antiplatelet agents may increase hemorrhagic complications during the peroperative period, especially in patients combined with hydrocephalus. Between May, 2003 and February, 2013, we treated 17 cases with ruptured dissecting vertebral arte ry aneurysms with coil occlusion of the aneurysm and parent artery simultaneous. After evaluated the collateral supply using balloon occlusion test (BOT) method, the aneurysm and parent artery was occluded with coils. One case and 6 cases received external ventricular drainage (EVD) before and after the surgery respectively. The follow-up ranged from 2 to 36 months. One case had aneurysm and parent artery not completely occluded, which had rapid recurrence and died 2 months later; 16 cases had aneurysms and parent arteries completely occluded, among which 1 case developed the Wallenberg syndrome early after the endovascular treatment. No hemorrhage occurred again. The 6-month control DSA showed complete exclusion of the VA dissecting aneurysm in 12 patients. To occlude the dissecting aneurysm and parent artery with coils for the prevention of rehemorrhage was effective. However, ischemia or infarction of the high level cervical spinal cord and medulla oblongata should be considered.

Keywords: Vertebral artery, dissecting artery aneurysm, occlusion, PICA

Introduction

For ruptured dissecting vertebral artery aneurysm, two clinical features are common: High rebleeding rate in short time [1] and severe clinical symptoms [2]. Subarachnoid hemorrhage (SAH) often occurred in the posterior fossa, and the patients often presented with hydrocephalus. Although the reconstructive procedure using stents, with or without adjunctive coil embolization, has been advocated as the primary treatment [3], the use of anticoagulation or antiplatelet agents in patients using stent technique may increase hemorrhagic complications during the peroperative period, especially in patients combined with hydrocephalus [4]. For these cases, considering possible postoperative EVD and postoperative anticoagulation treatment, multiple treatment options should be carefully evaluated. Between May, 2003 and February, 2013, 17 cases with ruptured dissecting vertebral artery aneurysms were treated with coil occlusion of the aneurysm and parent artery simultaneous. To evaluate the treatment efficacy, this study was carried out.

Patients and methods

Clinical data

As shown in **Table 1**, between May 2003 and February 2013, 17 cases with ruptured dissecting vertebral artery aneurysms were admitted to our Hospital. Brain CT scan, cerebral digital subtraction angiography (DSA) and three-dimensional DSA (3D DSA) confirmed the diagnosis. The 17 patients included 11 males and 6 females, aging from 33 to 62 years old with an average of 45.9 years. Relationship between lesions and ipsilateral posterior inferior cerebellar artery (PICA): for left PICA, 2 cases were proximal and 4 cases were distal. For right PICA, 3 cases were proximal and 6 cases were distal.

Table 1. Clinical data of patients

Males	Female	Age	Diagnosis	PICA condition
11	6	33-62, 45.9 average	Brain CT scan, cerebral digital subtraction angiography (DSA) and three-dimensional DSA (3D DSA).	For left PICA, 2 cases were proximal and 4 cases were distal. For right PICA, 3 cases were proximal and 6 cases were distal. PICA agenesis was found in 2 cases. Five patients had a history of hypertension and 3 patients had diabetes.

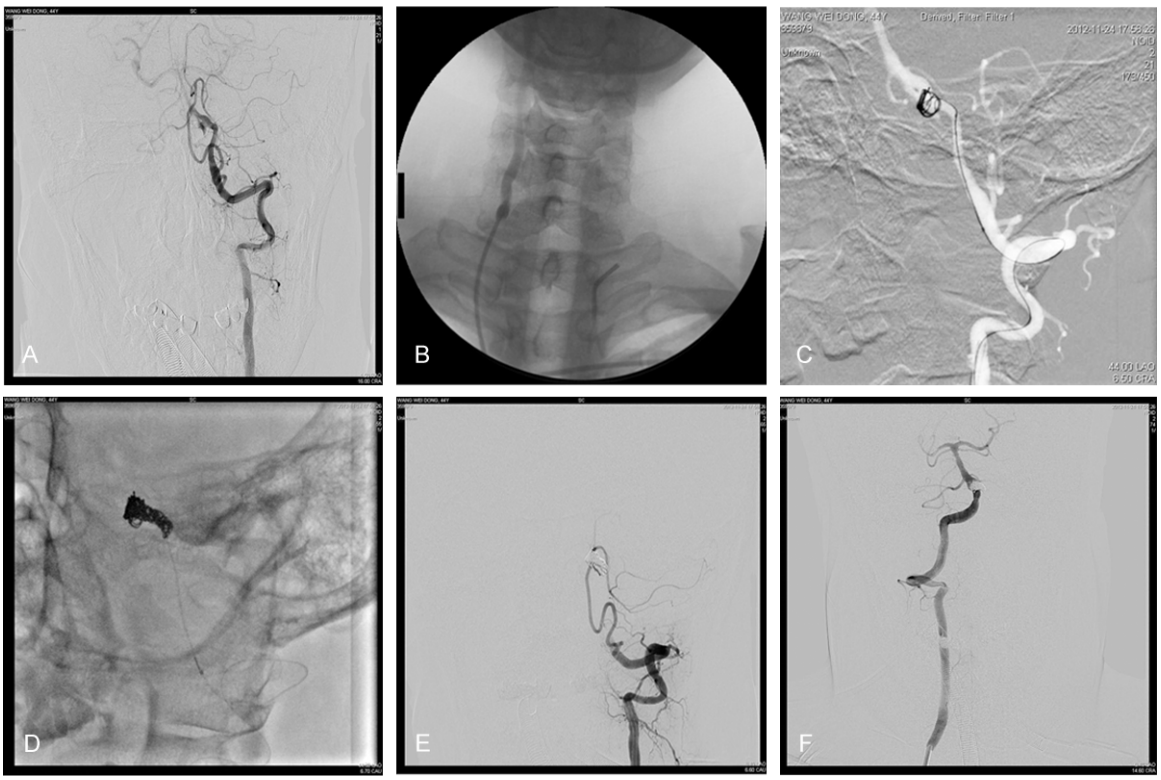

Figure 1. Occlusion with bare coils combined with hydrosoft expansion coils. A. DSA indicating left dissecting VA aneurysm. B. Balloon occlusion test, C. Embolization with bare coils, D. Occlusion with expansion coils. E. Complete occlusion with clear proximal PICA, F. Postoperative contralateral VA angiography.

PICA agenesis was found in 2 cases. Five patients had a history of hypertension and 3 patients had diabetes.

Methods

Preoperative patients' status and treatment occasion: Preoperative status evaluation: 1. Subarachnoid hemorrhage Fisher grade by brain CT: grade 1: 1 case; grade 2: 12 cases; grade 3: 4 cases. 2. Hunt-Hess scale: grade I: 4 cases; grade III: 12 cases; grade IV: 1 case. Among the 17 patients, 12 received cerebral angiography and endovascular treatment within 24 hours after the onset, 4 within 48 hours and 1 within 72 hours.

Treatment procedure: Two patients received general anesthesia due to irritation and poor compliance. Fifteen patients underwent cerebral angiography under local anesthesia. A 6F sheath was placed through the femoral artery and proceeded multi-angle cerebral angiography, rotational three-dimensional vascular reconstruction were performed to evaluate the blood supply, compensation and the collateral circulation of the intracranial artery. Also, small arteries around the PICA were analyzed. A 8F sheath was placed through the contralateral femoral artery to perform the balloon occlusion test (BOT) in the local anesthesia patients. For BOT, 3 cases used non-detachable balloons and 12 cases used balloon guildings to temporarily occlude the affected vertebral artery and perform contralateral vertebral artery angiography.

Endovascular treatment was performed under general anesthesia and systemic heparin use.

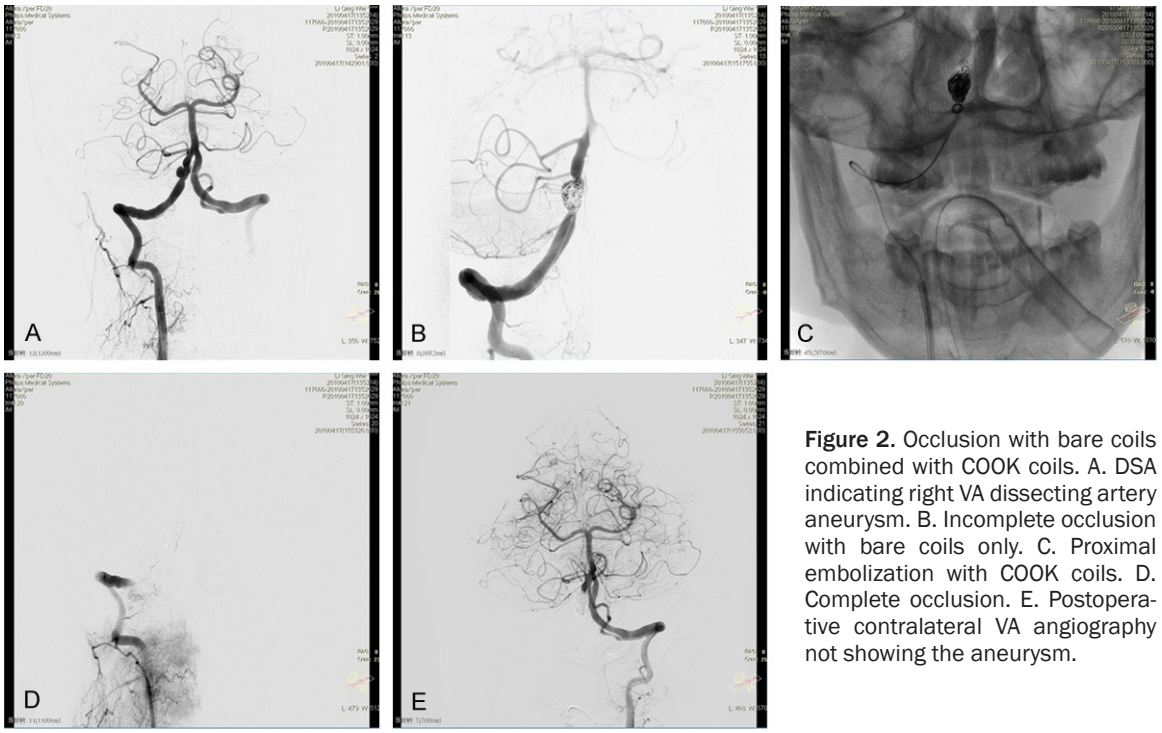

Figure 2. Occlusion with bare coils combined with COOK coils. A. DSA indicating right VA dissecting artery aneurysm. B. Incomplete occlusion with bare coils only. C. Proximal embolization with COOK coils. D. Complete occlusion. E. Postoperative contralateral VA angiography not showing the aneurysm.

A 6F or 5F guiding catheter (Neuron, Penumbra, Alameda, California, USA) reached the horizontal V3 segment with the guidance of a 0.035-in guidewire. Then under the guidance of a 0.014-in micro-wire (Boston Scientific, Natick, Massachusetts, USA), a micro-catheter (EV3, Irvine, California, USA) was placed in the distal segment to the aneurysm. Coils were used to occlude the aneurysm and the vertebral artery. The first coil employed a 3D bare coil with the similar diameter or 1 mm larger compared to the aneurysm. The distal vertebral artery and aneurysm was densely occluded. It would be better if the coils reach 1-2 mm into the normal vertebral artery distal to the dissection and 5-6 mm into the normal vertebral artery proximal to the dissection to maximize the occlusion of the parent vertebral artery.

Three methods were employed to occlude the dissecting artery aneurysm and parent artery. ① Simple bare coil (Guglielmi detachable coils, Boston Scientific, Boston, MA, USA). occlusion was used in 3 cases. ② Bare coil combined with hydrosoft coil (MicroVention, Aliso Viejo, CA) occlusion was employed in 11 cases. After the aneurysm was almost occluded, expansion coils with a diameter of 2 mm or 3 mm were used to occlude the aneurysm or the proximal artery (**Figure 1**). ③ Bare coil combined with COOK coil (Cook Medical, Bloomington, USA) occlusion was adopted in 3 cases. After dense but incomplete aneurysm occlusion, the COOK coil was employed to occlude the proximal normal vertebral artery (**Figure 2**).

Postoperative bilateral vertebral artery angiography showed that in one case the aneurysm was not completely occluded only with attenuated blood flow and in 16 cases the aneurysm and parent artery was completely occluded with clear PICA.

External ventricular drainage and anticoagulation and antiplatelet therapy: Seven patients received EVD. One patient with severe acute hydrocephalus was unconscious with irregular breathing after admission. External drainage was performed before the surgery. Five received EVD after occlusion within 4-6 hours after surgery and 1 on the next day. On the second day after EVD, brain CT scan was conducted to determine the location of the drainage tube, followed by oral or nasal feeding aspirin 100 mg, 1/day for three consecutive months. Other patients without EVD started to receive low-molecular heparin 0.4 ml 2 hours after endovascular treatment every 12 hours for 3 days. Clopidogrel was orally administered (75 mg/d) for three months and aspirin (100 mg/d) was taken for six months.

Table 2. Treatment and outcomes of the patients

Treatment procedure	Three methods were employed to occlude the dissecting artery aneurysm and parent artery. ① Simple bare coil (Guglielmi detachable coils, Boston Scientific, Boston, MA, USA) occlusion was used in 3 cases. ② Bare coil combined with hydrosoft coil (MicroVention, Aliso Viejo, CA) occlusion was employed in 11 cases. ③ Bare coil combined with COOK coil (Cook Medical, Bloomington, USA) occlusion was adopted in 3 cases.
External ventricular drainage and anticoagulation and antiplatelet therapy	Seven patients received EVD. Other patients without EVD started to receive low-molecular heparin 0.4 ml 2 hours after endovascular treatment every 12 hours for 3 days. Clopidogrel was orally administered (75 mg/d) for three months and aspirin (100 mg/d) was taken for six months.
Postoperative therapy	One patient with chronic hydrocephalus received ventricle-peritoneal shunt. 12 patients agreed to take DSA 6 months after the endovascular treatment.
Outcomes	Dissecting artery aneurysm and parent artery was not completely occluded in one case and the patient had a rapid recurrence and died 2 month later. Sixteen cases had complete occlusion, among which 1 case developed postoperative Wallenberg syndrome on the surgical day: PICA was distal to the dissecting aneurysm and was supplied well by the contralateral vertebral artery but with a relative long dead end.

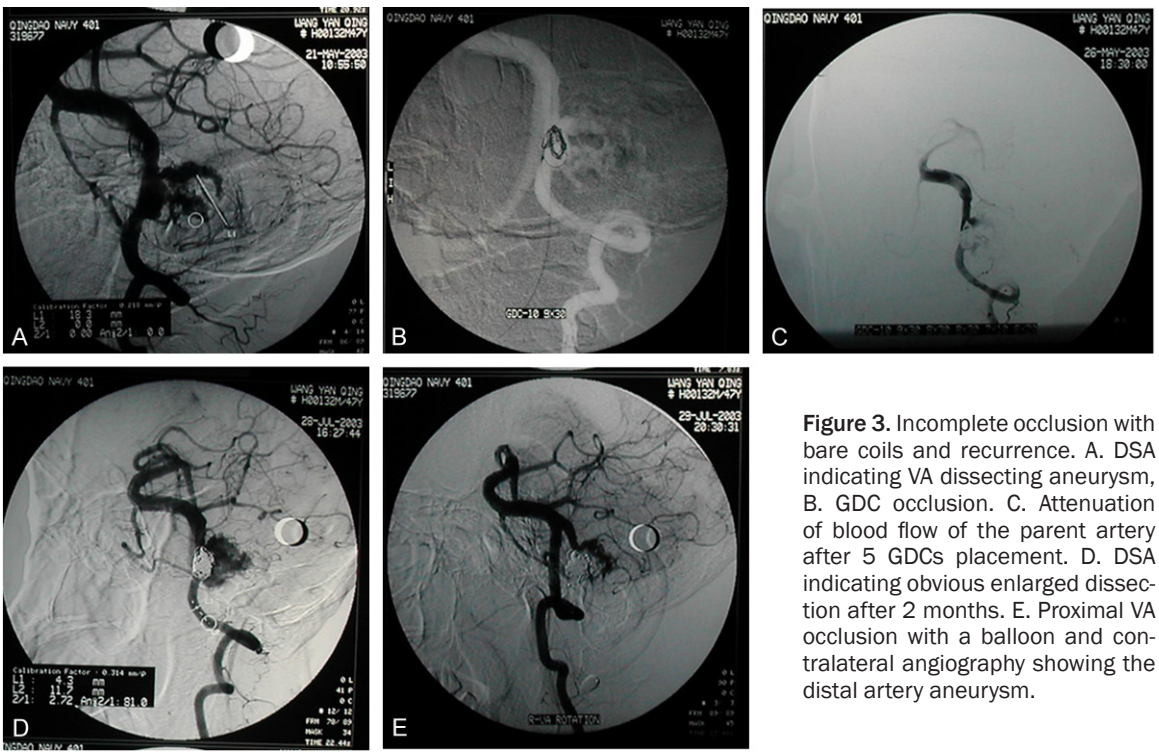

Figure 3. Incomplete occlusion with bare coils and recurrence. A. DSA indicating VA dissecting aneurysm, B. GDC occlusion. C. Attenuation of blood flow of the parent artery after 5 GDCs placement. D. DSA indicating obvious enlarged dissection after 2 months. E. Proximal VA occlusion with a balloon and contralateral angiography showing the distal artery aneurysm.

Postoperative therapy and follow-up: In addition to the anti-platelet therapy, conventional treatments such as anti-vascular spasm, bloody cerebrospinal fluid drainage and dehydration therapies were employed. One patient with chronic hydrocephalus received ventricle-peritoneal shunt. Followed-up ranged from 2 to 36 months. Clinical examination, vertebral artery ultrasound and DSA were employed to evaluate rebleeding, vertebral artery blood flow velocity changes as well as blood supply compensation after vertebral artery occlusion. 12 patients agreed to take DSA 6 months after the endovascular treatment.

Results

As shown in **Table 2**, in this study, dissecting artery aneurysm and parent artery was not completely occluded in one case and the patient had a rapid recurrence and died 2 month later (**Figure 3**). Sixteen cases had complete occlusion, among which 1 case developed postoperative Wallenberg syndrome on the surgical day: PICA was distal to the dissecting aneurysm and was supplied well by the contra-

Figure 4. Medulla infarction after PICA proximal aneurysm occlusion. A. Brain CT indicating SAH. B. DSA showing right PICA proximal VA dissecting artery aneurysm. C. Occlusion of right VA with BOT, angiography through the left VA demonstrating right PICA and dissecting aneurysm. D. Dense occlusion with coils and right VA angiography showed relative long "dead space". E. After occlusion, the healthy VA angiography showed well right PICA and no aneurysm, F. Brain MRI T2 imaging showed small pieces of medulla infarction with high signal.

lateral vertebral artery but with a relative long dead end (**Figure 4**). The patient presented with hoarseness, bucking, difficult swallowing, hypalgesia in the right face and left body, V grade limb muscle strength and normal muscle tension. Nasal feeding tube was placed and anticoagulation and antiplatelet therapy was adopted. After 3 days, hoarseness began to improve and after 8 days, swallowing function started to improve. Brain MRI implied small pieces of infarction in the right dorsal medullary (**Figure 4**). DSA review after 18 days showed no significant change. After 20 days, most swallowing function recovered and the nasal tube was removed. The patient felt a slight numbness of the left body and was discharged. All 16 cases had no further bleeding. The 6-month control DSA showed complete exclusion of the VA dissecting aneurysm in 12 patients.

Discussion

Dissecting aneurysm of the vertebral artery is now recognized as a common cause of stroke [5, 6]. Vertebrobasilar artery dissection is relatively rare with an annual incidence of 1.0 to 1.5/100 thousand [7]. Ischemia is the primary clinical manifestation of dissecting artery aneurysm of the posterior circulation. Hemorrhage accounts for a relatively small portion. Yamaura [8] et al. reported that among 86 patients with aneurysms arising from the vertebral artery or its branches, 24 had dissecting aneurysms, 21 patients presented with subarachnoid hemorrhage (SAH) and 3 with ischemia. Rebleeding rate of ruptured dissecting vertebral artery aneurysm was higher than that of the non-ruptured cases as well as the ruptured anterior circulation artery aneurysm, the rebleeding rate was 46.7%, significantly higher than that of the non-ruptured cases (8.3%) [9, 10]. Therefore, once the diagnosis of ruptured aneurysm was confirmed, early treatment should be initiated to prevent further bleeding [11-13].

Compared to the anterior circulation aneurysms, once the dissecting vertebral artery aneurysm is ruptured with bleeding, the condition is more critical. In addition to the common

sudden severe headache, patients were commonly accompanied with impaired consciousness: a brief loss of consciousness before its recovery, gradual going into coma with no secondary bleeding or being in a continually worsening coma after the onset. Besides, significant changes in vital signs could be noticed: significantly increased blood pressure, irregular heartbeat rate and significant breathing changes (from light fast to slow deep breathing, irregular breathing rhythm, or even apnea and so on) [14], which is attributed to the impairment of brainstem and medulla oblongata functions. At the moment dissecting aneurysm ruptured, due to the anterior bone structure, high-speed arterial blood flow stroke the posterior brain stem and caused direct damages within the small space of the posterior fossa.

In addition, subarachnoid hemorrhage (SAH) is mainly distributed in the posterior fossa [15]. Much blood accumulated in the fourth ventricle and tentorium cerebelli could block the aqueduct of midbrain and third ventricle with little blood spreaded in the suprasellar cistern and sylvian cistern, which could affect the circulation of cerebrospinal fluid and result in acute hydrocephalus. Increased pressure in the posterior fossa and brain stem shift can aggravate the damage. For such patients, after dealing with the ruptured aneurysm through interventional means, the high intracranial pressure and acute hydrocephalus issue should be immediately addressed. Under serious conditions in which patients have developed brain stem damages, lumbar puncture or continuous lumbar drainage bear certain risk in the acute phase. Partial incarceration at the foramen magnum could aggravate the condition. Therefore, external ventricular drainage which could simultaneously reduce the pressure both above and under the tentorium is more safe and effective, which calls for comprehensive preoperative evaluation and prudent determination of endovascular treatment methods.

Endovascular treatment for vertebral artery dissecting aneurysm has been widely recognized [16, 17]. Generally there are two treatment methods: the reconstructive methods, which mainly include stent-assisted coiling, multiple stents, multiple stent-assisted coiling, could keep the original normal vascular structure and remains the ideal option. Stent application requires perioperative anticoagulation, antiplatelet interventions and long-term postoperative anticoagulation therapy. In this circumstance, subsequent ventricular puncture and drainage could lead to hemorrhage in the puncture tract and ventricles. Another option is to embolize the dissecting artery aneurysm and the parent artery. This method is simple, nevertheless bears the cost of sacrificing a vertebral artery. Therefore, patients should be carefully evaluated. After diagnosis is confirmed, BOT should be performed through bilateral femoral arteries to determine the blood compensation and the relationship between the aneurysm and neighboring arteries, especially the posterior inferior cerebellar artery.

The embolization method was chosen depending on patients' conditions in this study. After full examination and careful evaluation, larger coils were used to cover the distal and proximal of the dissecting aneurysm. The coil should reach the normal artery in the distal to prevent the reverse blood flow to the aneurysm from the contralateral vertebral artery. The proximal artery should be completely occluded. In this study, we use three embolization methods: 1. Bare coil embolization: dissecting aneurysm often has fast and large volume blood flow. It is difficult to completely occlude the aneurysm and parent artery only with bare coils. 2. First embolization by 3-4 large and long bare coils combined with later 2-3 expansion coils from MicroVention Company in the aneurysm and proximal artery could quickly occlude the vertebral artery. 3. When dense embolization could not fully occlude the aneurysm, coils by U.S. COOK company placed in the proximal normal vertebral artery could achieve good results and save expanses.

Among the 17 patients, in one case the dissecting artery aneurysm and parent artery was not fully embolized. Those of the other 16 were completely occluded. When dealing with the first case in May 2003, we used 5 relatively long GDC bare coils to occlude. The aneurysm was mainly occluded and the parent artery blood flow was significantly attenuated. We considered complete embolization would develop due to thrombi formation. After 2 months the condition suddenly worsened and DSA indicated that the aneurysm significantly became enlarged. Although the proximal vertebral artery was occluded with a detachable balloon but contralateral vertebral artery angiography

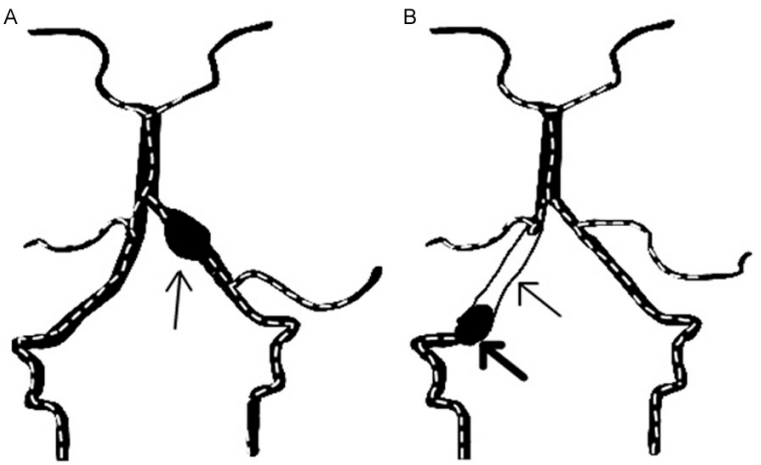

Figure 5. The role of PICA and the relative position of dissecting aneurysm in occlusion treatment. A. PICA Located in the proximal artery aneurysms (arrow) and there are small effects on collateral circulation after occlusion. B. PICA Located in the distal aneurysms(Coarse arrow) and "dead space" in distal aneurysm is longer after occlusion (Thin arrow).

showed the distal artery of the aneurysm was still in sight (**Figure 3**). The patient died a week later due to brain stem function failure. From this case, we believed that if the dissecting artery aneurysm was not completely occluded, it would even aggravate the condition instead of achieving therapeutic effects.

Depending on the condition and amount of bleeding, 7 patients (7/17) received external ventricular drainage. One patient developed late chronic hydrocephalus and received ventricle-peritoneal shunt. One patient with incomplete occlusion had rapid recurrence and died. Among 16 patients with complete embolization, 14 recovered and 1 remained slightly disabled due to hydrocephalus. One patient developed the Wallenberg syndrome on the surgical day postoperatively. MRI showed infarction in the right dorsal lateral medulla (**Figure 4**). Considering the relationship between the aneurysm and PICA, in this group the aneurysm was distal to the PICA in 10 cases, which did not develop ischemic incidents of the brainstem and medulla oblongata (0/10). The aneurysm was proximal to the PICA in 5 cases and one case developed the Wallenberg syndrome (1/5).

We believe that the relationship between the aneurysm and PICA is particularly important when employing the coil occlusion for the dissecting artery aneurysm and parent artery [2]. For patients with lesions distal to the PICA, after complete occlusion, contralateral vertebral artery angiography showed that blood reversely flowed to the distal vertebral artery through the basilar artery confluence. The affected side vertebral artery angiography showed that the proximal PICA was clear and the vertebral artery near the aneurysm was completely occluded. Under this circumstance, the distance between the PICA and vertebral artery was short, thus with small "dead space" (**Figure 5**). Plus the blood flow rate of the vertebral artery was relatively high. Therefore the possibility of ischemia was small. For 5 cases with lesions proximal to the PICA, the situation was quite the opposite. Although the distal PICA was well supplied through the contralateral vertebral artery, the proximal VA had relatively long "dead space" with no blood flow. Under this circumstance, the small or potential perforator arteries such as the anterior spinal artery were possible to be involved, which might lead to sever complications [18-20]. Thus, repeated evaluation of the cerebral angiography images and three-dimensional vascular imaging was necessary. If there were significant perforating arteries in the proximal vertebral artery, special attention should be given. If the aneurysm occurred in the dominant side and the contralateral vertebral artery was stenotic, occlusion of the aneurysm and parent artery may bear high risk [21].

Short term clinical follow-up showed that none of the 16 cases with complete occlusion had rebleeding and ultrasound follow-up indicated stable blood flow velocity of the bilateral vertebral arteries. DSA follow-up of a few cases showed no recanalization of the aneurysm and parent artery and no complications related to hemodynamic changes.

Complete occlusion of the artery aneurysm and parent artery with coils is effective on prevention of rebleeding of ruptured dissecting artery aneurysms. However, preoperative evaluation should be cautiously performed in case of ischemia complications.

Acknowledgements

This study was funded by Technology Bureau of the People's Livelihood Project of Qingdao (13-1-3-52-nsh) and Health Bureau of Qingdao (2014-WJZD191).

Disclosure of conflict of interest

None.

Address correspondence to: Tao Xin, Department of Neurosurgery, The People's Liberation Army 401 Hospital, 22# Minjiang Road, Shinan District, Qingdao 266071, China. Tel: +86-0532-51870182; E-mail: xintao_xt2015@163.com

References

[1] Narata AP, Yilmaz H, Schaller K, Lovblad KO, Pereira VM. Flow-diverting stent for ruptured intracranial dissecting aneurysm of vertebral artery. Neurosurgery 2012; 70: 982-8; discussion 8-9.

[2] Lee JW, Jung JY, Kim YB, Huh SK, Kim DI, Lee KC. Spontaneous dissecting aneurysm of the intracranial vertebral artery: Management strategies. Yonsei Med J 2007; 48: 425-32.

[3] Appelboom G, Kadri K, Hassan F, Leclerc X. Infectious aneurysm of the cavernous carotid artery in a child treated with a new-generation of flow-diverting stent graft: Case report. Neurosurgery 2010; 66: E623-4; discussion E4.

[4] Ducruet AF, Crowley RW, Albuquerque FC, McDougall CG. Reconstructive endovascular treatment of a ruptured vertebral artery dissecting aneurysm using the Pipeline embolization device. J Neurointerv Surg 2013; 5: e20.

[5] Droste DW, Junker K, Stogbauer F, Lowens S, Besselmann M, Braun B, Ringelstein EB. Clinically silent circulating microemboli in 20 patients with carotid or vertebral artery dissection. Cerebrovasc Dis 2001; 12: 181-5.

[6] Komiyama M, Morikawa T, Nakajima H, Nishikawa M, Yasui T. Embolic cerebellar infarction caused by spontaneous dissection of the extracranial vertebral artery--two case reports. Neurol Med Chir (Tokyo) 2000; 40: 310-4.

[7] Schievink WI. Spontaneous dissection of the carotid and vertebral arteries. N Engl J Med 2001; 344: 898-906.

[8] Yamaura A, Watanabe Y, Saeki N. Dissecting aneurysms of the intracranial vertebral artery. J Neurosurg 1990; 72: 183-8.

[9] Kurata A, Ohmomo T, Miyasaka Y, Fujii K, Kan S, Kitahara T. Coil embolization for the treatment of ruptured dissecting vertebral aneurysms. AJNR Am J Neuroradiol 2001; 22: 11-8.

[10] MacKay CI, Han PP, Albuquerque FC, McDougall CG. Recurrence of a vertebral artery dissecting pseudoaneurysm after successful stent-supported coil embolization: Case report. Neurosurgery 2003; 53: 754-9; discussion 60-1.

[11] Jin SC, Kwon DH, Choi CG, Ahn JS, Kwun BD. Endovascular strategies for vertebrobasilar dissecting aneurysms. AJNR Am J Neuroradiol 2009; 30: 1518-23.

[12] Mizutani T, Aruga T, Kirino T, Miki Y, Saito I, Tsuchida T. Recurrent subarachnoid hemorrhage from untreated ruptured vertebrobasilar dissecting aneurysms. Neurosurgery 1995; 36: 905-11; discussion 12-3.

[13] Aoki N, Sakai T. Rebleeding from intracranial dissecting aneurysm in the vertebral artery. Stroke 1990; 21: 1628-31.

[14] Naito I, Iwai T, Sasaki T. Management of intracranial vertebral artery dissections initially presenting without subarachnoid hemorrhage. Neurosurgery 2002; 51: 930-7; discussion 7-8.

[15] Cho IY, Hwang SK. A case of lateral medullary infarction after endovascular trapping of the vertebral artery dissecting aneurysm. J Korean Neurosurg Soc 2012; 51: 160-3.

[16] Guo XB, Fan YM, Zhang JN. HydroSoft coil versus HydroCoil for endovascular aneurysm occlusion study: a single center experience. Eur J Radiol 2011; 79: e42-6.

[17] Su W, Gou S, Ni S, Li G, Liu Y, Zhu S, Li X. Management of ruptured and unruptured intracranial vertebral artery dissecting aneurysms. J Clin Neurosci 2011; 18: 1639-44.

[18] Li Y, Horiuchi T, Nakagawa F, Hongo K. Vertebral artery dissecting aneurysm treated by proximal occlusion and posterior inferior cerebellar artery reconstruction with fenestrated clips. Case report. Neurol Med Chir (Tokyo) 2010; 50: 655-8.

[19] Zenteno M, Modenesi Freitas JM, Aburto-Murrieta Y, Koppe G, Machado E, Lee A. Balloon-expandable stenting with and without coiling for wide-neck and complex aneurysms. Surg Neurol 2006; 66: 603-10; discussion 10.

[20] Zenteno MA, Santos-Franco JA, Freitas-Modenesi JM, Gomez C, Murillo-Bonilla L, Aburto-Murrieta Y, Díaz-Romero R, Nathal E, Gómez-Llata S, Lee A. Use of the sole stenting technique for the management of aneurysms in the posterior circulation in a prospective series of 20 patients. J Neurosurg 2008; 108: 1104-18.

[21] Iihara K, Sakai N, Murao K, Sakai H, Higashi T, Kogure S, Takahashi JC, Nagata I. Dissecting aneurysms of the vertebral artery: A management strategy. J Neurosurg 2002; 97: 259-67.