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Review Article

Endovascular Recanalization for Chronic Total Occlusion of Intracranial Vertebral Artery: A Mini Review

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Intracranial vertebral artery (ICVA) refers to the intracranial segment of the vertebral artery which is usually involved with atherosclerosis and dissection. Considering the high incidence and severe consequence of occlusive artery disease in this location, little attention has been paid to the chronic total occlusion (CTO) of ICVA and the corresponding endovascular treatment (EVT). In this mini review, ICVA CTO is discussed based on the definition, incidence, clinical manifestation, endovascular recanalization treatment, complications, and outcomes.

Keywords ▶ intracranial vertebral artery, chronic total occlusion, endovascular treatment, recanalization

Introduction

According to the Stenting and Aggressive Medical Management for Preventing Recurrent stroke in Intracranial Stenosis (SAMMPRIS) trial, stent angioplasty for intracranial occlusive artery disease brings no benefit to patients.[1] However, a certain part of these lesions can cause hemodynamic failure with refractory symptoms and recurrent strokes even under aggressive medical treatment.[2] For these patients, endovascular treatment (EVT) may improve the brain perfusion and stop the stroke recurrence.

ICVA is one of the most involved location for intracranial occlusive artery disease. The ICVA CTO with hypo-perfusion may cause severe symptoms, such as vertigo, visual blurring, ataxia, and faintness. These symptoms can restrict patient daily activity and worsen the life quality. Some patients even develop recurrent stroke with poor prognosis. For them, antiplatelet therapy alone is helpless. Endovascular recanalization can provide them the chance to recover. However, little attention has been paid to the chronic total occlusion (CTO) and the endovascular recanalization of the ICVA.

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Definition and Incidence of ICVA CTO

According to the results of New England Medical Center Posterior Circulation Registry (NEMC-PCR),[3,4] ICVA was most common (132/407), followed by vertebral artery origin and the basilar artery (BA), considering the location of occlusive artery disease. For isolated single vessel involvement, ICVA is the second most involved (40/134), with the first most involved to be the vertebral artery origin (52/134). Nonetheless, several literatures give different definition on the keywords "chronic occlusion." Liu et al.[5] reported a patient who underwent intracranial angioplasty and Solitaire stent placement for vertebrobasilar artery occlusion 2 months after symptom onset and angiographic diagnosis. In one research, endovascular recanalization was used to treat patients with vertebrobasilar artery occlusion after index ischemic event for about 1.5 months.[6] Some recanalization may happen just after 2–3 weeks from acute infarction.[7] For these studies, "Chronic" is most of the time a symptomatic word rather than a pathophysiologic word. Considering the nature of symptoms recurrence and the necessities for best medical treatment before starting the EVT for the non-acute intracranial artery occlusive disease, at least 1 month after image-diagnosed occlusion is appropriate to define the CTO of ICVA.

ICVA lesions were divided into three groups by location. Those from dural penetration to origin of posterior

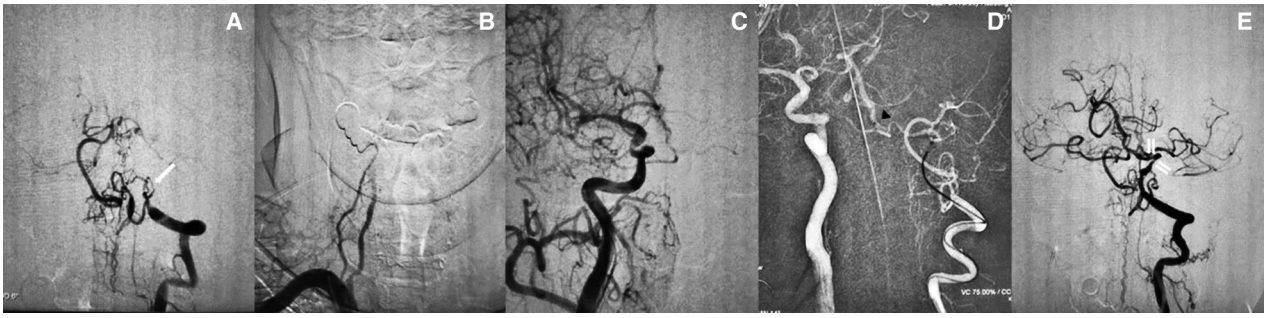

Fig. 1 **(A, B)** Digital Substrate Angiography disclosed the occlusion of left intracranial vertebral artery and right vertebral artery. Arrow (white) in A showed the occlusion of left ICVA. **(C)** Right common carotid artery injection revealed the compensatory flow from anterior circulation to basilar artery through posterior communicating artery. **(D)** Bilateral concurrent roadmaps (from right ICA and left VA) were used during endovascular recanalization. The distal mark of Rebar 18 had passed through the occlusion segment and reached basilar artery. Arrowhead (black) showed the distal mark of Rebar 18. **(E)** The control angiography of left vertebral artery after successful recanalization. Double arrows (white) showed the recanalized ICVA.

inferior cerebellum artery (PICA) were called proximal group. The lesions located at middle third part of ICVA were the middle group. Those involving distal third including the ICVA-BA junction were called distal group.[8] Most ICVA occlusive lesions involved the distal part of ICVA (66%) and beyond the origin of PICA.[9]

Clinical Manifestation of ICVA CTO

Interestingly, in patients with ICVA occlusive disease, the other side vertebral artery involvement is very common.[3] It might be the reason why over 80% of ICVA occlusive patients had widespread multifocal hypo-perfusion and distal territory infarcts due to embolism. Meanwhile, the infarcts limited to the proximal territory were only about one-fifth of all patients with ICVA occlusive disease.[10] In a recent study, researchers used the quantitative magnetic resonance angiography to proof the higher risk of subsequent posterior circulation stroke for symptomatic vertebrobasilar occlusive disease with flow compromise.[11] The basilarized vertebral artery territory becomes fragile when loss compensatory flows. For the occluded ICVA-BA junction, thrombus may extend distally and yield BA territory infarction. Patients can also present with visual blurring, diplopia, vertigo, ataxia, faintness, dysarthria, nausea, and vomiting. To note that in typical cases, the symptoms are postural.

Endovascular Recanalization for ICVA CTO

The ICVA itself has less perforator vessels compared with BA and middle cerebral artery. Most of the symptoms are hemodynamic related and benefit poor from medical treatment alone, especially with contralateral ICVA absence, hypoplasia, severe stenosis, or occlusion. Endovascular recanalization for ICVA CTO, as a last resort, can be applied for those patients of hypo-perfusion symptoms and recurrent strokes even with aggressive antiplatelets therapy.[12,13]

To realize a successful and safe recanalization, a thorough evaluation of collateral flow in advance is necessary. There are two common collateral flow phenotypes: from anterior circulation through posterior communicating artery and from pial artery of the posterior circulation (especially common for those occlusion distal from PICA). For those occlusions without collateral flow, the endovascular recanalization is dangerous and blind. It provides no information about the landing zone for microwire and microcatheter, which always brings complications like perforation or dissection.

All ICVA recanalization should be performed under general anesthesia. After general heparinization, physician can navigate one 6F guiding catheter from ipsilateral vertebral artery and one 5F angiography catheter from internal carotid artery (ICA) of trans-circulation collateral flow. With dual volume reconstruction after both sides 3D rotational angiography, it is not difficult to find the appropriate projection angle for bilateral concurrent roadmaps (**Fig . 1**). Using bilateral angiographic roadmaps, the success rate of ICVA CTO recanalization reached 85.7% (12/14) in a recent study.[12] For those with contralateral ICVA stenosis or hypoplasia, the antegrade roadmap from the non-occluded vertebral artery is available. No doubt it has a better resolution than the trans-circulation retrograde roadmap, but we should always keep in mind about the risks of flow blockage and distal embolization of the BA. Given the hypo-perfusion condition in most of the cases, vasospasm should be carefully avoided.

There is no particular requirement for which microwire to use. Almost every kind of neuro-intervention microwire

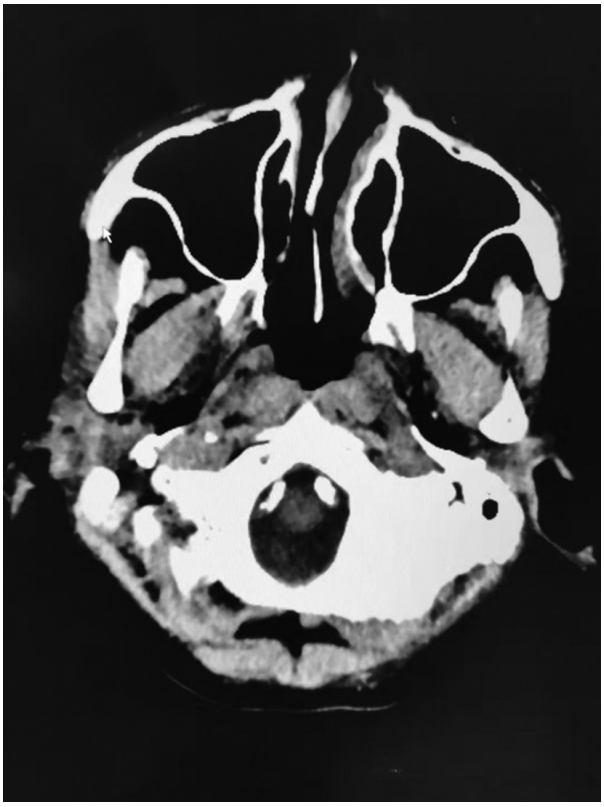

Fig. 2 The non-contrast CT of a patient with bilateral intracranial vertebral artery occlusion revealed the severe calcification of bilateral vertebral arteries.

works. So choose the one most compatible with your hands. On the contrary, microcatheters for thrombectomy use would be recommended, for example Rebar 18 (ev3; Covidien Neurovascular, Irvine, California), as a routine for all recanalization procedures in case of the urgent thrombectomy for distal embolization. And also, those microcatheters are stable enough to support the microwire when keeping penetrating the occlusion lesion. After reaching the distal BA, a regular injection from microcatheter can assure its location within the true lumen. Sometimes, a distal microcatheter road map can prevent microwire perforation during the following exchange technique manipulation. For balloon angioplasty, to start from a relative smaller diameter balloon with a higher dilating pressure is a safe way to avoid vessel rupture. For example, the first balloon chosen should be Gateway 1.5/9 or 15 with 8 atmospheres dilation (Boston Scientific, Natick, MA, USA). After that, the second balloon should be selected based on the control angiography. One should keep in mind that the balloon size with diameter at dilation atmospheres to be within 80% of the true lumen diameter of non-occluded adjacent segment.

With slow balloon inflation and deflation, severe dissection can be avoided. In cases with remaining stenosis or acute restenosis, stenting should be performed at a single stage because the balloon angiography alone has been proved inadequate. With the 300 cm exchange microwire, one can easily navigate the stent microcatheter across the lesion. Before stenting, a routine C-arm CT is a must to exclude any intracranial bleeding or subarachnoid hemorrhage.

Patients should be tolerant with dual antiplatelets therapy. After stenting, the antegrade flow of thrombolysis in cerebral ischemia (TICI) grade 3 should be double checked with at least 15 minutes interval. If an acute in-stent thrombosis was suspected, tirofiban is used and continued for at least 24 hours after the procedure.

Recently, a study including 2483 participants quantified the vertebrobasilar artery calcification (VBAC) with non-enhanced CT.[14] According to the results, the prevalence of VBAC was 21%. Some other study even reported the prevalence to be 42%.[15] Like cardiac intervention, arterial calcification predicts the higher risks for procedural complication and failure. The calcification of ICVA can be easily detected by non-contrast CT before EVT (**Fig. 2**). If the patient had severe burden of vertebral artery calcification, the decision of starting the endovascular recanalization should be very seriously considered.

Complications of EVT for ICVA CTO

Like endovascular recanalization for VBA CTO, the complications of endovascular recanalization for ICVA CTO can be divided into ischemic events and hemorrhagic events, with the reported peri-complication rate to be 17.6%[12] and 37.5%.[13] Dissection, distal embolization, in-stent thrombosis, and perforator infarction are often the causes for ischemic complications. Dissection is the most common, accounting for almost half of all complications, and sometimes even results the termination of the procedure.[6] A relative smaller size balloon angioplasty before stenting can alleviate the plaque squeezing and maintain the perforator patency. ICVA is a relative straight segment of the vessel, hemorrhagic complication, like vessel perforation, can be avoided if the physician control the tension and prevent unintentional forward movement of the microwire throughout the procedure. As mentioned before, evaluation of the extent of calcification of occluded ICVA based on non-contrast CT in advance is also helpful to prevent the probable hemorrhagic complication when penetrating the lesion. To avoid hyper-perfusion after successful recanalization, the blood pressure should be under intensive control, at least below the level of 140/90mmHg.

Outcome of ICVA CTO Recanalization

For CTO of ICVA, both the follow-up modified Rankin Scale (mRS) score and angiographic results are important to evaluate the value of endovascular recanalization with long-term outcome. Xu et al.[13] reported three of six patients with angiographic results with none to mild restenosis at 10–60 months follow-up.[13] The other three patients had their vessel patency confirmed with CTA and ultrasound. According to Gao et al.,[12] 11 of 12 patients underwent follow-up with a median of 43 months. The median mRS score was 1. Among them, only one patient had symptom recurrence. The other 10 patients were asymptomatic. In four patients with angiographic follow-up, with a median of 39.4 months, three had no stent restenosis and one had stent re-occlusion based on the CTA images. In the future, a more sensitive evaluation scale, other than the mRS score, should be developed to highlight the life quality improvement after the endovascular recanalization of ICVA CTO. And a prospective randomized controlled trial with large sample is warranted to affirm the safety and efficacy of this therapy.

Conclusion

The ICVA is the most common location for chronic occlusive diseases. Patients of ICVA CTO can suffer from refractory stroke caused by widespread posterior circulation hypo-perfusion even under aggressive antiplatelet therapy. The endovascular recanalization for ICVA CTO, as a last resort, can be considered for such patients. The EVT of ICVA CTO is technically feasible. However, the long-term outcomes need further thorough researches.

Disclosure Statement

The author has no conflict of interest related to this work.

References

1) Derdeyn CP, Chimowitz MI, Lynn MJ, et al: Aggressive medical treatment with or without stenting in high-risk patients with intracranial artery stenosis (SAMMPRIS): the final results of a randomised trial. *Lancet* 2014; 383: 333–341.
2) Wabnitz AM, Derdeyn CP, Fiorella DJ, et al: Hemodynamic markers in the anterior circulation as predictors of recurrent stroke in patients with intracranial stenosis. *Stroke* 2018: STROKEAHA118020840.
3) Caplan LR: The intracranial vertebral artery: a neglected species. The Johann Jacob Wepfer Award 2012. *Cerebrovasc Dis* 2012; 34: 20–30.
4) Caplan L, Wityk R, Pazdera L, et al: New England medical center posterior circulation stroke registry II. Vascular lesions. *J Clin Neurol* 2005; 1: 31–49.
5) Liu XC, Chen C, Shi MC, et al: Revascularization of vertebrobasilar artery occlusion at the chronic stage. *Neurosciences (Riyadh)* 2013; 18: 269–272.
6) He Y, Bai W, Li T, et al: Perioperative complications of recanalization and stenting for symptomatic nonacute vertebrobasilar artery occlusion. *Ann Vasc Surg* 2014; 28: 386–393.
7) Lin R, Aleu A, Jankowitz B, et al: Endovascular revascularization of chronic symptomatic vertebrobasilar occlusion. *J Neuroimaging* 2012; 22: 74–79.
8) Savitz SI, Caplan LR: Vertebrobasilar disease. *N Engl J Med* 2005; 352: 2618–2626.
9) Caplan LR, Wityk RJ, Glass TA, et al: New England medical center posterior circulation registry. Ann Neurol 2004; 56: 389–398.
10) Caplan L, Chung CS, Wityk R, et al: New England medical center posterior circulation stroke registry: I. Methods, data base, distribution of brain lesions, stroke mechanisms, and outcomes. *J Clin Neurol* 2005; 1: 14–30.
11) Amin-Hanjani S, Pandey DK, Rose-Finnell L, et al: Effect of hemodynamics on stroke risk in symptomatic atherosclerotic vertebrobasilar occlusive disease. *JAMA Neurol* 2016; 73: 178–185.
12) Gao P, Wang Y, Ma Y, et al: Endovascular recanalization for chronic symptomatic intracranial vertebral artery total occlusion: experience of a single center and review of literature. *J Neuroradiol* 2018; 45: 295–304.
13) Xu Z, Ma N, Mo D, et al: Endovascular recanalization for chronic symptomatic intracranial vertebral artery total occlusion. *Minim Invasive Surg* 2014; 2014: 949585.
14) van der Toorn JE, Engelkes SR, Ikram MK, et al: Vertebrobasilar artery calcification: prevalence and risk factors in the general population. *Atherosclerosis* 2019; 286: 46–52.
15) Gökçal E, Niftaliyev E, Özdemir T, et al: The association of vertebrobasilar calcification with etiological subtypes, stroke recurrence and outcome in acute brainstem ischemic stroke. *Neurol Neurochir Pol* 2018; 52: 188–193.