Case Report

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Neurovascular management of intracranial internal carotid artery dissection post-carotid endarterectomy: A case report of an innovative approach

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Abstract:

Carotid endarterectomy (CEA) is an established method of stroke prevention in patients with severe carotid artery stenosis, especially in those with symptomatic disease. Complications of CEA include perioperative stroke, cranial nerve palsy, hemorrhage, and vascular dissection. We present an unusual case of a 66-year-old man who presented for elective right CEA for symptomatic 70% right internal carotid artery (ICA) stenosis due to ulcerated plaque. Following surgery, the patient developed fluctuating neurological deficits consistent with involvement of the right middle cerebral artery territory. Imaging revealed possible mild clamp-induced ICA dissection limited to the ICA in the neck. Despite initial successful anticoagulation management in the neurointensive care unit, the patient returned 2 days later with stroke symptoms, necessitating urgent endovascular intervention. Neurovascular interventions involved aspiration thrombectomy and multiple stenting extending distally into intracranial ICA, which successfully restored cerebral arterial perfusion and normal neurological function. This case highlights the first reported instance of extensive intracranial ICA dissection managed with full-length stenting. This article offers an effective endovascular procedure for preventing a devastating stroke from a complication of a procedure that was performed to prevent it.

Keywords:

Carotid endarterectomy, internal carotid artery dissection, internal carotid artery stenosis, penumbra

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Introduction

Carotid endarterectomy (CEA) is a surgical procedure that reduces the risk of stroke in patients who have high carotid artery stenosis.[1,2] Early surgery or intervention for symptomatic carotid artery stenosis is essential to prevent major cerebrovascular insufficiency.[3]

Although CEA is an established procedure with relatively low perioperative and postoperative complications, it carries the risk of stroke, cranial nerve injury, hematoma, and vascular dissection; the latter most often reported in the internal carotid artery (ICA).[4] Traumatic ICA dissections are among the most common injuries encountered during intraoperative manipulation of the vessel and often occur when tearing of intima and media layers develops within the ICA, proximal to the carotid bifurcation. This injury leads to hematoma and separation of the arterial layers in the ICA.[5,6]

Our case illustrates the clinical management of a 66-year-old man who underwent right CEA for a symptomatic 70% right ICA stenosis due to ulcerated plaque. The surgery was successfully performed and the patient, initially, was free of any complications. However, the patient

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had sustained a clamp injury post-CEA and started to develop significant postoperative complications, including ICA dissection and subsequent occlusion. This case is unique in that it is the first reported instance of extensive dissection extending to the intracranial ICA, necessitating full-length stenting for reconstruction. By stenting the extracranial and intracranial ICA, this article demonstrated a long-term effective method for addressing such extensive dissection of the ICA.

Case Report

We report the case of a 66-year-old male who presented with symptoms indicative of significant right ICA stenosis. Preoperative imaging confirmed a 70% stenosis in the right ICA that was caused by an ulcerated plaque. Due to the symptomatic nature of the stenosis, a right CEA was performed. The procedure was conducted under regional anesthesia without the use of a shunt. Due to the high carotid bifurcation, the distal ICA was exposed. The surgery was completed without intraoperative complications, and the ICA was repaired using a bovine pericardial patch.

Postoperatively, the patient exhibited mild left-sided weakness with a National Institutes of Health Stroke Scale (NIHSS) score of 0. An immediate duplex ultrasound revealed a patent ICA, meaning it is open and unobstructed. Computed tomography (CT) without contrast of the head was negative for stroke or intracranial bleeding. Despite these findings, the patient's neurological examination continued to fluctuate, prompting magnetic resonance imaging (MRI) and computed tomography angiography (CTA).

Based on the results from MRI with diffusion-weighted imaging and apparent diffusion coefficient, the patient displayed several acute diffusion-restricting right-sided infarcts, involving the right frontal and temporal lobes which measure 2–3 mm [Figure 1a]. The CTA revealed a clamp injury to the ICA and further dissection that was sustained from the CEA [Figure 1b]. In addition, a computed tomography perfusion (CTP) scan was performed which represented watershed ischemia in the right hemisphere, particularly in the middle cerebral artery (MCA)–posterior cerebral artery territories, with lesser involvement in the anterior cerebral artery-MCA regions. The CTP scan also demonstrated a 42% penumbra in the right MCA territory [Figure 1c]. Upon assessment of the penumbra, it was determined that the area with a T max >6 s corresponded to a volume of 42 cubic centimeters.

The patient was transferred to the neurointensive care unit with blood pressure systolic maintained around 140–160 mmHg. It is important to note that permissive hypertension was allowed to optimize cerebral perfusion and prevent further ischemic injury, especially given the risk of infarct core growth during acute ischemic events. Permissive hypertension is often recommended in the acute management of ischemic stroke to maintain sufficient cerebral blood flow, particularly when autoregulation is impaired. This approach is supported by guidelines from the American Heart Association/American Stroke Association, which suggest maintaining elevated blood pressure to ensure adequate perfusion in the setting of an acute stroke, provided that there are no contraindications such as intracranial hemorrhage or hypertensive encephalopathy.[7] The target range of systolic blood pressure of 140–160 mmHg was chosen based on these guidelines and the patient's clinical condition, balancing the need to prevent exacerbation of cerebral ischemia with the risks of excessive hypertension.

Moreover, magnetic resonance angiography (MRA) was performed the next day, revealing normal intracranial and extracranial vasculature with no evidence of significant vascular abnormalities that could suggest

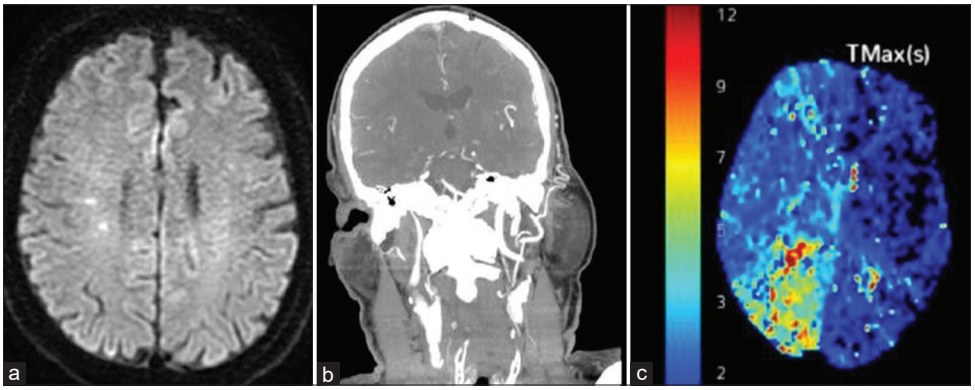

Figure 1: (a) Magnetic resonance imaging (MRI) of the brain was performed. Several acute diffusion-restricting right-sided infarcts noted through the MRI with diffusion-weighted imaging sequence. (b) Postsurgically, computed tomography (CT) angiogram of the neck and intracranial arterial circulation was obtained with Intravenous (IV) contrast. There is a clamp injury to the internal carotid artery and further dissection that was sustained from the CEA. (c) CT perfusion scan was performed which demonstrated a 42% penumbra in the right middle cerebral artery territory

acute ischemic injury [Figure 2]. The patient was discharged with apixaban and aspirin, an anticoagulant and antiplatelet agent respectfully. The patient was asked to take these medications for 3 months only and remain on aspirin monotherapy. The decision to continue aspirin monotherapy after 3 months was based on normal follow-up MRA findings, indicating no ongoing ischemia and stabilization of the patient's condition. Given the patient's clinical stability and a documented allergy to Plavix, the risk of bleeding with dual therapy outweighed the benefits. Aspirin alone was chosen as a safer option in the long run. This is consistent with guidelines that recommend tailoring treatment to individual risk factors, including bleeding risks and allergies.[8,9]

Two days later, the patient presented to the emergency room, displaying MCA distribution stroke-like symptoms with an NIHSS score of 8. A cervical–cerebral angiography demonstrated that the right ICA was open at the endarterectomy site, but a tapered occlusion of the distal ICA typical of dissection was seen [Figure 3]. The patient was not given thrombolysis for this new acute stroke as the dissection had no obvious thrombus burden. Since the patient was still on apixaban, a direct oral anticoagulant (DOAC), there was a significantly increased risk of hemorrhagic complications with the further administration of thrombolytic therapy, such as tissue plasminogen activator (tPA). Apixaban inhibits clot formation by blocking Factor Xa in the coagulation cascade, and its anticoagulant effect can make the use of tPA, which works to dissolve existing clots, especially dangerous. This combination increases the likelihood of uncontrollable bleeding, particularly intracranial hemorrhage.[8]

Given the dissection and neurological symptoms, urgent endovascular intervention was pursued to mitigate the neurological symptoms and treat the acute occlusion. An SL-10 microcatheter was advanced through the Neuron MAX into the distal right ICA over a Synchro 2 exchange guidewire. However, the clot had traveled further into the brain, necessitating an aspiration thrombectomy using a 6 French Sofia intermediate catheter to remove the clot from the ICA [Figure 4a]. Intracranial stenting was performed to address the dissection in the petrous segment of the ICA using a Resolute Onyx 4 mm × 15 mm balloon-expandable stent [Figure 4b and c]. This was followed by the placement of two additional Resolute Onyx stents in the cervical ICA. Recognizing the extensive nature of the dissection, an 8 mm × 40 mm PRECISE Stent was advanced from the carotid bulb to the mid-cervical ICA, providing further structural support and ensuring adequate blood flow restoration [Figure 4d-f].

The intervention was successful as the patient displayed normal neurological function. Since this was a case of an ischemic penumbra, there was no permanent injury induced in the brain.[10] Success of the interventions was confirmed by a 1-month follow-up of CTA which demonstrated a widely patent extracranial and intracranial stented ICA [Figure 5]. A 3-month follow-up ultrasound carotid Doppler was performed with spectral waveform analysis. The results demonstrated widely patent right proximal and distal ICA [Figures 6a and b]. A duplex ultrasound examination was conducted once for every 6 months, with the 21 months. The results demonstrated a widely patent stented ICA with no restenosis [Figures 6c and d]. Furthermore, the patient has remained asymptomatic for more than 2 years postintervention.

Discussion

Clamp-induced ICA dissection is a complication that can develop from CEA. Without prompt medical attention,

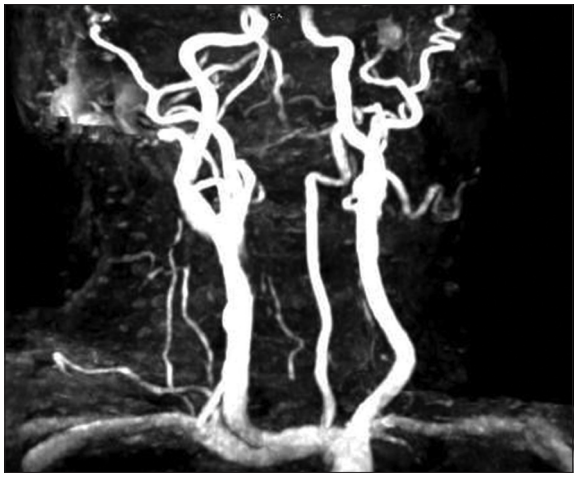

Figure 2: A magnetic resonance angiography was performed the following day of carotid endarterectomy, displaying normal results with no signs of acute ischemic injury

Figure 3: Cervical – Cerebral angiography via neuron max was performed. As the angiogram demonstrates, the right internal carotid artery (ICA) is open at the endarterectomy site, but a tapered occlusion of the distal ICA typical of dissection can be seen as demonstrated by the arrow

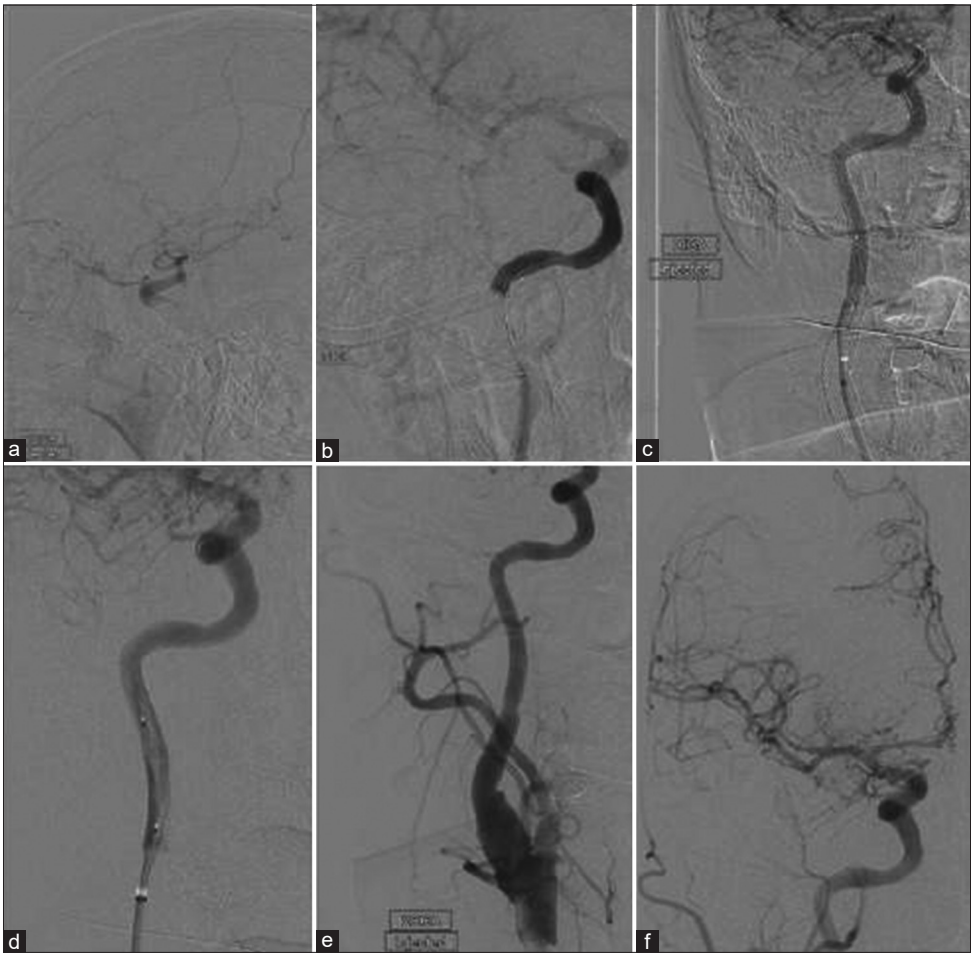

Figure 4: (a) Aspiration thrombectomy via 6 Fr. Sofia intermediate catheter was performed. (b) Resolute Onyx 4 mm × 15 mm balloon expandable stent in petrous internal carotid artery (ICA) was utilized. (c) Intracranial stenting of the petrous right ICA for long-segment dissection was performed. (d) Two additional resolute onyx stents in the cervical ICA were required to complete the repair. (e) 8 mm × 40 mm precise stent was applied from the bulb to mid-cervical ICA for extensive dissection. (f) Completion angiogram intracranial view can be seen

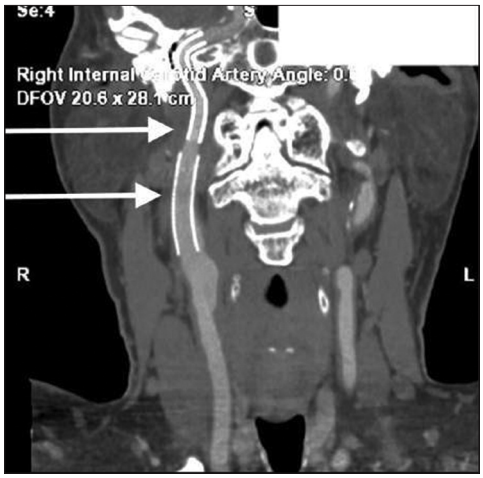

Figure 5: 1-month follow-up of computed tomography angiography demonstrated a widely patent extracranial and intracranial stented right internal carotid artery, as indicated by the white arrows (Note: Patient's name and information are erased with the white mark to ensure confidentiality)

patients face the risk of developing severe complications, such as acute carotid artery occlusion resulting in stroke in the short term followed by false aneurysm formation in the long term.[11-13] Previously reported clamp-induced ICA injuries have mostly been confined to the cervical area. For instance, Takahashi *et al*. reported a case of a 78-year-old patient who sustained a right ICA injury during CEA. During the procedure, the insertion of a shunt device caused active bleeding from the cervical ICA. For treatment, an emergent carotid artery stenting was performed using two overlapping stents, successfully managing the clamp injury and stopping the bleeding with no further complications.[14]

Similarly, a retrospective study by Ciaramella *et al*. reviewed patients who underwent distal ICA stenting during CEA between September 2008 and July 2022. Six male patients were primarily treated for asymptomatic carotid stenosis. Stenting was indicated for distal ICA dissection or inadequate endpoint of the endarterectomy in the ICA. Direct access through the common carotid artery followed by angioplasty and stenting using standard carotid stents was employed. The procedure

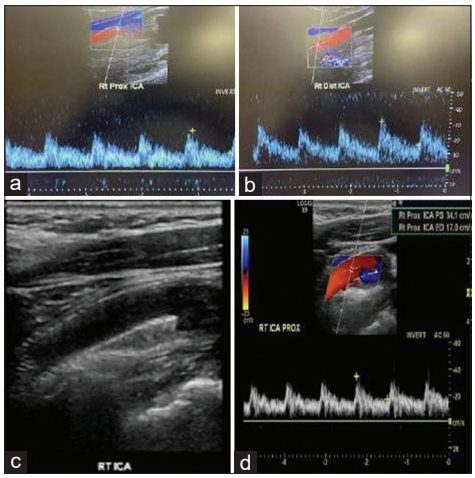

Figure 6: Three-month ultrasound carotid Doppler scan was conducted bilaterally demonstrating a widely patent internal carotid artery (ICA) and no restenosis. (a and b) Annual duplex ultrasound exams which were conducted once every 6 months for 21 months period, demonstrated a widely patent stented ICA with no restenosis (c and d)

had a 100% technical success rate, with no perioperative strokes or myocardial infarctions and a median hospital stay of 2 days. Over a median follow-up of 17 months, there were no strokes, carotid restenosis, or reinterventions.[15]

In contrast to previous reports, our case is novel because it involves a dissection extending into the intracranial ICA, needing a full-length stenting for reconstruction of the damaged artery. Intracranial ICA dissection presents a unique clinical challenge compared to cervical dissection due to its association with extensive strokes with very high mortality rates.[16] Intracranial involvement has a direct potential to impact critical cerebral arteries and brain perfusion, leading to more profound neurological deficits.[17] In our case, the rationale for stenting both the intracranial and extracranial portions of the ICA was driven by the extensive nature of the dissection, which posed a significant risk of recurrent ischemic events. While conservative management is often sufficient for cervical artery dissections, the severity of this dissection, coupled with symptomatic ischemia, necessitated an aggressive approach. The use of extensive stenting ensured long-term vessel patency and reduced the risk of further ischemic complications. Therefore, the decision to perform the procedure was made under general anesthesia.

Therefore, our case provides an endovascular treatment strategy that manages dissection in both the cervical and intracranial segments of the ICA. Such intervention can be potentially considered in similar cases. Furthermore, this approach mitigates the risk of extensive strokes and restores normal cerebral perfusion, resulting in minimal or no neurological deficits.

However, some limitations need to be considered and addressed by future studies. First, our finding is limited to a single patient presentation, which limits its generalizability. While our endovascular intervention was effective, it needs to be applied in larger patient populations with similar vascular conditions to truly understand its efficacy and safety. Furthermore, future studies need to also compare the outcomes of the intervention to other potential treatments or management strategies for ICA dissection extending into the intracranial region. This will truly ascertain the relative efficacy of our intervention.

Conclusion

This unique report describes the successful salvage of ICA dissection using pipeline stenting of both the extracranial and intracranial ICA, induced by a clamp injury during the performance of CEA. A successful durable result was obtained. The case is unique as it exemplifies neurorescue possible to improve patient outcomes in the domain of neurovascular interventions.

Author contributions

Bibhas Amatya: Definition of intellectual content, literature search, data acquisition, data analysis, manuscript preparation, manuscript editing, manuscript review. Dipankar Mukherjee: Concepts, design, definition of intellectual content, literature search, data acquisition, data analysis, manuscript preparation, manuscript editing, manuscript review. Ameet Chitale: data acquisition, data analysis, manuscript revising and review.

Ethical policy and institutional review board statement

Not applicable.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understands that his name and initials will not be published and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Data availability statement

All data generated and/or analyzed during this study are included in this article.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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