Surgical Management of Intracranial Artery Dissection

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Abstract

Intracranial artery dissection (IAD) is a relatively rare cause of stroke, but it has been recognized increasingly with recent advances of the neuroimaging technique. Since rebleeding occurs frequently in the acute stage in the ruptured IAD, urgent surgical treatment should be performed to prevent rebleeding. On the other hand, surgical treatment for unruptured IAD is controversial because it has little risk for bleeding. However, surgical treatment for unruptured IAD may be considered if the formation or enlargement of the aneurysmal dilatation has been confirmed. Since there are several proposed surgical strategies for IAD, it is important to select an appropriate strategy on a case-by-case basis. If the risk of infarction due to vessel occlusion is high, combined bypass surgery should be considered.

Key words: dissection, surgery, intracranial

Introduction

Intracranial artery dissection (IAD) is an important cause of stroke in children, young and middle-aged adults, and in the East Asian population. Although IAD is an uncommon disease, it has been recognized as a cause of subarachnoid hemorrhage (SAH) and ischemic stroke. IAD of hemorrhagic presentation requires an urgent surgical treatment to prevent hemorrhagic recurrence,¹ but optimal strategies should be selected to spare the adequate blood flow for the normal brain tissue. In this review, we provide a comprehensive overview of the surgical management of IAD.

Indications of Surgical Treatment in IAD

IAD is a relatively rare cause of stroke, but it has been recognized increasingly with recent advances of the neuroimaging techniques especially among the East Asian population. IAD is one of the important causes of stroke in children, young and middle-aged adults, and most case series of IAD were reported from Asia.²–⁴ It has been demonstrated that the internal elastic lamina and media were disrupted in the IAD patients.⁵,⁶ Additionally, the detailed pathological mechanism of IAD differs depending on the symptom. The plane of dissection is mainly in subintimal space in the IAD presenting with ischemia. Enlargement of subintimal space may lead to the stenosis of the true lumen of parent artery, which may result in brain infarction. On the other hand, if the plane of dissection extends to subadventitial space, patients will present with hemorrhage, compression sign of brainstem, or cranial nerves.⁷–⁹

Since rebleeding occurs frequently in ultra-early stage in ruptured IAD, which may result in severe outcome, urgent surgical or endovascular treatment to prevent rebleeding should be performed.¹,⁵,10,11 Mizutani et al. reported that majority of dissecting aneurysms had one entrance into the pseudolumen (entry-only type) but some aneurysms had both entrance and exit (entry-exit type).¹² They suggested that entry-only type is unstable and rebleeding can easily occur, so that most cases of ruptured IAD are fragile and should be treated to prevent rebleeding. On the other hand, since the natural course of IAD without hemorrhage was relatively good, indication of the surgical treatment for unruptured IAD is still controversial.²,¹³,¹⁴ Antithrombotic therapy might be the first-line treatment for unruptured IAD presenting with ischemic stroke. The choice of antithrombotic agent (anticoagulants or antiplatelets) has not been assessed in randomized controlled trials.

Besides, several papers have reported that unruptured IAD had bled during the course of conservative
treatment. Mizutani demonstrated that most IAD causing SAH bled within a few days after onset of dissection indicated by preceding headache.\textsuperscript{15} Since it was reported that serial angiographic change was seen in 88.2\% of unruptured vertebral artery (VA) dissection and it may be amenable for surgical treatment,\textsuperscript{16} a follow-up angiography should be recommended during the early stage (within approximately 3 weeks after onset).\textsuperscript{16,17} Moreover, another paper reported that unruptured VA dissection had bled 4 months after onset.\textsuperscript{18} Consequently, even unruptured IAD should be followed carefully at least a few months by neuroimaging, and surgical treatment may be considered if the formation or enlargement of the aneurysmal dilatation has been confirmed.

**Surgical Strategy**

1. **Vertebral artery**

   VA is the most frequently affected site in IAD. In the nationwide study of IAD in Japan, 82\% of IAD is located in VA.\textsuperscript{3} There are several treatment strategies for VA dissection; proximal occlusion, trapping (surgical or endovascular) with or without extracranial-intracranial (EC-IC) bypass, clipping or wrapping of the aneurysm sac,\textsuperscript{19,20} stent-assisted coil embolization of the aneurysm sac,\textsuperscript{21} and stent monotherapy including the use of flow diverters\textsuperscript{22,23} (Fig. 1). Therapeutic safety and efficacy of endovascular and surgical treatment have not been tested in a randomized trial. Recently, endovascular (internal) trapping is undertaken more frequently than surgical treatment for ruptured intracranial VA dissection.\textsuperscript{24} Although internal trapping is effective to avoid rebleeding and less invasive, postoperative medul- lary infarctions remains unresolved.\textsuperscript{25}

   Recent nationwide study of vertebrobasilar artery dissections in Japan demonstrated that craniotomy accounted for 20\% of all intervention (including surgical and endovascular treatment), and trapping was the most frequent (62.5\%) procedures in the craniotomy.\textsuperscript{26} Since proximal occlusion cannot completely block the retrograde flow from the contralateral VA, trapping will be most effective to prevent rebleeding.\textsuperscript{27} However, it was reported that higher incidence of ischemic complication was observed in trapping than proximal occlusion.\textsuperscript{26}

![Fig. 1 Treatment strategies for vertebral artery dissecting aneurysms. An: aneurysm, EC-IC: extracranial-intracranial.](image-url)
These facts suggested that an appropriate treatment should be selected on a case-by-case basis.

If the affected VA is dominant, occlusion of the parent artery may cause the ischemic complications, depending on the size of contralateral VA and posterior communicating artery. If the patient is shown to tolerate temporary occlusion of the dominant VA at the balloon test occlusion (BTO), permanent occlusion seems to be feasible. If intolerable, stent-assisted coil embolization or stent monotherapy including flow diverter may be a treatment option. Other treatment options are clipping or wrapping of the aneurysm sac, occlusion of affected VA combined with EC-IC bypass [superficial temporal artery (STA) to posterior cerebral artery (PCA) or superior cerebellar artery (SCA)], and reconstruction of the affected VA using radial artery (RA), V3-to-V4 bypass grafting.

The surgical treatment for VA dissection involving posterior inferior cerebellar artery (PICA) is still controversial. Although proximal occlusion is simple, it has the risk of rebleeding due to the retrograde flow. Trapping without bypass can avoid rebleeding, but it has the risk of infarction in the PICA territory including inadvertent occlusion of brainstem perforators. Therefore, trapping combined with occipital artery (OA)-PICA bypass or PICA side-to-side anastomosis seems an optimal treatment strategy for PICA-involved VA dissection, but it is relatively an invasive procedure for the poor grade patients. Iihara et al. proposed a reasonable management strategy for PICA-involved VA dissection that proximal endovascular occlusion is performed in the acute stage followed by clipping of the origin of the PICA with revascularization of the PICA territory if the aneurysm size does not decrease (Fig. 2).

**2. Basilar artery**

Basilar artery (BA) dissection is very rare, and treatment for BA dissection is still challenging. Clinical manifestations are SAH, brainstem compression, and ischemia, which may result in severe outcome. Endovascular treatment including stent-assisted embolization, stent monotherapy with flow diverters might be the treatment options. Additionally, bilateral VA or BA occlusion may be effective for BA dissection if the collateral flow from the posterior communicating arteries is sufficient.

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Fig. 2 Proposed management strategy for VA dissecting aneurysms. An: aneurysm, PICA: posterior inferior cerebellar artery, SAH: subarachnoid hemorrhage, VA: vertebral artery. (Figure reproduced from Reference 17.)

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3. Internal carotid artery

IAD is the internal carotid artery is mainly the “blood blister-like” aneurysm (BBA) of C2 anterior wall. Because BBA is usually fragile, the rate of intraoperative rebleeding is higher than saccular aneurysm, so that the treatment of BBA is still challenging.\(^{50–54}\) In the systematic review of BBA, the overall mortality of all treatment modalities (surgical, endovascular, and conservative treatments) was 19%, and the estimated morbidity (modified Rankin Scale > 2 or reported neurological deficit after the procedure) was 17%.\(^{45}\)

The treatment strategies for BBA are as follows: trapping (surgical or endovascular) with or without bypass, clipping,\(^{46}\) clipping on wrapping,\(^{47–49}\) coil embolization, and stenting including flow diverters.\(^{50–52}\) Since regrowth and rerupture of BBA may occur frequently,\(^{40–44,53}\) trapping is one of the optimal treatment to prevent these complications. Vascular reconstruction with EC-IC bypass should be considered if the patient is judged intolerable to parent artery occlusion, but the assessment of tolerance with BTO is not usually feasible in acute stage because of the sedation. Therefore, EC-IC bypass is usually combined with trapping.\(^{42,54–56}\) Although the choice of bypass (low flow bypass or high flow bypass) remains elusive, recent reports have suggested that high flow bypass should be better as a substitute for the normal ICA.\(^ {53,54,56,57}\) High flow bypass prior to trapping reduces the risk of global cortical ischemia in case with intraoperative rebleeding. Additionally, Oono et al. suggested that high flow bypass should be selected if operated in the acute stage after SAH just in case vasospasm may occur in the collateral vessels.\(^ {53}\) Clipping or clipping on wrapping method might be considered if possible because it has an advantage of preserving the antegrade blood flow,\(^ {46–49}\) but it has the risk of ischemic complication if intraoperative rebleeding occurs.

4. Middle cerebral artery

Middle cerebral artery (MCA) dissection is a very rare cause of stroke. Most cases were young, presenting with ischemic stroke (68.9%), M1 dissections accounted for 75%, and most cases were reported from the Asian countries.\(^ {58}\) Surgical strategies for MCA dissection are as follows: trapping,\(^ {59}\) wrapping or coating,\(^ {60,61}\) clipping, resection\(^ {42–44}\) with or without EC-IC bypass for hemorrhage, and EC-IC bypass only\(^ {63}\) for ischemia. Furthermore, dissected segment might be resected with reanastomosis of the arterial stumps. If the affected lesion includes large perforating artery, trapping or resection may result in ischemia so that wrapping or coating might be considered. If the lesion is located in the distal MCA, resection or trapping with or without vascular reconstruction may be recommended to prevent rebleeding.

5. Anterior cerebral artery

Suzuki et al. reported the review of the nontraumatic arterial dissection of the anterior cerebral artery (ACA).\(^ {66}\) They have demonstrated that cerebral infarction (or ischemic presentation) caused by ACA dissection accounted for 58% of all ACA dissection cases, which was mostly located in A2 segment, and the prognosis was relatively good with conservative treatment. On the other hand, they also have demonstrated that hemorrhage caused by ACA dissection accounted for 31% of all cases, which was mostly located in A1 segment and surgical treatment had been performed. Surgical strategies are as follows: trapping with or without bypass,\(^ {12,67}\) clipping,\(^ {68}\) and wrapping.\(^ {69}\) The strategies of bypass surgery for ACA territory are A3–A3 side-to-side anastomosis, STA-ACA anastomosis, and RA, STA-to-A3 bypass grafting.\(^ {12,65,70–73}\)

Conclusion

IAD is one of the important causes of stroke, and recognized increasingly with recent advances of the neuroimaging technique especially among the East Asian population. Since rebleeding occurs frequently in the acute stage in the ruptured IAD, urgent surgical treatment should be performed to prevent rebleeding. On the other hand, surgical treatment for unruptured IAD is controversial because it has little risk for bleeding. Surgical treatment for unruptured IAD may be considered if the formation or enlargement of the aneurysmal dilatation has been confirmed.

There are several surgical strategies for IAD, and it is important to select an appropriate strategy on a case-by-case basis. If the risk of infarction due to parent artery occlusion is high, additional bypass surgery should be considered.

Conflicts of Interest Disclosure

All authors who are members of Japan Neurosurgical Society (JNS) have registered online self-reported COI Disclosure Statement Forms through the website for JNS members. K.A. has no interests to declare. K.I. received grants from Nihon Medi-Physics, Otsuka Pharmaceutical Co., Ltd., AstraZeneca K.K.

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