THE ROLE OF INTERVENTIONAL RADIOLOGY IN CAROTID CAVERNOUS FISTULA (CCF)

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OUTLINE

1. Introduction
2. Carotid Cavernous Fistula (CCF)
3. The Role of Interventional Radiology in CCF
4. Conclusion

INTRODUCTION

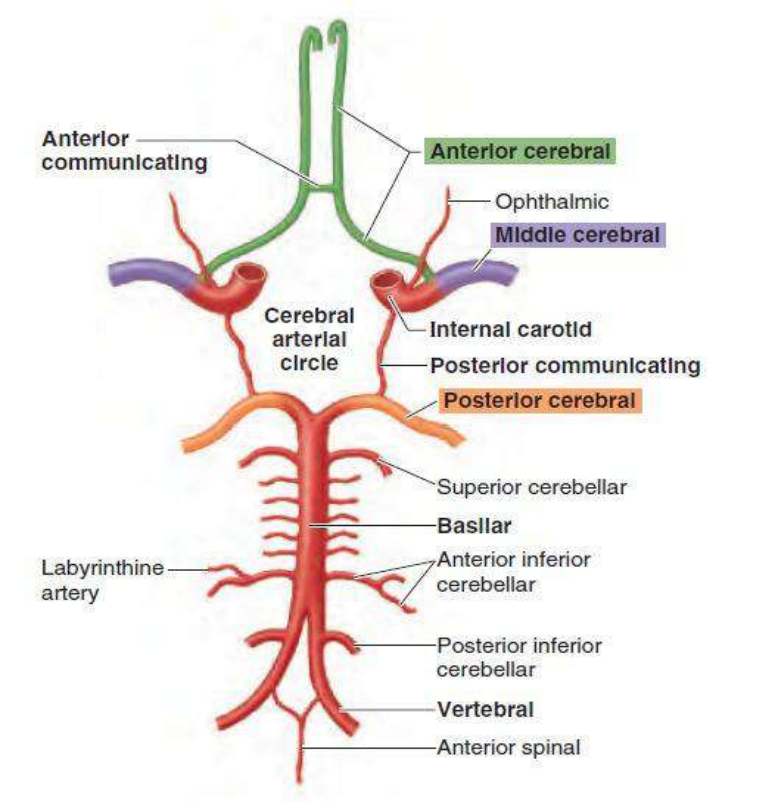
Carotid Cavernous Fistula (CCF)

- A vascular shunt that allows blood to flow from the carotid artery to the cavernous sinus.
- Clinical manifestations: bruits, diplopia, blurred vision, headaches.

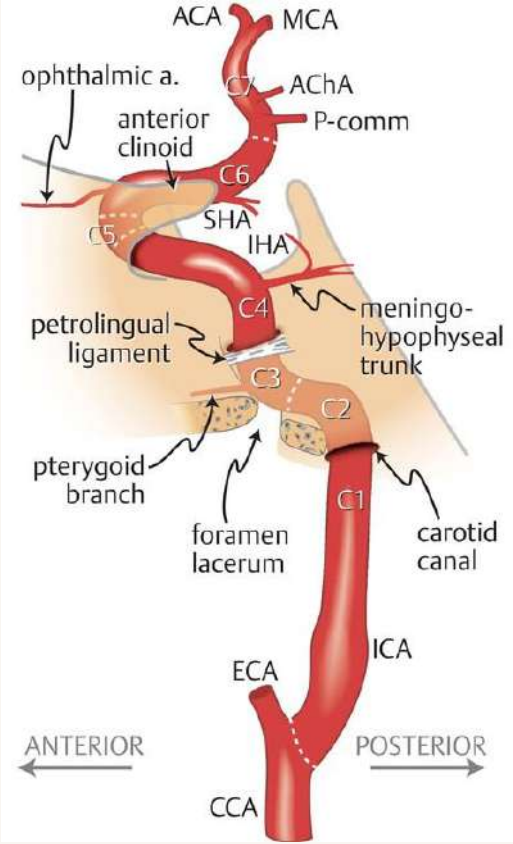
Radiology role in CCF cases

- Gold standard examination for the diagnosis of CCF
- Interventional radiology with endovascular techniques → first-line treatment modality for most CCFs.

ANATOMY
Vascular - Circle of Willis



Internal Carotid Artery



Embryology of Veins and Cavernous Sinus

At 4–5 weeks, neural tube is surrounded by a network of primitive capillary

The primitive capillary plexus drains into 3 venous plexuses in the dural layer.

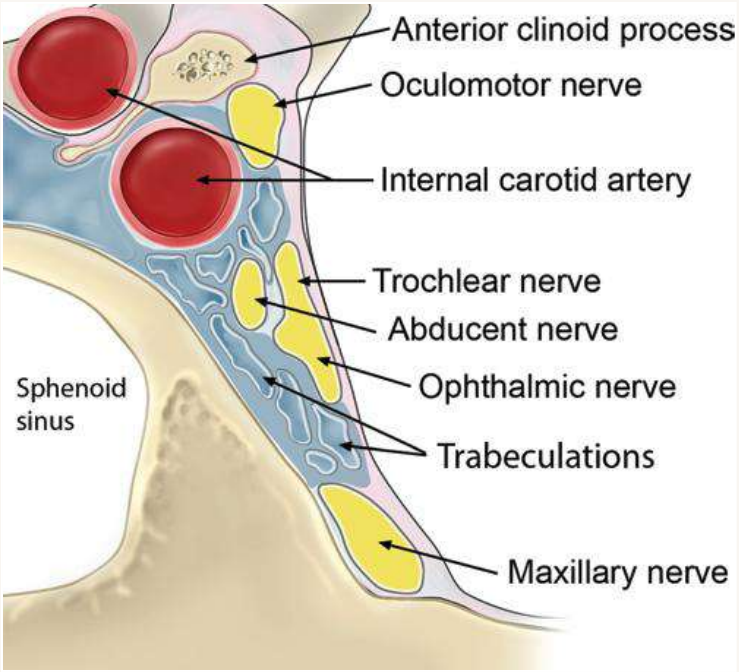
Dural plexus will empty in the ventral into the primary head sinus (PHS).

The pro-otic sinus and the primitive tentorial sinus → become prominent

The medial branch of the prootic sinus

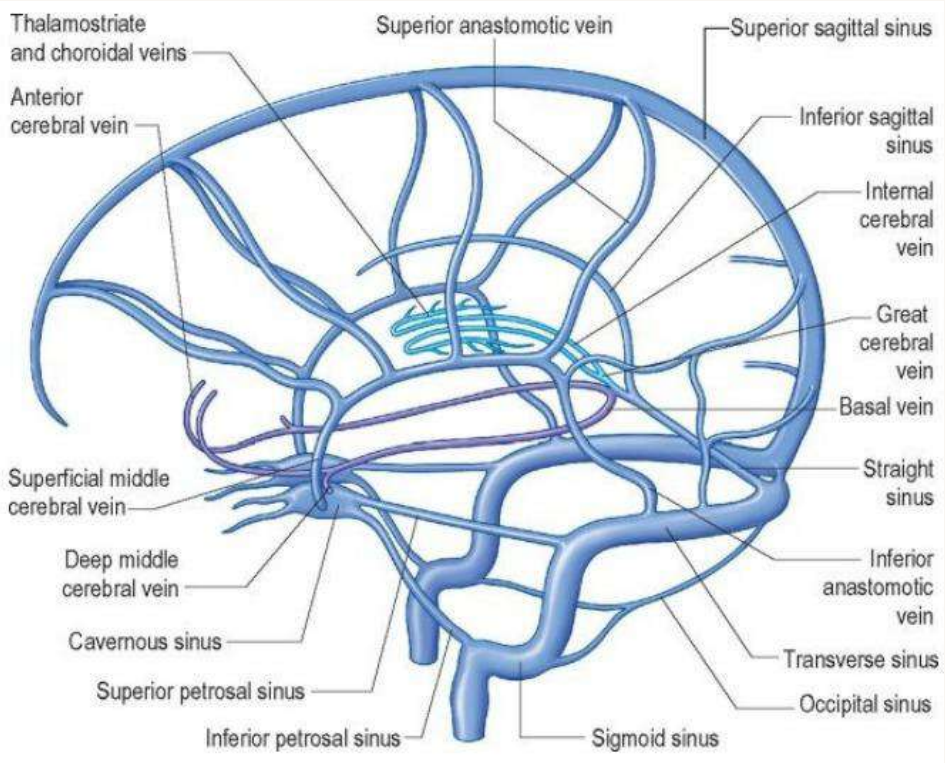
Cavernous sinus

Anatomy of Cavernous Sinus



- The cavernous sinus is on average 2 cm anteroposterior, 1 cm laterally, and vertically 1.3 cm.
- The major nerve and blood vessel structures that tranverse the cavernous sinus

Cavernous Sinus



Carotid Cavernous Fistula (CCF)

DEFINITION :

- A vascular shunt that allows blood to flow from the carotid artery to the cavernous sinus.
- Carotid cavernous fistula have been classified according to the hemodynamic, aetiological, and anatomical characteristics of the fistula.

Type	Classification
Hemodynamic	High-flow vs low-flow
Etiology	Spontaneous vs traumatic
Anatomy	Direct vs indirect

Etiology and Epidemiology

Traumatic CCF is the most common type of CCF, accounting for up to 75% of all CCFs.

Bilateral CCF is seen in 1%-2% of patients with posttraumatic CCF.

Spontaneous CCF account for approximately 30% of all CCF, usually found in older female patients.

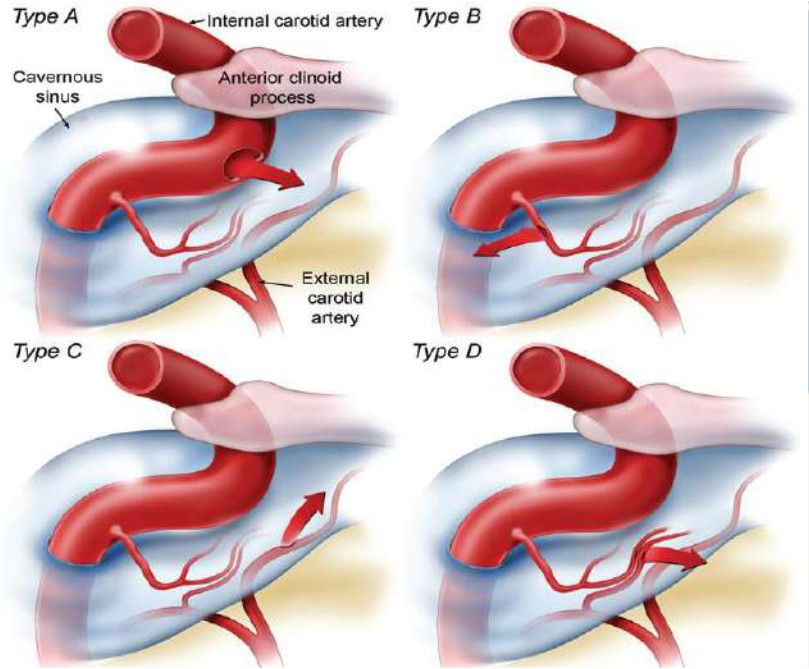
CCF is reported to occur in 3% to 24% of patients with carotid cavernous aneurysms

Barrow's Classification

Type A: direct shunting from ICA to the cavernous sinus.

Types B and C: shunting to the sinus of the ICA branch and ECA.

Type D: shunting of the ICA and ECA.



Pathophysiology

Shunting of blood between the high-flow arterial system and the low-flow venous system

Increased vascular pressure and resistance in the venous system.

Back-up and vascular congestion in the area normally drained by the cavernous sinus.

Obstruction in and around the sinuses explains the clinical features and possible adverse sequelae of CCF

Clinical Manifestations

Bruit

Diplopia

Abducens nerve paresis

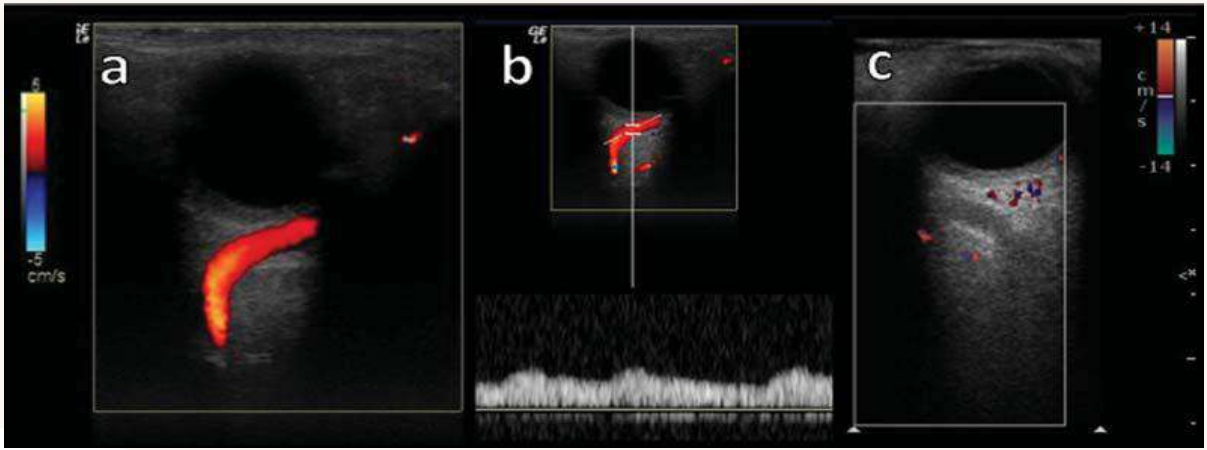
Oculomotor nerve paresis

Blurred vision

Headache

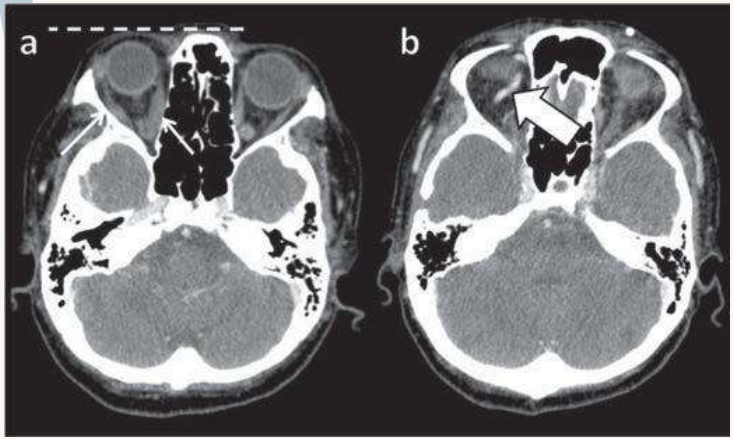
Radiological Features
Orbital Doppler Ultrasound

- Arteriovenous fistula (AVF) in the cavernous sinus is indicated by color Doppler **backflow or thrombosis of the superior ophthalmic vein (SOV).**
- Examination using spectral Doppler → arterialization with low resistance flow



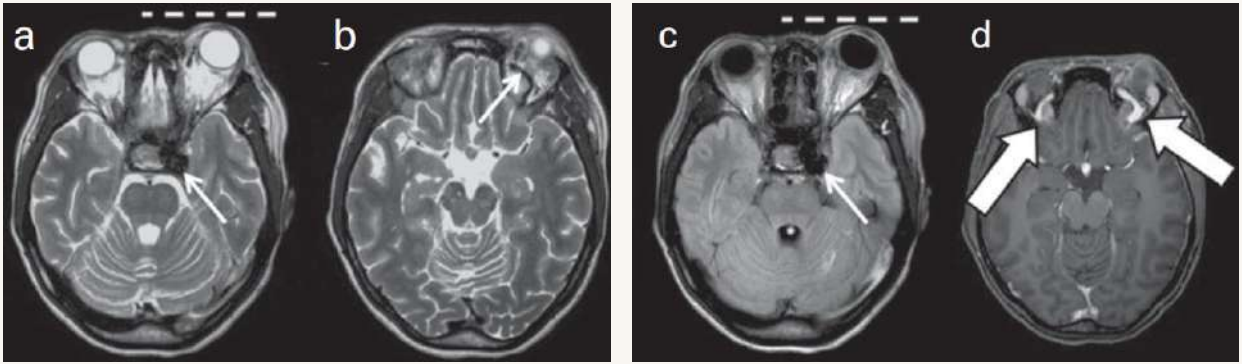
Radiological Features
Computed Tomography Scan (CT scan)

- **SOV dilatation or thrombosis**, extraocular muscle thickening, and periorbital lipid edema
- Increased flow in direct CCF → **cavernous sinus dilatation.**
- Cavernous sinus **enhancement** → used to differentiate fistulas



Radiological Features
Magnetic Resonance Imaging (MRI)

- Minimum SOV dilatation, smooth proptosis and small extraocular muscle thickening.
- Reflux into the dural sinuses and cortical veins



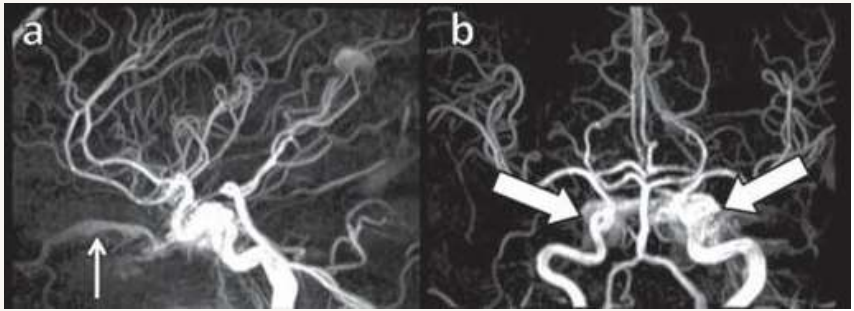
High flow in the sinus and left SOV (thin arrow).

Increased volume → proptosis (thin arrow).

Enhancement and ecstasy of SOV (bold arrows).

Radiological Features
Magnetic Resonance Angiography (MRA)

- Initial contrast enhancement in the cavernous sinus, superior ophthalmic vein and fistula venous drainage.



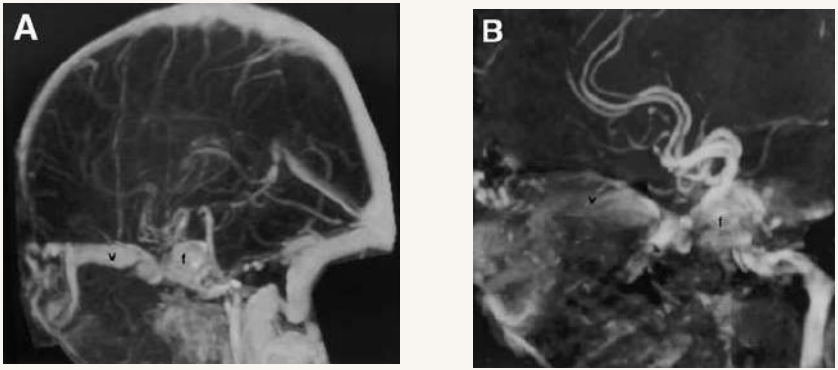
Contrast enhancement of the left sinus

Reflux into the right sinus (bold arrow).

Enhancement of SOV (thin arrow).

Radiological Features
Magnetic Resonance Venogram (MRV)

- Provide better visualization for carotid cavernous fistula
- Directly visualize venous angioma and arteriovenous fistula locations and determine the location and extent of dural sinus involvement.



Fistula (f), orbital vein and dilated ophthalmic vein (v) are better seen on contrast-enhanced sagittal 3-D gradient–echo MRV
(A) than sagittal 3-D TOF MRA (B) contrast

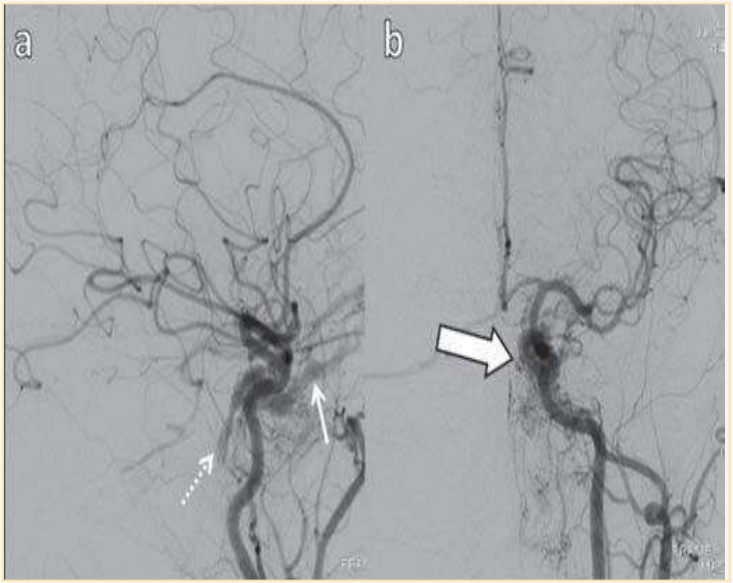
Radiological Features
Angiography

Angiography is the **gold standard** diagnostic examination for CCF

High flow	• Rapid filling of the cavernous sinus through the fistula with minimal or no intracranial vascular filling.
Low flow	• Slower filling of the cerebral venous system through the fistula, with retained intracranial arterial filling.
CCF Traumatic	• In traumatic CCF, laceration of the associated vessels and dilatation of the cavernous sinus can be observed

Radiological features
Angiography

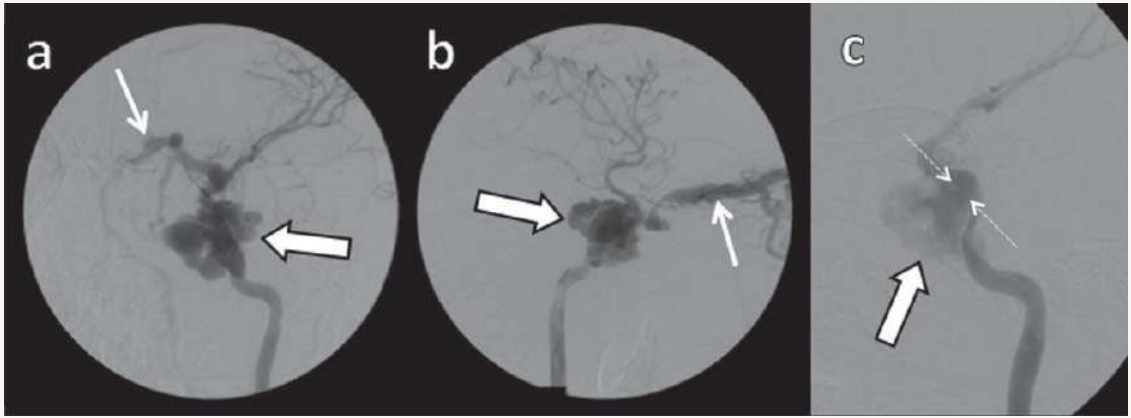
Digital subtraction angiography (DSA)
Spontaneous CCF



- Increased contrast (bold arrow).
- Dilatation and enhancement of SOV (thin arrows).
- Anterior drainage to SOV and posterior drainage to IPS (dotted arrow)
- Several small meningeal branches (bold arrow).

Radiological Features
Angiography

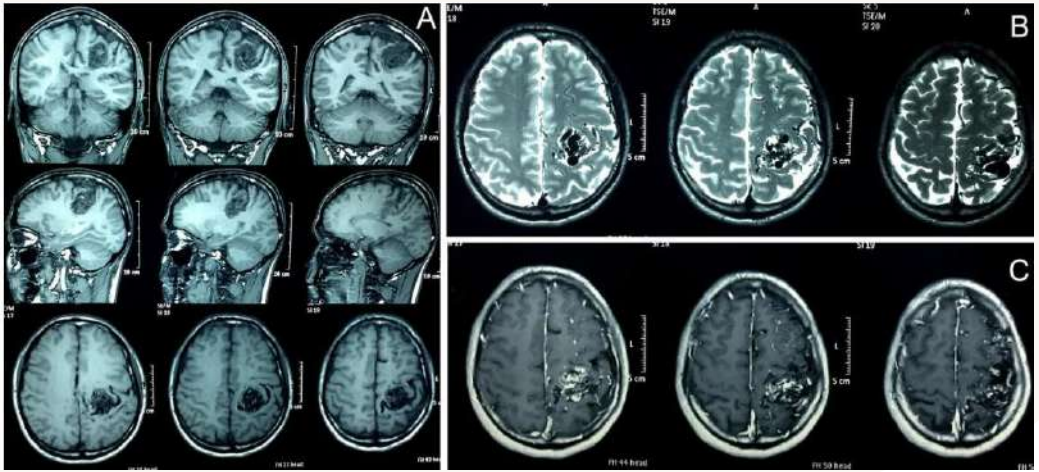
Digital subtraction angiography (DSA)
Traumatic CCF



- Initial CS contrast enhancement (bold arrow).
- Initial drainage to an ecstatic SOV (thin arrow).
- Laceration of ICA (between the dotted arrows).

Differential Diagnosis
Arteriovenous Malformations

- Arteriovenous malformations (AVMs) : A developmental anomalies of the vascular system → the arteries are directly connected to the venous drainage without a capillary system.

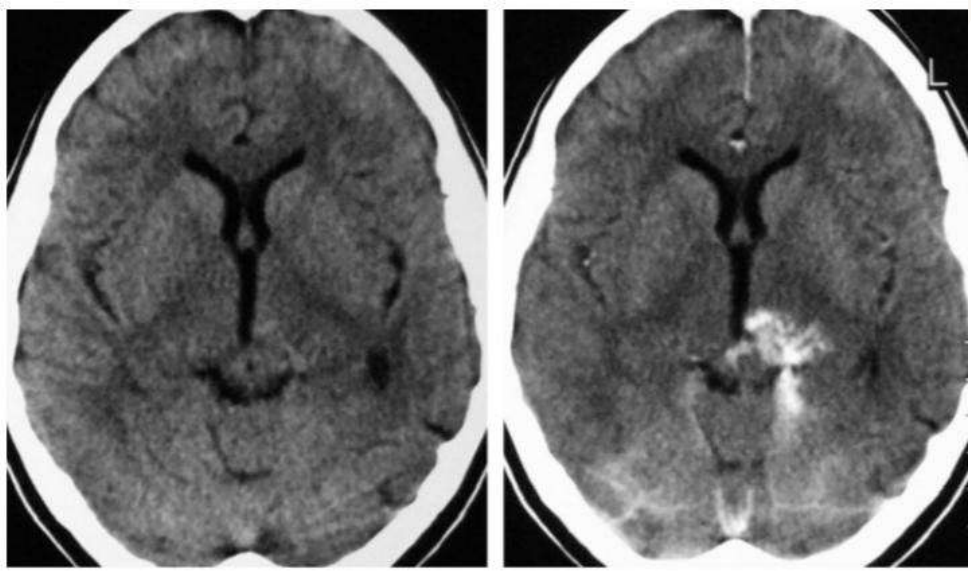


Homogeneous hypointense lesion in left postcentral gyrus

"flow-voids" within the lesion

Contrast MRI (figure 1C) → homogeneous lesion became heterogen

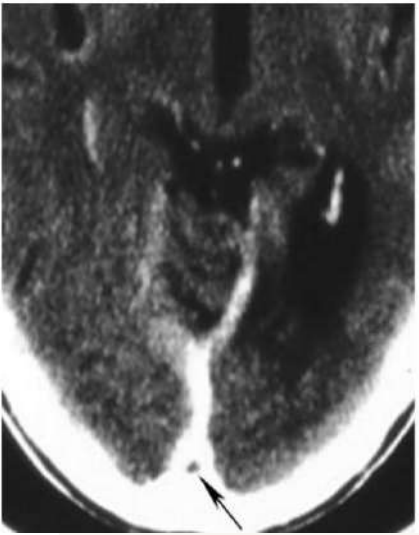
Arteriovenous Malformations



- Visible bilateral cranial nerve VI palsy on physical examination.
- (a, b) Axial CT scan without contrast (a) and with contrast (b) Increased vascular structures in the left thalamus.

Cavernous Sinus Thrombosis

- CST can occur as a complication of facial infections, sinusitis, orbital cellulitis, pharyngitis, or otitis or after traumatic injury or surgery.



Contrast CT

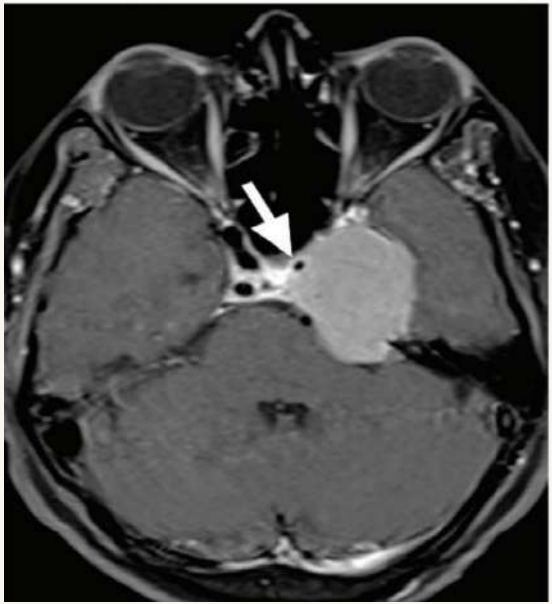
- Superior sagittal sinus thrombosis
- Central filling defect, surrounded by a stinging dura mater.

Coronal MR venography contrast

- Nonenhanced thrombus (arrows) surrounded by a sinus wall and dural cavernous space.

Cavernous Sinus Tumor

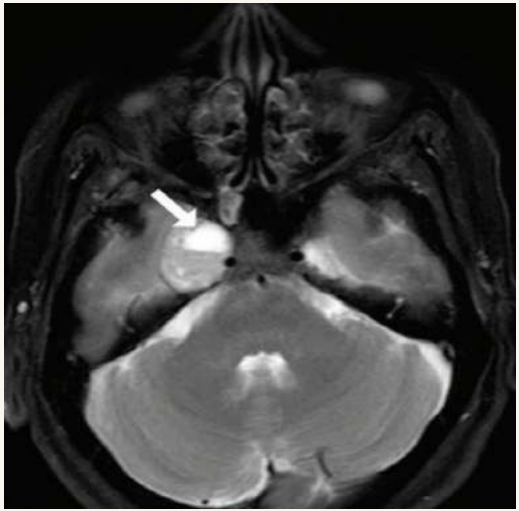
- Common neoplasms involving the cavernous sinus include pituitary adenomas, meningiomas, neural sheath tumors, nasopharyngeal carcinoma, and metastases.



Cavernous sinus meningioma in a 50-year-old woman.

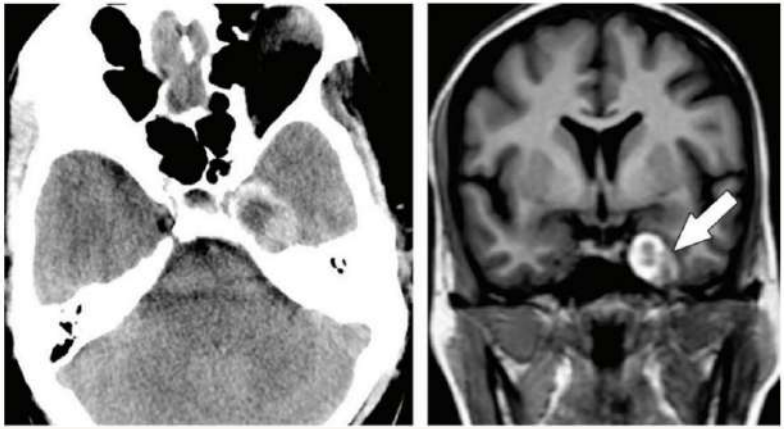
- T1 sequence MRI with enhanced fat-suppressed axial contrast.
- Homogeneously increasing mass.
- Narrowed empty flow from left ICA (arrow)

Cavernous Sinus Tumor



Schwanoma

- Axial fat-suppressed T2 MRI
- Hyperintense lesion in the right cavernous sinus



Cavernous sinus melanoma

- (a) CT → a mass with peripheral hyperattenuation in the left cavernous sinus.
- (b) T1 MRI coronal section showing a hyperintensity mass (arrow).

Management

1. External manual carotid compression
2. Surgical Ligation
3. Interventional Radiology

Management
The Role Of Interventional Radiology

Transarterial or transvenosus embolization

First-line treatment modality for most CCFs.

This procedure intentionally injects emboli (blockage material) into selected blood vessels

Efficacy

Endovascular coiling close the fistula in 90% cases

Endovascular management in CCF is the right choice since it is minimally invasive and has lower risk of cerebral infarction

Types of Embolizing Agents

Stent graft

Liquid embolism

N-butyl cyanoacrylate (acrylic glue)

Ethylene vinyl alcohol copolymer

Platinum coil

- Focal occlusion
- The coil cannot be picked up after extruding

Detachable balloon

- First line therapy
- ICA patency 59 - 88%
- Block large blood vessels
- Can be repositioned

Preparations

Make sure the patient is diagnosed with CCF

All procedures are performed under general anesthesia

Catheter and sheath preparation

- Prepare a 5F vascular sheath and a 6F vascular sheath, a 100 cm long 4F H1 catheter and a 90 cm 6F or 5F guiding catheter, two 150 cm long microcatheters with an inside diameter of 0.017'.
- Prepare a 150 cm guidewire with a diameter of 0.035' and a length of 200 cm with a diameter of 0.014'.

Check the pulse of the femoral artery

Endovascular Embolization With Coil

Percutaneous injection of the **left femoral artery** and insertion of the **5F** vascular sheath with the modified Seldinger technique

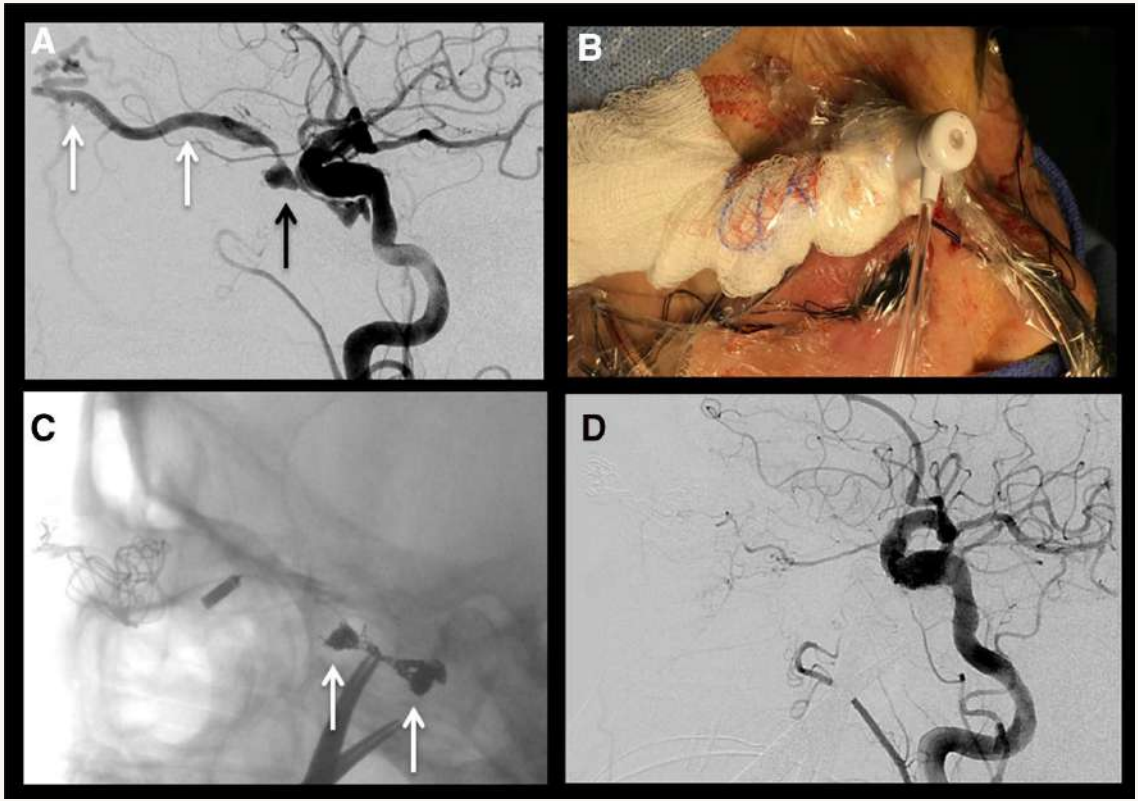
Inject the right **femoral vein percutaneously** and insert the **6F** vein sheath with the same technique

Position the **guiding catheter** 6F or 5F through the sheath with continuous heparin saline solution (1000 U of heparin diluted per 500 mL)

Confirm IPS with **angiography**

Coaxially guide two microcatheters with microwires **into the cavernous sinus** through the IPS and slowly **inject contrast** medium

Endovascular Embolization With Coil



Endovascular Embolization With Balloon

Test ICA occlusion manually or with a balloon

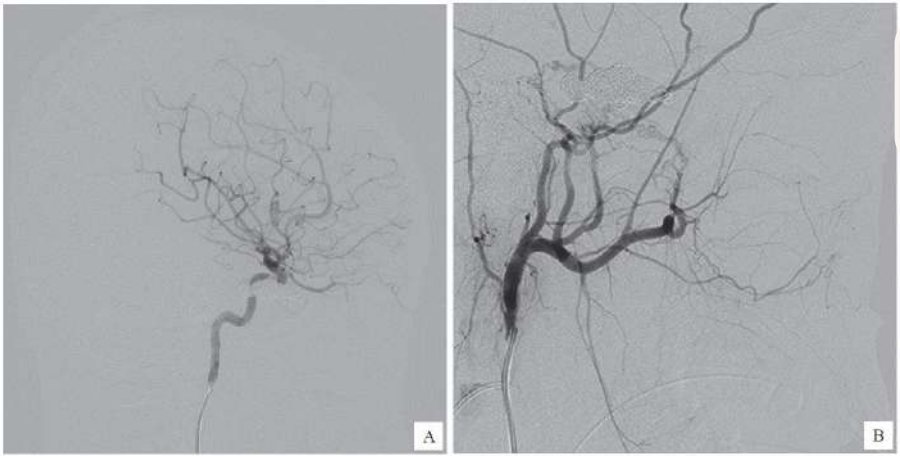
The balloon is attached to the end of the microcatheter with the support of microguidewires

The balloon is navigated across the fistula gap until it reaches the cavernous sinus compartment

The balloon is inflated until the fistula shows complete obliteration

Management

- Transarterial approach → a microcatheter is passed through the fistula into the cavernous sinus.
- Transvenous approach → cavernous sinus is accessed via the inferior petrosal sinus.



Post coil embolization

- Right ICA (A) and ECA(B) angiography
- **Complete obliteration** of the fistula and its retrograde venous flow.

Complication

- Pseudoaneurysm
- Micro coil does not decompose
- Delayed onset diplopia
- Cerebral infarction
- Decreased visual acuity
- Femoral vein thrombosis
- Ophthalmoplegia
- Subarachnoid or intracerebral hemorrhage
- Rupture of sinus
- Extradural contrast extravasation
- Cranial nerve paresis.

Direct Carotid-Cavernous Fistula

Transarterial Coiling and Onyx Embolization under Balloon protection

Sandeep Burathoki

Interventional Neuroradiologist

Conclusion

Endovascular embolization is the first-line therapy for the management of carotid cavernous fistula (CCF).

Approach

- Direct CCF can use the transarterial approach
- Indirect CCF can use the transvenosus approach

Emboli agent

- Detachable balloon, coil, liquid, ethylene-vinyl alcohol copolymer, and n-butyl cyanoacrylate (acrylic glue).
- **Coil and balloon** embolization: **first-line therapy for CFF.**

Efficacy

- Endovascular coiling can close the fistula through radiological evaluation in **90% of cases**.


thank
you