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CASE REPORT

Subintimal recanalization for non-acute occlusion of intracranial vertebral artery in an emergency endovascular procedure: A case report

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Abstract

BACKGROUND

Endovascular recanalization of non-acute intracranial artery occlusion is technically difficult, particularly when the microwire enters the subintima. Although the subintimal tracking and re-entry technique has been well established in the endovascular treatment of coronary artery occlusion, there is limited experience with its use in intracranial occlusion due to anatomical variations and a lack of dedicated devices.

CASE SUMMARY

A 74-year-old man was admitted to the hospital two days after experiencing acute weakness in both lower extremities, poor speech, and dizziness. After admission, imaging revealed acute ischemic stroke and non-acute occlusion of bilateral intracranial vertebral arteries (ICVAs). On the fourth day of admission, the patient's condition deteriorated and an emergency endovascular recanalization of the left ICVA was performed. During this procedure, a microwire was advanced in the subintima of the vessel wall and successfully reentered the distal true lumen. Two stents were implanted in the subintima. The patient's Modified Rankin Scale was 1 at three months postoperatively.

CONCLUSION

We present a technical case of subintimal recanalization for non-acute ICVA occlusion in an emergency endovascular procedure. However, we emphasize the necessity for caution when applying the subintimal tracking approach in intracranial occlusion due to the significant dangers involved.

Key Words: Subintimal tracking and re-entry; Large artery intracranial occlusive disease; Chronic total occlusion; Endovascular treatment; Acute ischemic stroke; Case report

Core Tip: Technical challenges arise during endovascular recanalization of non-acute intracranial artery occlusions, particularly when the microwire enters the subintima. To our knowledge, this article details the first successful case of subintimal recanalization for non-acute intracranial vertebral artery occlusion in a patient with progressive ischemic stroke. However, we emphasize the necessity for caution when applying the subintimal tracking approach in intracranial occlusion due to the significant dangers involved.

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INTRODUCTION

Intracranial vertebral artery (ICVA) occlusion is a prevalent but frequently disregarded condition[1-3]. There are no established recommendations for endovascular recanalization of ICVA non-acute occlusion (mostly chronic occlusion). Previous studies have indicated procedural success rates of 75%-100% and perioperative complications of 0%-37.5%[4-6].

When there is heavy fibrous calcified plaque or when the course of the occlusion is unclear during neuro-endovascular interventions, the guidewire frequently fails to cross the occlusive lesion[4]. Additionally, the guidewire favors areas of low resistance, which makes it enter the subintima automatically.

The subintimal tracking and re-entry (STAR) technique has been well-established in peripheral vasculature[7-9]. In chronic total occlusion (CTO) of the internal carotid artery (ICA), Chen *et al*[10] indicated that the STAR technique may be used liberally below the ophthalmic artery segment due to a lack of major side branches. This article describes a case of fortuitous subintimal recanalization for non-acute ICVA occlusion.

CASE PRESENTATION

Chief complaints

A 74-year-old man presented acute weakness in both lower extremities, poor speech, and dizziness for two days.

History of present illness

At the beginning of the two days, prior to admission, the patient awoke in the morning with a sudden onset of weakness in both lower extremities, poor speech, and dizziness, with a spinning sensation that lasted for several minutes, without headache, nausea, vomiting, or any difficulty swallowing.

History of past illness

The patient had a history of hypertension with poor management for over 10 years. He began experiencing recurrent episodes of vertigo six months prior, and the transcranial Doppler (TCD) revealed a peak systolic/end-diastolic flow velocity of 26/11 cm/s in the left ICVA. At that time, he was taking aspirin and a statin.

Personal and family history

He had been smoking for over 60 years. He declined to provide other personal and family medical history.

Physical examination

The National Institutes of Health Stroke Scale (NIHSS) at admission was 4. The main neurological examinations included grade 4+ muscle strength of both lower extremities, mild facial and tongue paralysis on the right side, and the presence of bilateral Babinski's sign.

Laboratory examinations

No obvious abnormalities were found on routine blood tests, routine urine tests, routine fecal tests, blood biochemistry and immune indexes.

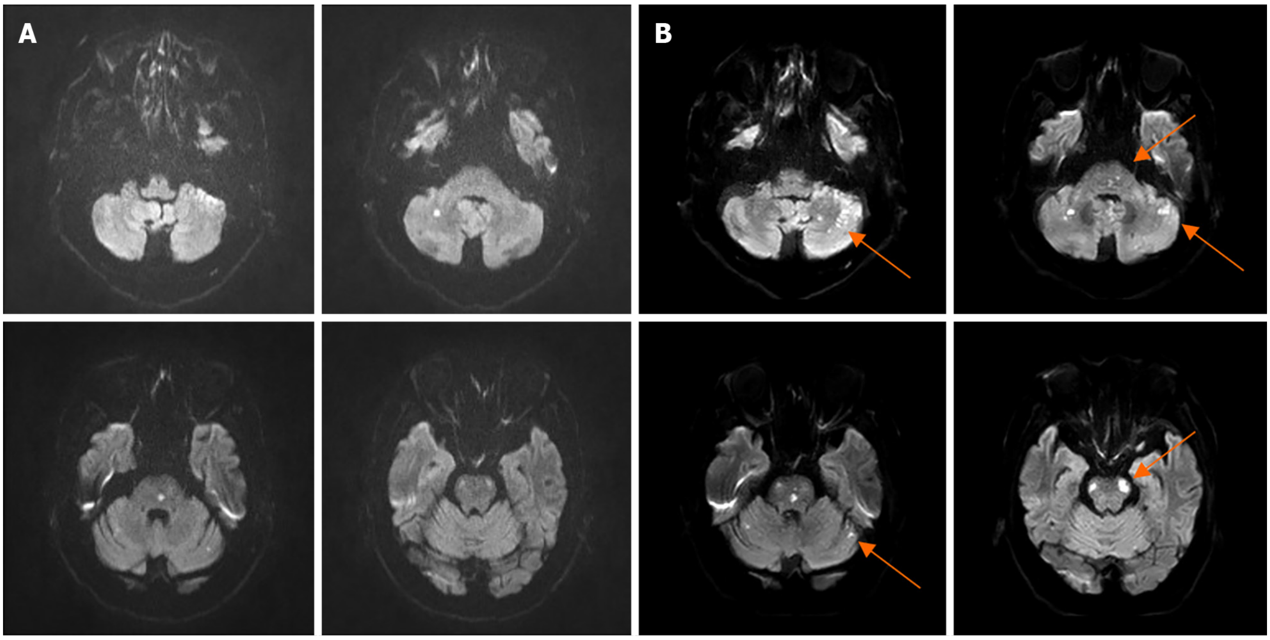

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Figure 1 The brain diffusion-weighted magnetic resonance imaging at different time intervals. A: Diffusion-weighted magnetic resonance imaging (DW-MRI) at initial admission; B: DW-MRI on day 4 of admission showed multiple infarcts enlarged than before (orange arrows).

Imaging examinations

A brain Magnetic Resonance Imaging (MRI) revealed scattered acute infarcts in the posterior circulation (Figure 1A).

On the second day of admission, cerebral angiography revealed that the left vertebral artery (VA) had been occluded close to the origin of the left posterior inferior cerebellar artery (PICA) with a blunt proximal stump, and the right VA had been occluded near the junction of the basilar artery (BA). The BA was supplied by the anastomosis of the right VA branch vessels. No patent posterior communicating artery (PComA) was identified (Figure 2).

Then, a High-Resolution Magnetic Resonance Imaging (HRMRI) in the T1-weighted sequence revealed long-range thrombosis, lumen occlusion, wall thickening and no notable hyperintense signals far from the V4 segment of the left VA (Figure 3).

FINAL DIAGNOSIS

The final diagnosis was progressive ischemic stroke coupled with intracranial vertebral artery occlusion.

TREATMENT

On admission, aspirin, clopidogrel, and atorvastatin were administered orally. Meanwhile, the intravenous fluid infusion was increased to improve cerebral perfusion. Nevertheless, the patient's symptoms fluctuated.

On the fourth day of admission, the patient's condition deteriorated and the NIHSS increased to 10, in addition to a repeat brain MRI which revealed a larger infarct (Figure 1B). Then, we decided to perform an emergency endovascular procedure to open the left ICVA. After we explained the patient's situation and the treatment plan to his family, they expressed their understanding and signed their written informed consent to the procedure.

Aspiration thrombectomy was initially used. The 6F Sofia intermediate catheter (MicroVention) was introduced close to the left vertebral artery occlusion through the 6F long sheath, however, no thrombus was retrieved *via* intermediate catheter aspiration.

Subsequently, the Synchro microwire (Stryker) and PILOT-50 guidewire (Abbott) were used alternatively to try to penetrate the proximal end of the occlusion with the assistance of a Rebar 18 microcatheter (eV3 Covidien) under the guidance of a roadmap. However, the organization of thrombus and the stiffer proximal fibrous cap, as well as the frequent slips of the microwire into the nearby PICA branch made it challenging to manipulate the microwire through the occlusion. After changing its direction of advancement, the microwire eventually entered the proximal end of the occlusion. The resistance and morphology of the advancing microwire indicated that it entered the subintima. Since the guidewire was located in the subintima, we were unable to perform routine mechanical thrombectomy using a stent retriever.

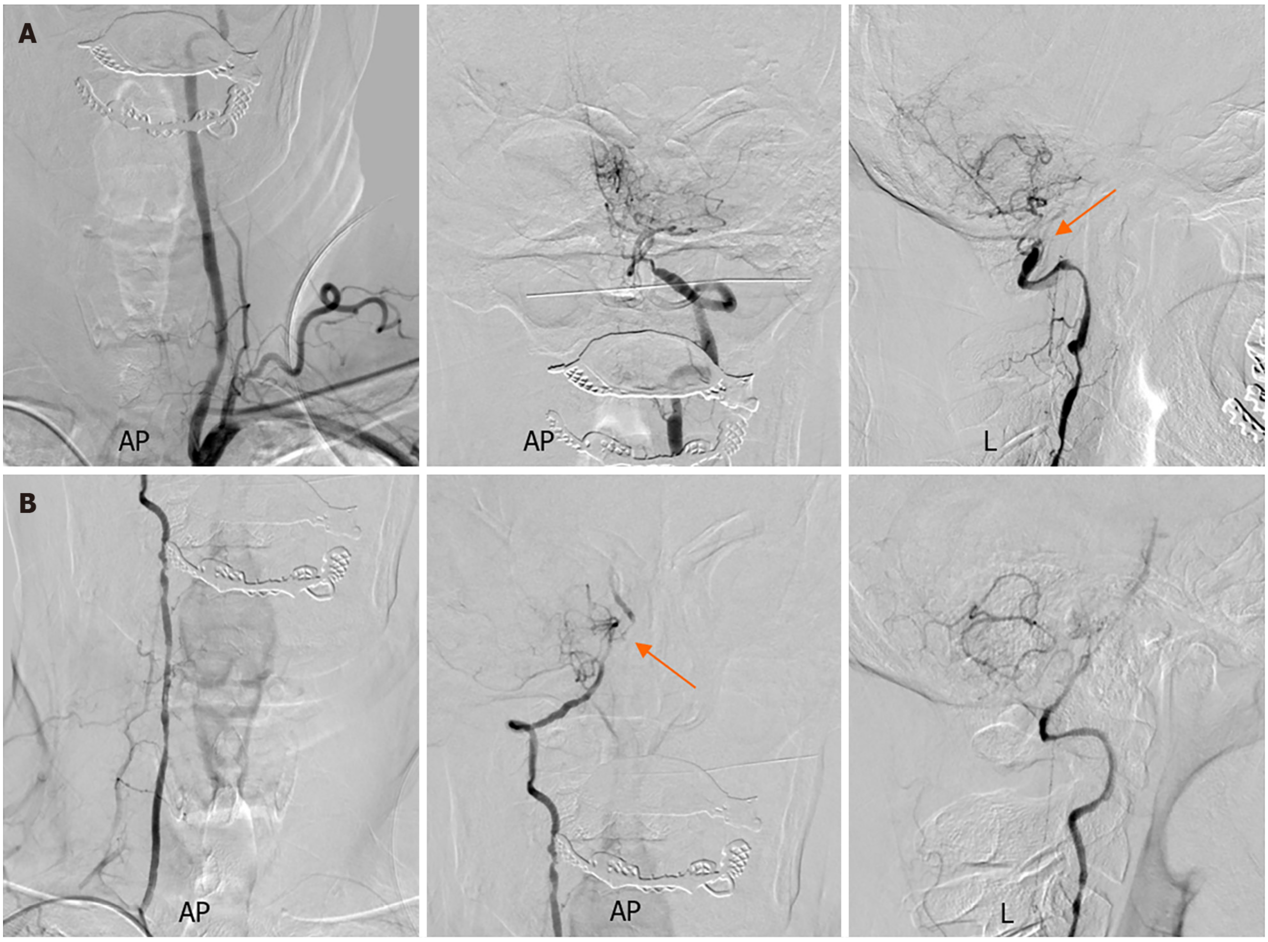

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Figure 2 Digital subtraction angiography of bilateral vertebral arteries. A: The left intracranial vertebral artery (VA) has been occluded with a blunt proximal stump (orange arrow); B: The right VA has been occluded near the junction of the basilar artery (BA), and the BA was supplied by the anastomosis of the right VA branch vessels (orange arrow). AP: Anterior-posterior; L: Lateral.

The roadmap served as a guide as the microwire was repeatedly repositioned so that it advanced into the subintimal space with a sigmoid curve. Microcatheter angiography was then used to evaluate the position of the microwire, the morphology of the subintimal channel, and to look for potential microchannels leading to the true lumen (Figure 4).

When the subintimal microwire approached the anterior inferior cerebellar artery (AICA), the microcatheter angiography implied entry into the AICA branch. The microwire was then carefully withdrawn, reoriented, and it continued advancing in the subintima. As the microwire advanced to the distal end of the occlusion, microcatheter angiography revealed the position of the true lumen and the existence of microchannel connectivity between the subintima and the true lumen. Subsequently, the microwire and the microcatheter were manipulated to attempt to cross the microchannel under the guidance of the roadmap. Eventually, the microwire re-entered the true lumen and was advanced to the left superior cerebellar artery (Figure 5).

The subintimal channel was completely covered by the placement of two Enterprise stents (Codman) after distal and proximal dilation twice with a balloon (Figure 6). Repeat imaging revealed the Thrombolysis in Cerebral Infarction score of 3, and satisfactory stent apposition, therefore the procedure was completed. There were no intraoperative complications such as distal embolism from thrombus dislodgment, subarachnoid hemorrhage from vessel perforation, or in-stent thrombosis.

OUTCOME AND FOLLOW-UP

On postoperative day 1, repeat brain MRI did not reveal any new infarction or hemorrhage, and TCD demonstrated smooth in-stent flow with a flow velocity of 78/24 cm/s. Upon discharge, the patient's symptoms had greatly improved, and the NIHSS score was 3.

At 3 mo postoperatively, the follow-up angiography revealed satisfactory vascular healing and smooth blood flow in the subintimal channel without in-stent re-stenosis (Figure 6). At that time, the patient's modified Rankin Scale was 1.

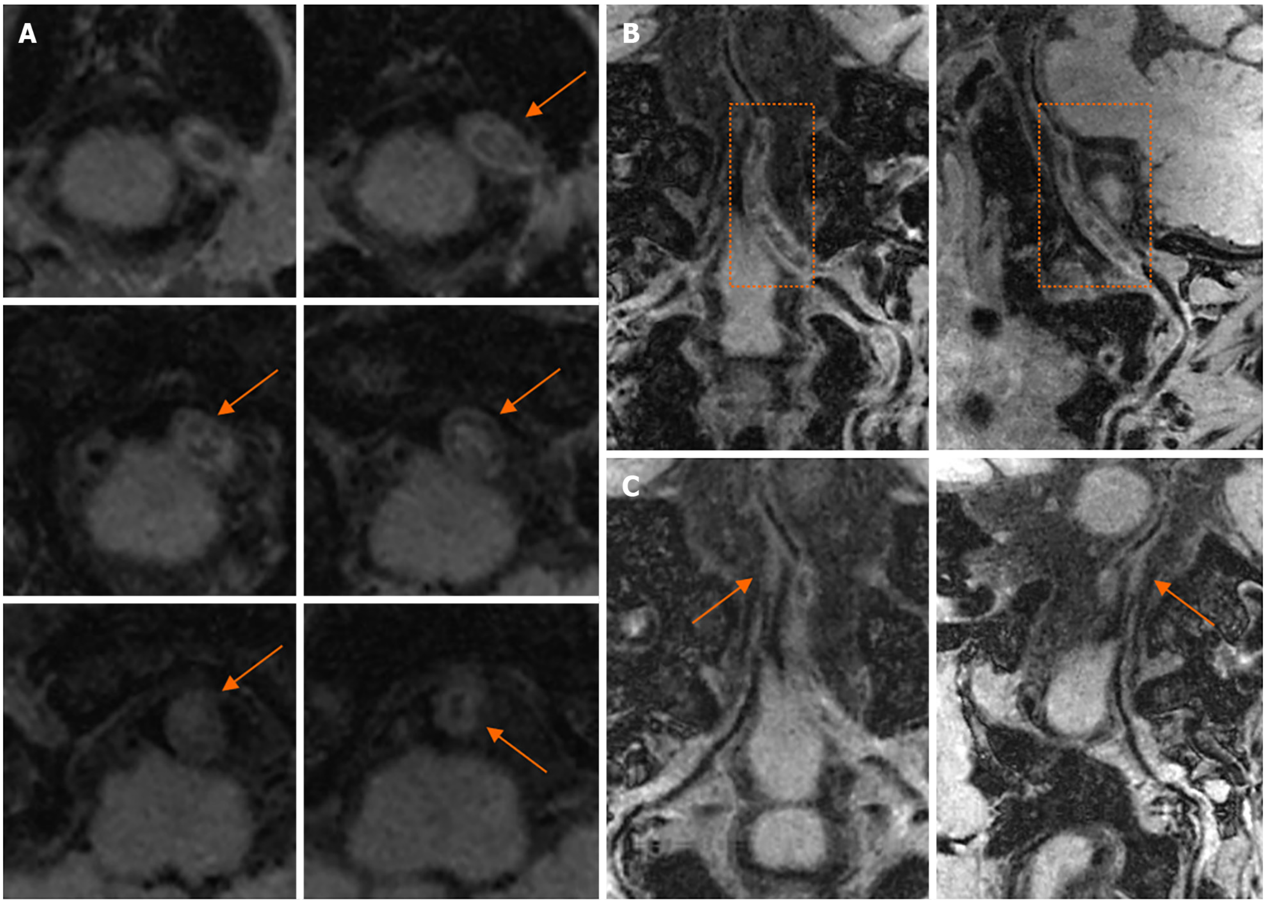

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Figure 3 The high-resolution magnetic resonance imaging of bilateral vertebral arteries. A: The T1-weighted sequence of several axial levels of the left intracranial vertebral artery (VA) showed mixed equal, slightly low, and slightly high signal intensity in the occluded VA lumen, with obvious wall thickening (orange arrows); B: The curved planar reformation (CPR) images of left VA showed long-range thrombosis, lumen occlusion, and wall thickening (orange dashed zones); C: The CPR images showed occlusion of the right intracranial VA (orange arrows).

DISCUSSION

Patient evaluation

In this patient, cerebral angiography revealed that the lesions involved bilateral vertebral arteries. No patent PComA was found (Figure 2). We speculated that the progressive stroke mechanism was hypoperfusion, which would have affected the clearance and destination of embolic particles due to the poor vascular state and collateral circulation[11].

We viewed the patient's left VA lesion as a non-acute occlusion in this case. According to prior studies, the blunt stump was associated with a CTO at a late stage[10,12]. Additionally, we did not detect any notable hyperintense signals in the HRMRI, indicating the absence of any fresh thrombus or intraplaque hemorrhage[13,14]. Furthermore, the operator felt more resistance when attempting to push the microwire through the proximal end of the occlusion, which differed from acute occlusion due to atherosclerosis-related in situ stenosis. As a result, we could reasonably assume that it was a chronic occlusion with more fibrous composition and organized thrombus[15].

Although initially optimal medical therapy was administered, this patient's symptoms worsened, but the infarct size was not large, resulting in a clinical-core mismatch. We thought that urgent endovascular recanalization was necessary, as stated by Aghaebrahim *et al*[16] as a reason for the intervention.

We discovered that the existence of a branch vessel close to the proximal occlusion may have made the procedure more difficult[17]. As in this case, the left VA was occluded after the PICA originated and the guidewire repeatedly entered the PICA branch (Figure 4). However, obvious wall thickening in the occlusive lesion, acceptable occlusion length, and the absence of lumen collapse made us more confident in the successful subintimal recanalization in this patient.

Recanalization technique

The STAR technique was initially presented in the 1980s to treat superficial femoral CTO[7]. Subsequently, it was developed in coronary CTO, where a more systematic subintimal recanalization strategy was designed based on modern percutaneous transluminal coronary intervention techniques and dedicated CTO devices[18].

Currently, endovascular recanalization of intracranial non-acute occlusion lacks dedicated CTO devices and techniques. For this patient, depending on the resistance of the guidewire in the occluded lesion, we alternated between the Synchro microwire and the PILOT-50 guidewire. The Synchro microwire has a softer tip and is safer in low resistance

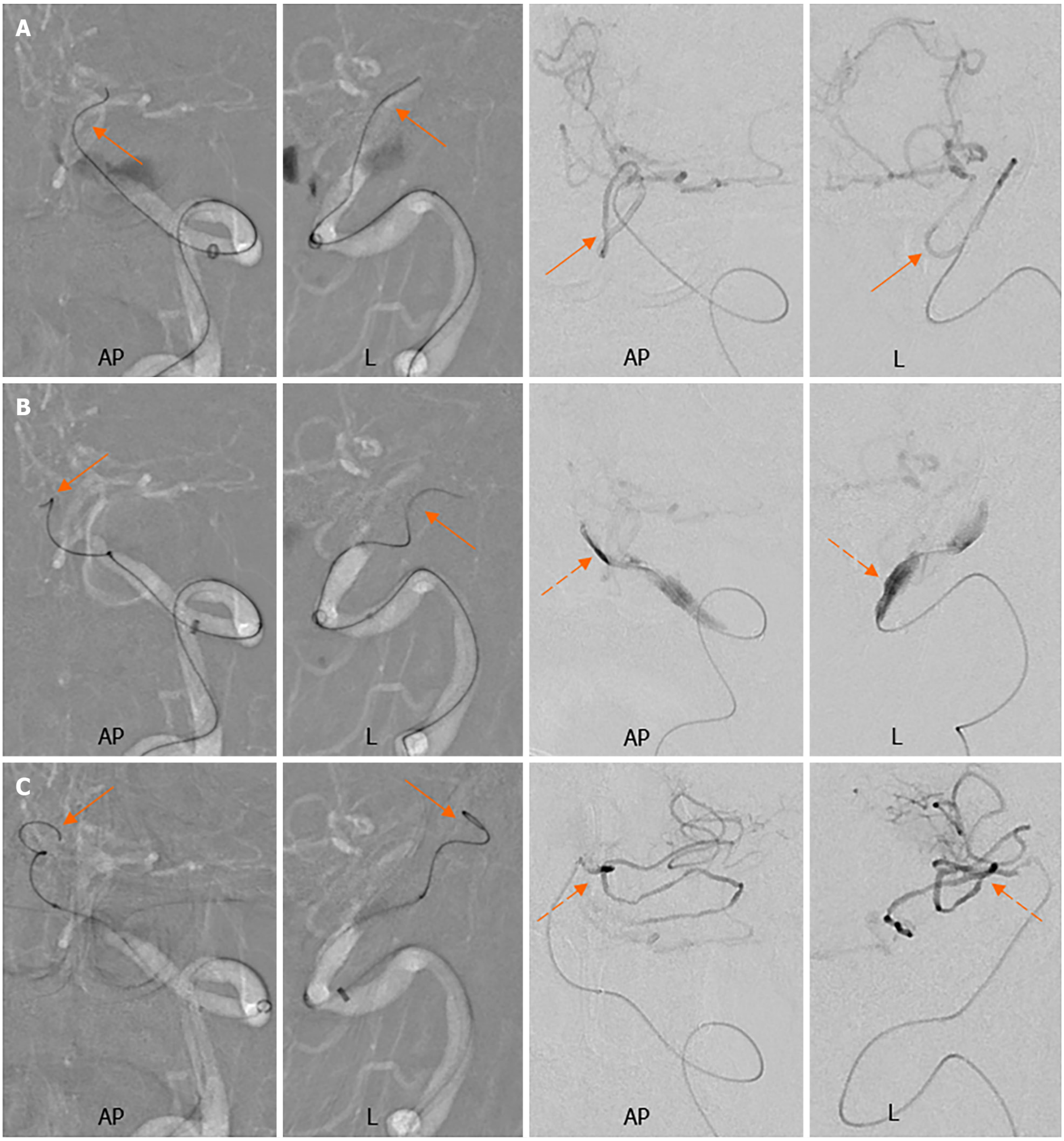

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Figure 4 The course of microwire in the subintima and microcatheter angiography. A: The microwire entered the posterior inferior cerebellar artery (orange arrows); B: The microwire advanced in a sigmoid curve in the subintima (orange arrows) and the microcatheter angiography identified the subintimal dissection (orange dashed arrows); C: The subintimal microwire kept advancing in a spiral shape (orange arrows) and the microcatheter angiography showed the microwire entered the anterior inferior cerebellar artery (orange dashed arrows). AP: Anterior-posterior; L: Lateral.

locations, although excessive guidewire bending should be avoided to expand the subintimal space. The PILOT guidewire has better penetration and can more easily enter the subintima, although attention is required to prevent perforation. Additionally, the microcatheter can increase the backup support and improve guidewire penetration. Subintimal microcatheter angiography can evaluate the morphology of the subintimal channel and look for potential microchannels leading to the true lumen.

The morphology of the subintimal channel or dissection is associated with technical success. According to interventional cardiologists Carlino *et al*[19], a "tubular" dissection shows that the microcatheter is in the subintima, and the success rate of guidewire re-entry into the real lumen is higher; in contrast, a "storm cloud" dissection suggests that the contrast has extravasated into the peri-adventitial regions. If a "storm cloud" dissection occurs, it is important to carefully evaluate the danger of vascular perforation and the procedure should be stopped if required. For this patient, the microcatheter angiography revealed a "tubular" pattern, indicating that the guidewire was in the subintima and the procedure was eventually successful (Figure 5).

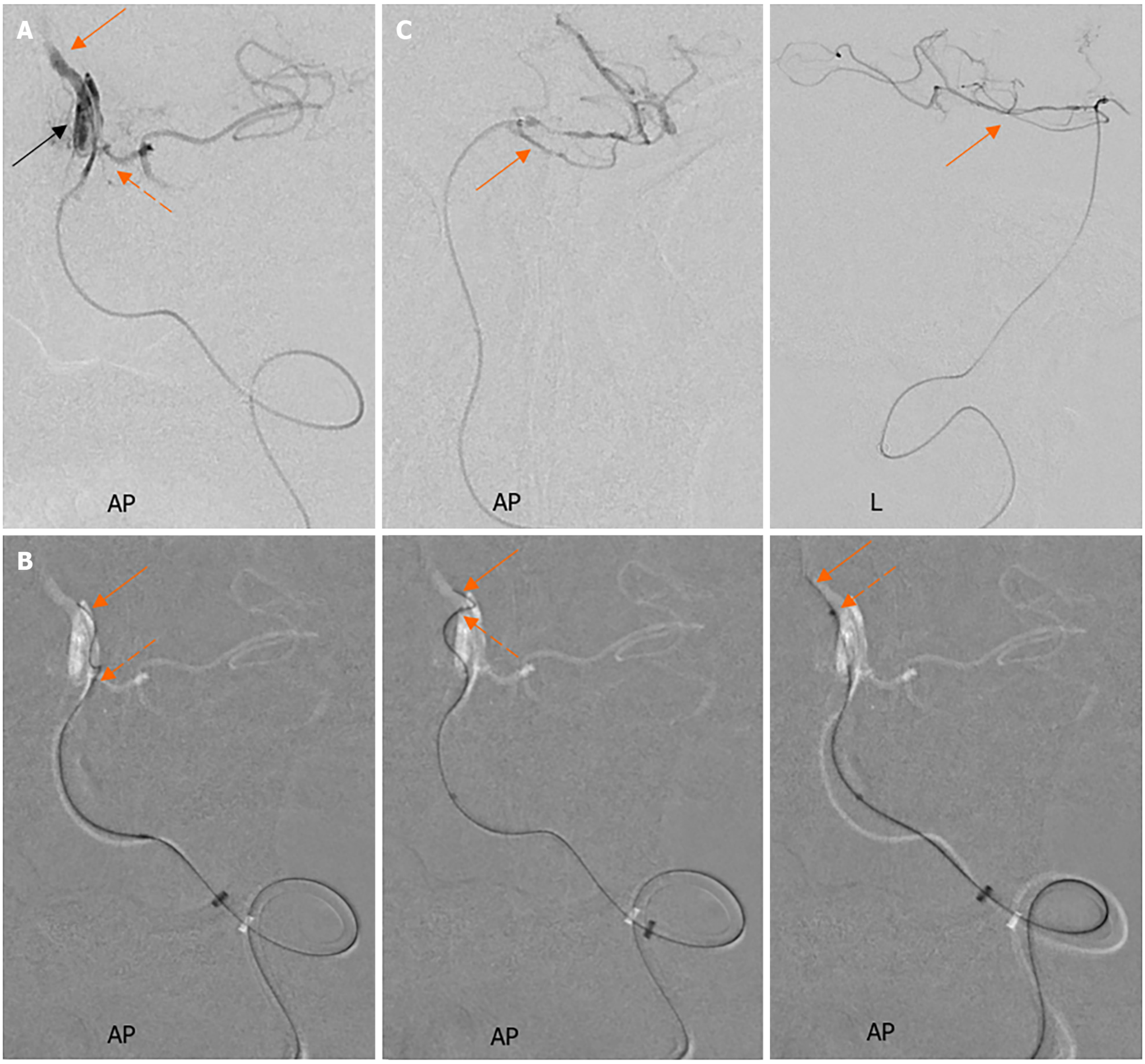

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Figure 5 The subintimal microwire re-entered the true lumen. A: The microcatheter angiography at the level of anterior inferior cerebellar artery (AICA) orifice revealed the true lumen's position (orange arrow), the AICA branch (the orange dashed arrow), and the subintimal "tubular" dissection (black arrow); B: Under the guidance of a roadmap, the microwire (orange arrows) and the microcatheter (the orange dashed arrows) were manipulated to re-enter the true lumen; C: The microcatheter angiography showed the microwire was advanced to the superior cerebellar artery (orange arrows). AP: anterior-posterior; L: lateral.

According to several CTO pathologic and imaging studies[15,20], the neo-vessels within the intimal plaque are in touch with the subintimal vasa vasorum. These microchannels may be detected by microcatheter angiography making it easier for the guidewire to re-enter the true lumen. For this patient, we performed microcatheter angiography with about 0.2 mL of contrast by hand and found the location of the distal true lumen. Subsequently, the guidewire was successfully manipulated to re-enter the true lumen under the guidance of the roadmap (Figure 5).

Potential procedural risk

Although a positive clinical outcome was achieved in this case with subintimal stenting, adoption of the subintimal recanalization technique in intracranial non-acute occlusions is still debatable because of the technical challenges and the high risk of the procedure.

The architecture of intracranial vessels differs from that of the peripheral vasculature. In the intradural portion of intracranial arteries, the external elastic lamina progressively disappears and connective tissues are sparse[21-23], so advancement of the subintimal guidewire can easily cause vascular perforation and catastrophic subarachnoid hemorrhage. Only lesions with sufficient wall thickening and no lumen collapse should be attempted on. Fortunately, there was no vascular perforation in this case.

Evaluation of the distal branches is crucial. According to Galassi *et al*[24], the subintimal guidewire is frequently re-entered into the true lumen at the distal vascular branch in coronary CTO. As for ICA CTO, the level of distal ICA reconstitution at the ophthalmic or communicating segments was predictive of a significantly lower rate of success[10].

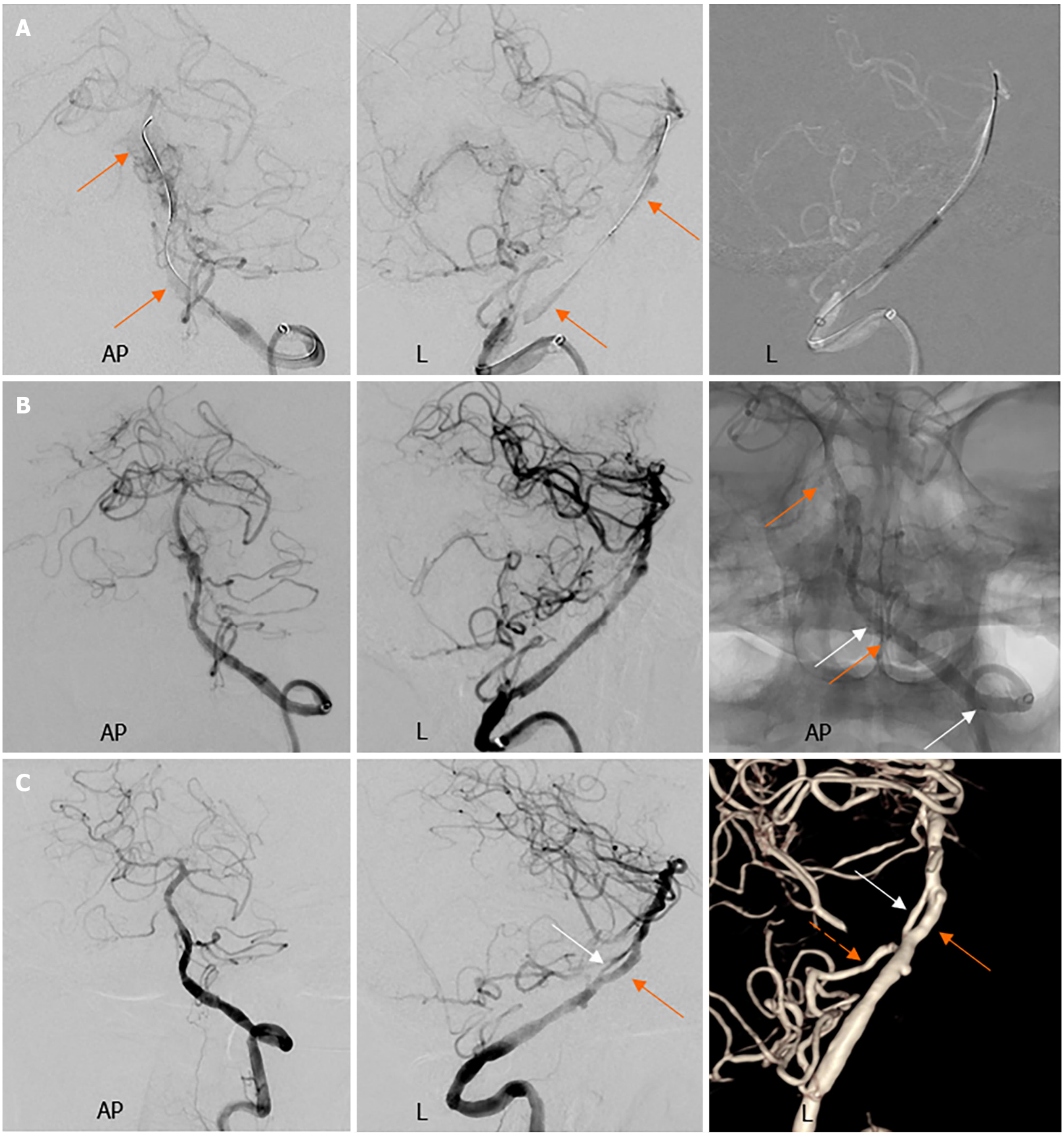

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Figure 6 Cerebral angiography of left vertebral artery before balloon dilatation, after stent implantation and at three months postoperatively. A: Digital subtraction angiography (DSA) before balloon dilatation showed the subintimal canal (orange arrows); B: Angiography revealed reconstruction of the left vertebral artery after implantation of two stents, with four stent markers visible on fluoroscopy (orange and white arrows); C: Follow-up DSA revealed that a residual true lumen (white arrows) was seen in parallel with the subintimal canal (orange arrows) far from the left anterior inferior cerebellar artery (orange dashed arrows), giving the impression of fenestration. AP: Anterior-posterior; L: Lateral.

Distal branches may occasionally be penetrated by the subintimal guidewire. Careful manipulation is necessary to prevent branch perforation due to the fragility of the intracranial branches. Additionally, the subintimal tracking technique should be avoided in the presence of major branches since subintimal balloon dilation or stenting may result in intima tears and subsequent branch occlusion. It is fortunate that the AICA, a significant branch, was preserved in this patient (Figure 6).

Additionally, the subintimal tracking technique may result in subintimal hematomas, which could compress the distal true lumen and hinder attempts of re-entry[25]. As a result, careful guidewire manipulation is necessary to prevent expanding the subintimal space. At present, we recommend avoiding subintimal guidewire manipulation for chronic intracranial occlusion whenever feasible, particularly for neuro-interventionalists with limited expertise in CTO recanalization.

CONCLUSION

We present a fortuitous case of successful subintimal recanalization for non-acute occlusion of the intracranial vertebral artery in an emergency endovascular procedure. However, we emphasize the necessity for caution when applying the subintimal tracking approach in intracranial occlusion due to the significant dangers involved. Nevertheless, we are optimistic that this case study will be beneficial for furthering understanding of this topic.

FOOTNOTES

Author contributions: Fu JF performed the manuscript writing; Zhang XL edited the figure of the article; Lee SY acquired the data; You JS and Zhang FM contributed to conceptualization and supervision; All authors contributed to the article and approved the submitted version.

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