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Case Report

Radiological findings and endovascular management of internal carotid artery pseudoaneurysm in the setting of mucormycosis and COVID-19

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Abstract

The coronavirus pandemic is now a public health emergency and has spread to nearly 206 countries across the globe. This novel disease has shaken the psycho-social, economic, and medical infrastructure of India. This has become even more challenging, considering the country's huge population. With the increase in the number of coronavirus disease (COVID) cases, our country has seen an unforeseen, unprecedented rise in a potential life and organ-threatening disease—mucormycosis. Mucormycosis is a deadly, extremely morbid, possibly life-threatening, and most feared complication of the coronavirus, caused by environmental molds belonging to the order Mucorales. Here, we report 2 cases of massive epistaxis due to internal carotid artery (ICA) pseudoaneurysm secondary to mucormycosis, post-COVID-19 pneumonia, which was managed by the endovascular route. To the best of our knowledge, there is very sparse literature available describing endovascular treatment of intracranial ICA pseudoaneurysm in a patient with COVID-induced mucormycosis.

Keywords: mucormycosis; COVID; pseudoaneurysm; endovascular.

Summary

The coronavirus pandemic is now a public health emergency and has spread to nearly 206 countries across the globe. In January 2020, the coronavirus disease-2019 (COVID-19) was declared a Public Health Emergency of International Concern (PHEIC).[1] With the rise in the cases of COVID, several new side effects of this virus have become apparent, including an increased risk of secondary bacterial and fungal infections.[2-5] Mucormycosis, now a well-known complication of COVID-19 in immunocompromised patients, is a deadly, and one of the most feared complications of the coronavirus. It spreads across tissue planes, to involve paranasal sinuses. The sphenoid sinus is a common route of spread of mucor to the cavernous sinus.[6] Due to its angio-invasive nature, it can invade the arterial wall, forming pseudoaneurysms.

Here, we report 2 cases of massive epistaxis due to internal carotid artery (ICA) pseudoaneurysm secondary to mucormycosis, post-COVID-19 pneumonia, which was managed by the endovascular route.

To the best of our knowledge, there is very sparse literature available describing endovascular treatment of intracranial ICA pseudoaneurysms in patients with COVID-induced mucormycosis.

Case 1

Clinical presentation

A 64-year-old man, known diabetic and hypertensive, presented with a bout of massive epistaxis (around 120 mL) and 2 episodes of syncope. He had a history of COVID pneumonia 6 months ago and was subsequently diagnosed with mucormycosis. He underwent nasal endoscopy with debridement twice and was on intravenous liposomal amphotericin B for 1 month. Following this, he started having epistaxis. He had multiple episodes of epistaxis since then with progressively increasing quantity over the last 2 months. On examination, the patient was haemodynamically stable. Nasal packing was done. Lab parameters revealed anaemia (haemoglobin—7.4 g/dL).

Imaging findings

MRI brain with orbits and paranasal sinuses for mucormycosis and CT angiogram (CTA) were advised for epistaxis. MRI (Figures 1A and B) showed bilateral maxillary, ethmoid, and sphenoid sinusitis with enhancing soft tissue in the left cavernous sinus and pachymeningeal enhancement along the left anterior temporal lobe (black arrow in Figure 1A). An additional T2 flow void (block arrow in Figure 1D) was seen adjacent to the left cavernous ICA flow void, with a laminated mixed-intensity thrombus (elbow arrow in Figure 1D) adjacent to it, strongly suggestive of a left ICA pseudoaneurysm.

CT of the brain with angiography was performed and revealed a large pseudoaneurysm arising from the cavernous portion of the left ICA (chevron arrow in Figure 1E and F) projecting into the sphenoid sinus in the background of invasive fungal sinusitis and skull base osteomyelitis (Figure 1C, star in Figure 1D).

An emergency digital subtraction angiogram (DSA) revealed a large pseudoaneurysm arising from the

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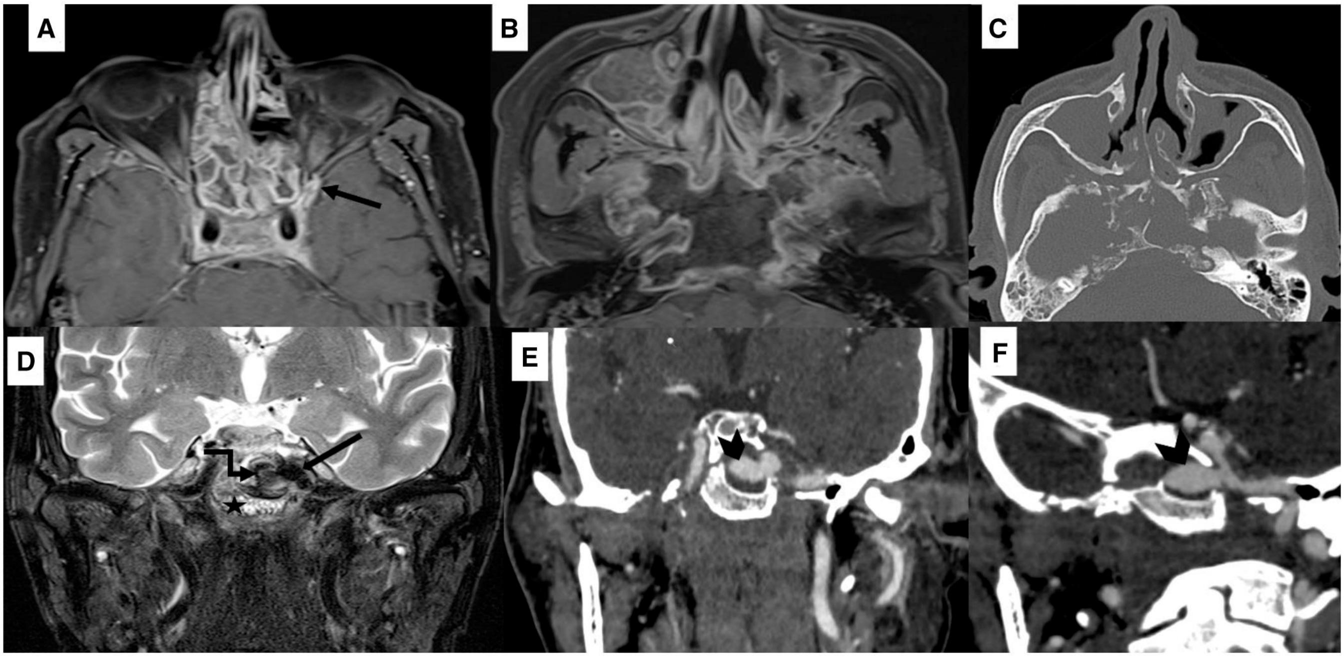

Figure 1. MR axial T1-weighted post-contrast images (A and B) shows an enlarged left cavernous sinus with mild pachymeningeal enhancement along the left medial temporal lobe (black arrow) and mucosal thickening of bilateral ethmoid sinuses. There is extensive skull base osteomyelitis with destruction of the clivus and bilateral petrous temporal bone with abnormal post-contrast enhancement in both pterygopalatine fossae. (C) CT brain in bone window shows osteolytic destruction of the clivus, body of sphenoid, petrous part of bilateral temporal bones and bilateral pterygoid plates. (D) MR T2-weighted fat saturated image shows an additional flow void (block arrow) medial to the cavernous portion of the left ICA projecting into the sphenoid sinus and posteriorly into the eroded petrous bone. There is a mixed density laminated thrombus around it (elbow arrow). There is hyperintense signal in the body of the sphenoid suggesting fungal involvement (star). CT angiogram (maximum intensity projection) in oblique (E) and coronal plane (F) shows a large pseudoaneurysm (chevron arrow) arising from the cavernous portion of the left ICA projecting into the sphenoid sinus.

anteromedial wall of the proximal C5 segment of the left cavernous ICA (Figure 2A and B). The pseudoaneurysm was bulging into the sphenoid sinus. There was mild focal narrowing in the distal petrous segment of the left ICA (arrowhead in Figure 2A). There was contour irregularity and mild narrowing in the entire proximal cavernous (C5 segment) of the left ICA suggestive of vasculitis secondary to fungal invasion in the setting of mucormycosis. There was a foetal left posterior cerebral artery (PCA). On cross-compression study from the right ICA, there was a small calibre anterior communicating artery (Acom) with faint opacification of the left anterior cerebral artery. Vertebral angiograms showed a hypoplastic P1 segment of the left posterior cerebral artery (PCA).

Treatment and outcome

Urgent endovascular treatment was planned. As there was poor cross flow through a small calibre Acom and foetal PCA, the treatment approach needed to be targeted towards the preservation of the left ICA. The treatment options were stent grafts and flow diversion. An appropriately sized stent graft that could be negotiated into the cavernous ICA was not available, hence, flow diversion was opted as the best treatment choice.

Under general anaesthesia, right 8 Fr and left 6 Fr femoral arterial access were taken.

A coaxial system was used with Neuron Max long sheath and 5F Navien distal access catheter.

Phenom 27 microcatheter was negotiated over a Synchro microwire across the cavernous pseudoaneurysm. Pipeline Flex embolization Device with shield technology (5 × 35 mm) was then deployed across the rent of the pseudoaneurysm in the petro-cavernous segment of the left ICA.

DynaCT angiogram with maximum intensity projection (MIP) reconstruction (notched arrow in Figure 2E and G) and plain radiograph (Figure 2F) showed good apposition of the stent.

The final angiogram showed stasis in the pseudoaneurysm (Figure 2C and D) with good distal flow.

Follow-up

In the postoperative period, there was epistaxis through the anterior and posterior nasal packs, hence, one antiplatelet drug was stopped and he was kept only on Ticagrelor. His packs were changed to Nasopore (bioresorbable and dissolvable nasal packing) which could be placed for a longer duration. He was started on intravenous liposomal amphotericin. There was no further episode of epistaxis.

CT brain angiogram was performed after 1 month, which showed complete thrombosis of the pseudoaneurysm (Figure 2H) with good reconstruction of the cavernous ICA. The patient was discharged after 8 weeks of treatment for mucormycosis. Follow-up angiogram done at 8 months showed complete obliteration of the aneurysm with mild intimal hyperplasia in the stented segment (Figure 2I).

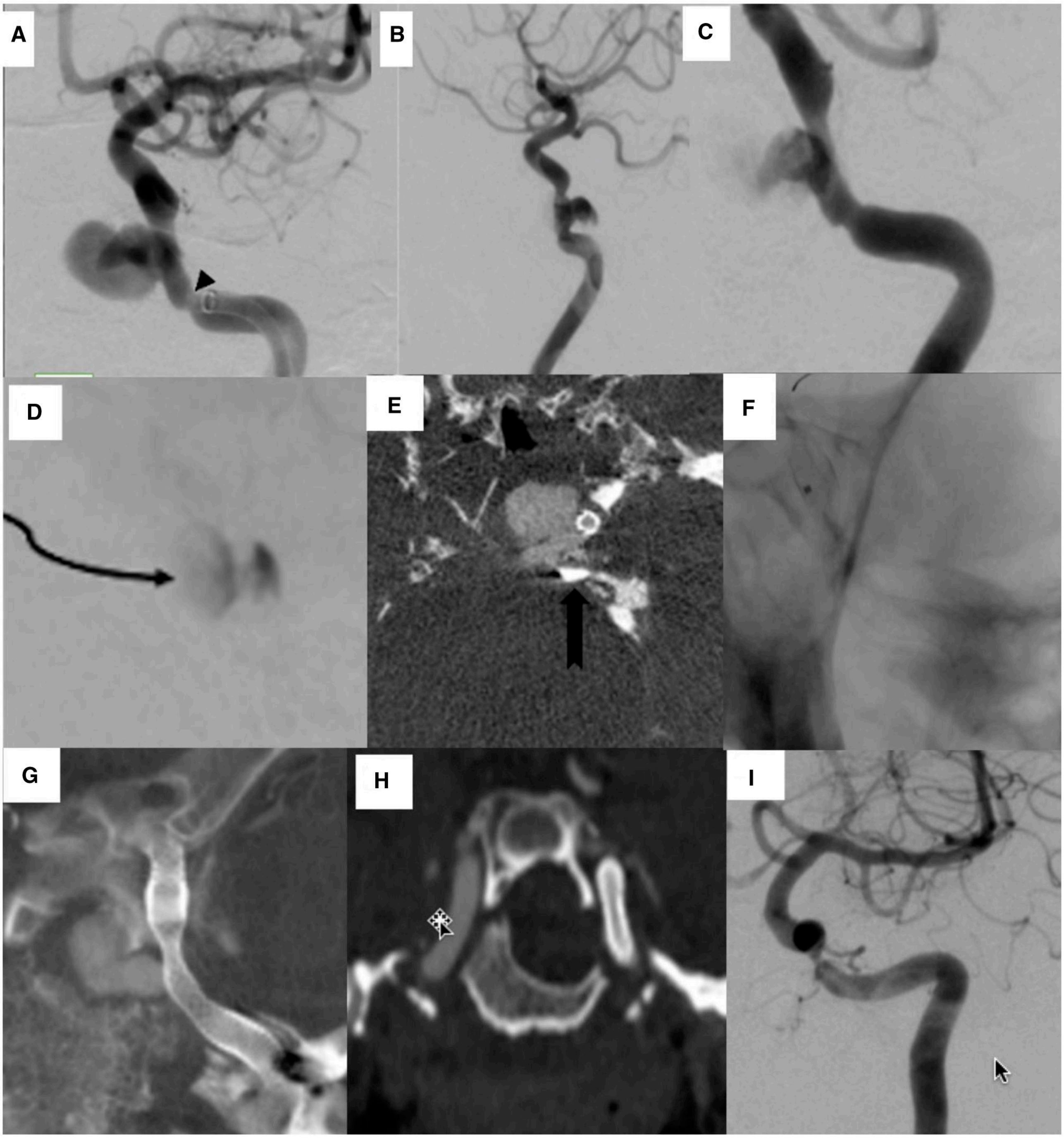

Figure 2. Digital subtraction angiogram in Towne's view (A) and lateral view (B) shows a large pseudoaneurysm arising from the petro-cavernous segment of the left ICA. The pseudoaneurysm is projecting medially into the sphenoid sinus with extension posteriorly into the body of the sphenoid and the clivus. There is narrowing of the distal petrous segment and proximal cavernous segment, adjacent to the rent (arrowhead). Endovascular treatment was performed using a flow diverter (Pipeline Embolization Device, Medtronic Pvt Ltd). Left ICA angiogram post-stent placement (C and D) shows good calibre of the stented segment with stasis within the pseudoaneurysm (curved arrow). Dyna CT angiogram axial section (E) post-stent placement shows reconstruction of the left cavernous ICA with contrast stasis (notched arrow). Plain radiograph (F) and Dyna CT angiogram reconstructed MIP image (G) shows flow diverter stent apposition. A thick MIP coronal section of the CT angiogram (H) done 8 weeks after the procedure shows thrombosis of the pseudoaneurysm and good flow through the stented segment of the cavernous ICA. Cerebral angiography (I) performed 8 months later revealed complete obliteration of the aneurysm with preservation of ICA and good distal flow.

Case 2

Clinical presentation

A 51-year-old male presented with intermittent epistaxis, pain, and numbness in the left half of the face and head. He underwent anterior nasal packing at a local hospital before presenting to us. He was a known diabetic and developed COVID pneumonia followed by mucormycosis 1 month ago, for which he underwent endoscopic debridement twice.

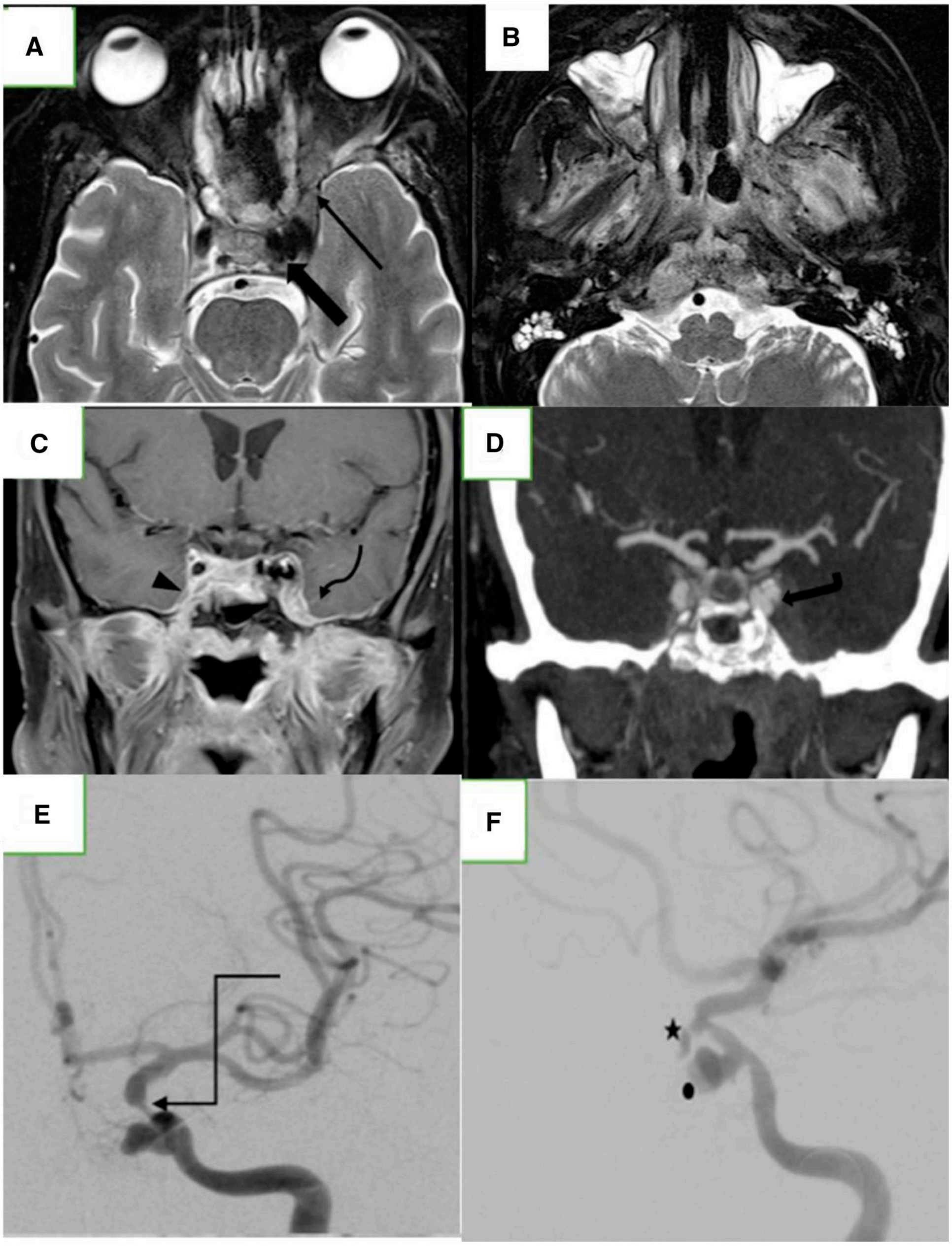

Figure 3. A 51-year-old male with COVID 19 infection and intermittent epistaxis. MRI T2-weighted fat saturated image (A) shows T2 intermediate intensity abnormal soft tissue in the left orbital apex (black arrow) with mild ethmoid sinusitis. There is an abnormal flow void adjacent to the left ICA (block arrow), raising suspicion of pseudoaneurysm. MRI T2-weighted fat saturated image (B) shows mucosal thickening in bilateral maxillary sinuses with T2 hyperintense signal in bilateral pterygoid muscles and clivus. Post-contrast T1-weighted image (C) shows bulky left cavernous sinus with abnormal pachymeningeal enhancement along the left medial temporal lobe (curved arrow). There is abnormal post-contrast enhancement of the mandibular division of the right trigeminal nerve suggesting perineural extension (arrowhead). CT angiogram coronal section with MIP reconstruction (D) shows the left cavernous ICA pseudoaneurysm (thick bent arrow). Left ICA Towne's view (E) shows a pseudoaneurysm arising from the cavernous ICA with narrowing of the distal cavernous segment (elbow arrow). Anterior cerebral and middle cerebral artery branches are normal. Left ICA left anterior oblique view (F) shows 2 rents in the cavernous segment of ICA, one small rent in the proximal C3 segment (star) and another large rent in the distal C3 segment of cavernous ICA (circle).

On examination, he was haemodynamically stable. Laboratory parameters showed anaemia (haemoglobin of 7.3 g/dL).

Imaging findings

MR of the brain with paranasal sinuses and orbits showed abnormal T2 flow void adjacent to the cavernous segment of the left ICA (block arrow in Figure 3A) with abnormal T2 intermediate signal intensity soft tissue in the left orbital apex (arrow in Figure 3A) and abnormal pachymeningeal enhancement along the left medial temporal lobe (curved arrow in Figure 3C). There was perineural extension along the right mandibular nerve (arrowhead in Figure 3C). Post functional endoscopic sinus surgery changes were seen in the nose and bilateral paranasal sinuses.

CT with angiogram revealed a pseudoaneurysm arising from the left cavernous ICA (bent block arrow in Figure 2D).

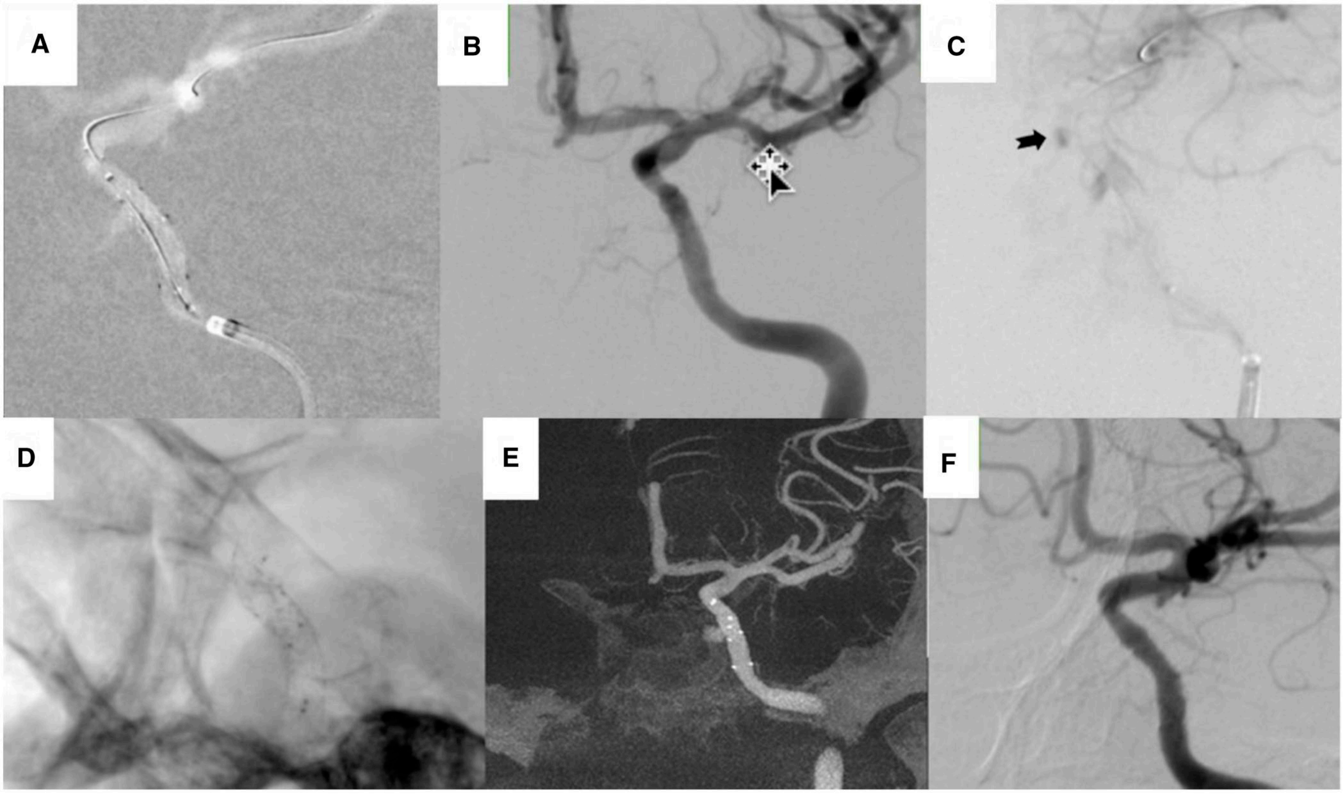

Figure 4. Intraoperative cerebral angiography road map image of the left ICA angiogram (A) shows deployment of the overlapping Xcalibur stents covering both the rents in the ICA. Post-stent left ICA angiogram (B and C) shows good apposition of the stents with significant improvement in the calibre of the distal cavernous ICA and stasis (notched arrow) in both pseudoaneurysms. Plain Radiograph (D) shows the overlapping stents with good apposition along the C1 and C2 segment of cavernous ICA. Dyna CT angiogram (E) confirms the apposition of the stent. Left ICA angiogram (F) 2 days post-stent placement shows complete thrombosis of the pseudoaneurysm with good calibre of the stented segment.

DSA revealed narrowing (elbow arrow in Figure 3E) in the distal cavernous left ICA with 2 rents in the C3 segment(dot and star in Figure 3F). The pseudoaneurysms were seen projecting into the sphenoid sinus.

Treatment and outcome

Urgent endovascular treatment was planned under general anaesthesia. A coaxial system was used with Neuron Max long sheath and 6F Neuron guiding catheter. Synchro microwire was negotiated across the diseased segment of the ICA into the posterior temporal branch of the left middle cerebral artery (MCA). Subsequently, an XCalibur Aneurysm Occlusion device (3.25 × 30 mm) was deployed across the distal cavernous ICA (Figure 4A). Another overlapping stent (4.5 × 30 mm) was used to cover both the rents. Post-stent left ICA angiogram showed good apposition of the stents with significant improvement in the calibre (Figure 4B) of the distal cavernous ICA and stasis (notched arrow in Figure 4C) in both the pseudoaneurysms.

The final angiogram and DynaCT MIP reconstruction showed stasis in the pseudoaneurysm with good distal flow (Figure 4E). There was good apposition of the stent.

Follow-up

He had a stable postoperative course with no further epistaxis. Follow-up cerebral DSA was performed after 48 h and showed complete thrombosis of pseudoaneurysm with good patency of the stent (Figure 4F). At 1-month follow-up, there was good clinical recovery and no further episodes of epistaxis. CTA performed at 1-year follow-up showed good patency of the stented segment.

Discussion

'Zygomycosis' is a taxonomic term for invasive fungal infections caused by Zygomycetes, which reproduce by the formation of sexual spores called zygospores. Mucormycosis is an angio-invasive, deadly infection caused by fungi belonging to the order Mucorales.[7] It is characterized by extensive invasion of vessel walls causing vascular thrombosis and tissue necrosis, especially in immunocompromised patients.[8] These pathogens colonize the sphenoid sinus which is separated from the ICA and intracranial compartment by a thin bony lateral sphenoid wall.[9] This is the most common mode of intracranial spread of this disease.

Intracranial involvement is characterized by meningeal enhancement, dural sinus thrombosis, cerebral abscess, haemorrhage, ICA occlusion, and pseudoaneurysms of the intracranial vasculature. The cause of the pseudoaneurysms in such cases is attributed to the infectious occlusion of the vasa vasorum and subsequent focal weakening of the vessel wall.[10,11] Cavernous ICA pseudoaneurysms most commonly present with mass effect on the surrounding neurological structures causing diplopia, visual disturbances, and facial paraesthesia.[12] Infectious pseudoaneurysms are less predictable, follow a malignant course and confer a higher risk of catastrophic complications including rupture, when compared to non-infectious aneurysms.[13-18]

Epistaxis is a rare symptom of carotid artery pseudoaneurysms leading to frequent delay in diagnosis with potentially disastrous results.[16] In the setting of mucormycosis, the clinician must have a high index of suspicion for a possible underlying pseudoaneurysm, when the epistaxis is severe, recurrent, and not controlled even by posterior nasal packing. An angiogram must be urgently advised in such patients.

MRI, due to its superior soft-tissue contrast, is the preferred modality, in the detection of perineural spread, orbital, meningeal, skull base, cavernous sinus, and ICA involvement.[19]

CT is preferred to assess bone erosion and involvement and widening of skull base foramina, an indirect indicator of perineural spread.

Fungal hyphae tend to deposit heavy metals resulting in variable (often dark) signals on T2-weighted imaging. Hence, T2-weighted sequence may underestimate disease extent and must be read in conjunction with other sequences.[20] Also, an additional flow void on T2-weighted images must raise alarm bells for possible ICA involvement and subsequent pseudoaneurysm, and angiography must be advised. Hence, the radiologist must be extremely vigilant and aware of the potentially catastrophic effects mucormycosis can have on intracranial vasculature.

Intravenous liposomal amphotericin is the first-line treatment option in mucormycosis.[21] However, these drugs do not penetrate necrotic tissue. Hence, tissue debridement is key in these patients.[22] The pseudoaneurysms are contained by the thrombus and the soft tissue debris around it which prevents bleeding. Post debridement, there is exposure of the pseudoaneurysm, leading to increased epistaxis. This clinical finding should strongly raise the suspicion of an underlying pseudoaneurysm, and further evaluation should be considered.

Recently, endovascular therapy is considered one of the mainstays in the treatment of cavernous ICA infectious pseudoaneurysms with treatment options ranging from parent vessel occlusion to parent vessel preservation techniques.[6] Parent vessel occlusion can be performed only if there is good collateral flow and should be the treatment of choice in patients with good collateralisation.[23]

In the absence of good collaterals and good surgical candidacy, bypass followed by parent artery occlusion is an alternative option to parent vessel preservation techniques.[24-26] Bypass could be superficial temporal artery – middle cerebral artery (STA-MCA) bypass or high flow bypass using radial artery or saphenous vein graft. Although STA-MCA bypass is a technically easier procedure to perform, the blood flow through it is much lesser than ICA and hence, high flow bypass is always preferred.[27]

Parent vessel preservation techniques include stent-grafts, balloon mounted flow diverters (excalibur), flow diverters with and without coils. There are limited options of stent graft available for neurovascular use. If anatomy is simple and the sizing of the target vessel is suitable then stent graft is a good option. Flow diverters are a good alternative option with or without coils; however, it is safer if nasal packing is done in the perioperative period and continued for 1–2 weeks postoperatively. This will give adequate time for initiating aneurysmal thrombosis. Flow diverters are specifically suitable if the pseudoaneurysm is there for more than 2 weeks duration which allows better containment of aneurysm in the sphenoid sinus, thereby reducing the risk of bleed postoperatively.

Very sparse literature is available on the use of flow diverter stents in the endovascular management on infectious pseudoaneurysms and its safety and long-term effectiveness. However, it is an emerging and useful indication.[28-30]

Parent artery occlusion may be chosen over parent vessel preservation techniques in such patients due to the friable nature of these infected vessel walls and better source control. On the other hand, flow diverter placement has certain advantages, including preservation of distal perfusion and hence a lower risk of ischaemic complications, although the risk of haemorrhage is higher.

Kim et al[31] reported a case of fungal ICA aneurysm treated with a stent graft. The patient, however, went on to develop 2 new aneurysms downstream to the affected ICA and it was postulated that these aneurysms were mycotic and had developed secondary to stent infection.

Both options, that is, parent artery occlusion with high flow bypass and endovascular flow diverter placement were explained to both the patients with its advantages and possible complications. Both the patients opted for endovascular flow diverter placement.

The advent of flow diverters and devices like XCalibur, have revolutionized the treatment of cavernous ICA pseudoaneurysms and enabled good delayed reconstruction of the diseased ICA with stable occlusion of pseudoaneurysms. This has helped the neurointerventionists to incline towards ICA preservation techniques.

While most coil embolization procedures, such as balloon-aided and stent-assisted coiling, are aimed at the pseudoaneurysm sac (endo-saccular approach), flow diverters constitute a paradigm shift because they are used in the parent artery, resulting in endoluminal reconstruction with eventual aneurysm thrombosis.[32,33]

A flow diverter is a safe and durable option for wide-necked, large aneurysms as it covers the neck of the aneurysm limiting the inflow of blood and promoting thrombosis. It also results in better neo-endothelialization of the vessel wall as compared to stents alone.[34,35] It is gradually being used as the first choice for such aneurysms.

We, hereby, report 2 cases of post-COVID mucormycosis with ICA pseudoaneurysms due to fungal vascular invasion. In both cases, there was narrowing and irregularity of the cavernous segments of ICA suggestive of vasculitis along with pseudoaneurysms. In addition, one of the patients had 2 rents suggesting the invasive nature of the disease.

Both our patients were middle-aged diabetics with poor cross flow and active fungal infection at the time of presentation. ICA preservation is a priority in such cases and the availability of flow diverters had simplified our decision-making. There is good clinical and imaging outcome in both the patients with more than 8 months of follow-up. The Pipeline with Shield Technology helps to reduce the use of antiplatelet drugs in patients who have nasal bleeds.[36,37]

Balloon-mounted flow diverters, that is, XCalibur is a microporous polymer membrane-covered implant providing high surface coverage and rapid thrombosis of pseudoaneurysms. Some of the patients may require prolonged nasal packing which is now safely possible with bioresorbable and dissolvable nasal packing, which provides time for pseudoaneurysm thrombosis. Flow diversion is a relatively safe and durable technique for cavernous ICA pseudoaneurysms especially coated Flow diverters (The Pipeline Flex Embolization Device with Shield Technology, Medtronic) which can be placed without the need of antiplatelets if the situation arises.[38,39]

Learning points

- This report illustrates 2 cases of infectious cavernous ICA pseudoaneurysms post mucormycosis secondary to COVID pneumonia.
- Through this report, we would like to emphasize the importance of early and prompt diagnosis of vascular complications of mucormycosis by both the treating physician and the interpreting radiologist, especially in the presence of red flags like massive epistaxis post debridement and abnormal T2 flow voids on cross-sectional imaging.
- Today, endovascular therapy is the cornerstone in the management of infectious pseudoaneurysms and ICA preservation with flow diverter placement is a relatively safe and durable option in such patients.

Funding

None declared.

Conflicts of interest

None declared.

Consent for publication

Consent to publish has been duly obtained from both patients and an attempt has been made to maintain their anonymity.

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