Carotid-Cavernous Fistula

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[Etiology 1](#_Toc6534189)

[Pathophysiology 1](#_Toc6534190)

[Classification 1](#_Toc6534191)

[Clinical Features 1](#_Toc6534192)

[Diagnosis 2](#_Toc6534193)

[Treatment 3](#_Toc6534194)

[Prognosis 3](#_Toc6534195)

[Other AV fistulae 3](#_Toc6534196)

CCF - dural fistula characterized by A-V shunting within cavernous sinus.

* cavernous sinus is network of venous channels traversed by intracranial portion of internal carotid artery.

Etiology

1. **head trauma** (75-80%) - ***blunt*** (esp. with temporal or sphenoid bone fractures) or ***penetrating*** (i.e. shearing or laceration of intracavernous ICA, incl. iatrogenic angiographic injury).
2. **spontaneous** (≈ 20%) - associated with (1)***ruptured intracavernous aneurysm***, (2)***fibromuscular dysplasia***, (3)***Ehlers-Danlos syndrome*** and other collagen vascular diseases, (4)atherosclerotic vascular disease, (5)pregnancy, (6)straining.

Pathophysiology

- ***high-pressure arterial blood*** enters ***low-pressure venous cavernous sinus*** → interference with normal venous drainage → *compromised blood flow* within cavernous sinus (cerebral venous infarction may occur) and orbit (ophthalmic venous hypertension and orbital venous congestion).

* can be **bilateral**.

Classification

Direct type (70-90%):

Type A fistula - direct connection between **intracavernous ICA** and cavernous sinus.

* high-flow and high-pressure fistulas → fast progression of clinical features!!!
* more common in *young males*.
* most commonly traumatic etiology.

Dural types:

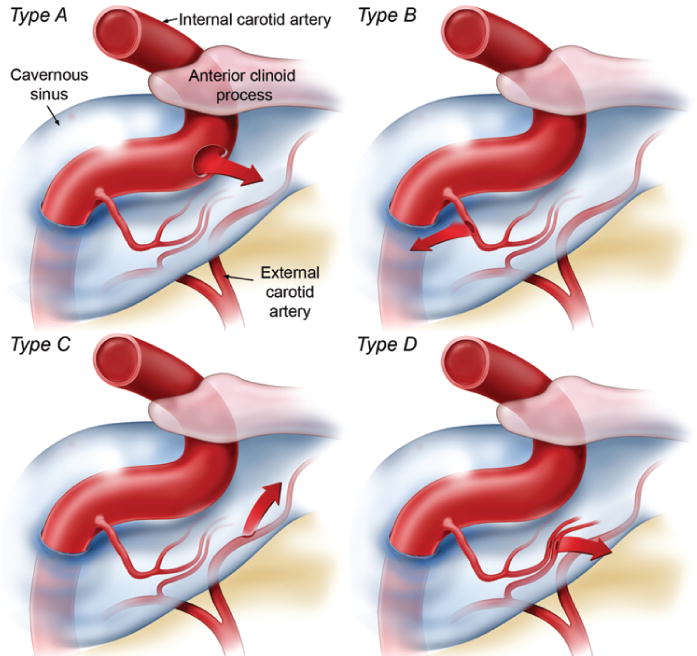
* low-flow.
* more common in *women > 50 years* (7:1 female-to-male ratio).
* most commonly spontaneous etiology.

Type B fistula - dural shunt between intracavernous branches of **ICA** and cavernous sinus.

Type C fistula - dural shunt between meningeal branches of **ECA** and cavernous sinus.

Type D fistula - **combination** of types B and C (i.e. dural shunts between ICA and ECA branches and cavernous sinus).

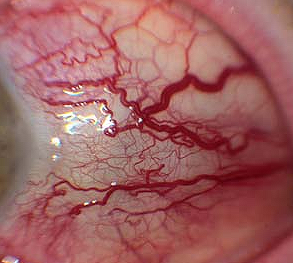
Diagrammatic representation of 4 types of fistulas:



Clinical Features

- sudden onset:

1. Ipsilateral **ocular manifestations**:
   1. progressive pulsatile proptosis (→ corneal exposure → dehydration, traumatization), chemosis (dilated and tortuous episcleral and conjunctival vessels), arterialization of episcleral veins, edema of conjunctiva and periorbital soft tissues.
   2. cranial nerve palsy (III-VI) ipsilaterally or bilaterally.
   3. progressive (over days or weeks) monocular visual loss in late stages
   4. dilatation of retinal veins, optic disc swelling, retinopathy.
   5. central retinal vein occlusion → secondary open-angle glaucoma.

1. Self-audible **bruit** synchronous with pulse (**pulsatile tinnitus**);

* many are also audible to examiner – at temple or orbit.
* reduced by manual occlusion of carotid artery in neck (recession of exophthalmos may also be observed).

1. **Headache** (± other signs of ICP↑)
2. Exsanguinating **epistaxis** (H: place Foley into nose and hold manual carotid compression on the side of bleed while transporting to OR)

Diagnosis

1. **CTA** (look for dilated ophthalmic veins\*, contrast extravasation).

\*esp. superior ophthalmic vein (SOV)!

1. **Selective carotid angiography** (high-­speed digital subtraction imaging in multiple views of both bilateral ICA and ECA\*) - diagnostic test of choice (confirms diagnosis): early filling of cavernous sinus and its draining tributaries (esp. ophthalmic veins).

\*only for spontaneous fistulas

1. **Contrast CT of orbit** - proptosis, swelling of extraocular muscles, dilation of superior ophthalmic vein (→ enlarged superior orbital fissure), enlarged cavernous sinus.
2. **Orbital ultrasound** - findings as CT.
3. **Complete ophthalmologic workup**: visual acuity, funduscopy (direct and indirect), intraocular pressure & gonioscopy.

Ask ophthalmologist to measure IOP!!!!

**A–D** (axial contrast CT): right cavernous sinus (A, *thick black arrow*) is enlarged, and large enhancing mass runs forwards into orbit through widened superior orbital fissure (B, *arrowheads*); sigmoid structure (*open arrow* in C) in upper part of right orbit represents greatly dilated superior ophthalmic vein (cf. normal left side in C, *small white arrow*); some extraocular muscles are thicker than on left, and there is marked right proptosis.

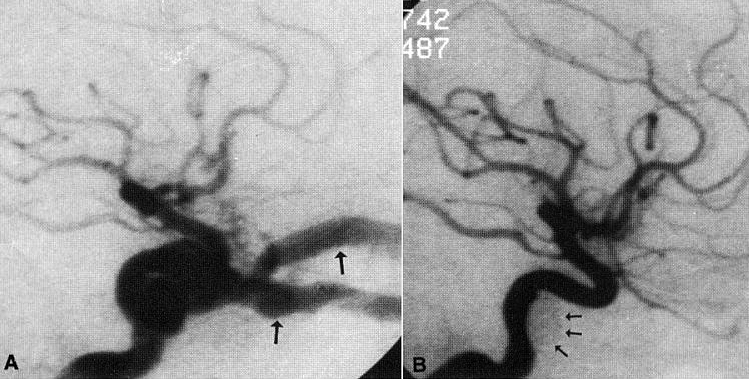
**E** (right ICA intra-arterial DSA, lateral projection, arterial phase) - contrast medium floods into cavernous sinus (S), and drains forwards into grossly dilated superior ophthalmic vein (V); there is also shunting posteriorly and via inferior petrosal sinus (P); intracranial arterial filling is poor.

**F, G** - after therapeutic detachment of balloon (B) in cavernous sinus (F, lateral projection), shunting particularly anteriorly, is greatly reduced, and intracranial filling much improved (G):



A. Left ICA (lateral DSA) - rapid opacification of cavernous sinus and both superior and inferior ophthalmic veins (*arrows*).

B. Following detachment of balloon (*arrows*) within cavernous sinus - fistula is occluded and ICA now appears normal.



Carotid angiogram - large communication (*vertical arrow*) between ICA (above) and cavernous sinus; in addition to enlarged orbital veins that drain forward from cavernous sinus, there is backward drainage through petrosal sinus (*horizontal arrow*):



Treatment

Measure IOP – if > 20 → emergent treatment!

Cortical venous drainage → treat!

In acute setting of vision loss / CN paralysis, **glucocorticoids** (e.g. dexamethasone), Diamox may be used while waiting for definitive diagnosis and treatment.

Type-A fistulas rarely resolve spontaneously because of high flow (fistula enlarges, causing decreased chances of visual recovery).

* treatment indications - progressive visual loss (main complication!!!), intolerable bruit, cosmetic effects of proptosis.

Definitive management - **obliteration of fistulous connection** with preservation of ICA patency:

* 1. **Endovascular approach** - through arterial approach (N.B. ICA hole may be big – use balloon-assisted technique!)
     1. detachable coils – preferred method (pack cavernous sinus as much as you can) for simple and complex fistulas
     2. Onyx – if one simple cavity with one arterial feeder
     3. detachable balloon
     4. ICA stenting (pipeline) across fistula may have role.
  2. **Direct** **surgical exposure and obliteration** of fistula (now rarely indicated).
* symptoms & signs improve within days after treatment, but complete resolution may take weeks to months.
* severely refractory fistulas → surgical or endovascular **sacrifice of ICA** (+ clipping of supracavernous segment proximal to PComA to prevent fistula from stealing blood from cerebral vasculature).

Type B, C, D fistulas have higher incidence of *spontaneous resolution*.

* **carotid self-compression** for 20-30 seconds 4 times per hour may lead to fistula thrombosis.
* patient is instructed to compress carotid artery on side of lesion using contralateral hand (should patient develop cerebral ischemia during compression, contralateral hand likely will be affected, releasing compression).
* if compression is not effective or if more rapid intervention is indicated → **endovascular fistula embolization**

N.B. may prefer venous approach (posterior approach via *inferior petrosal sinus* or transocular via *superior ophthalmic vein*\*) \*surgically expose vein to allow direct cannulation

Prognosis

* recurrence rate 1-3.9%.
* routine ***follow-up angiogram*** - to ensure that fistula has not recurred or that alternate fistulous pathways have not developed. (H: second balloon treatment)

Other AV fistulae

- abnormal com­munications between artery and vein secondary to:

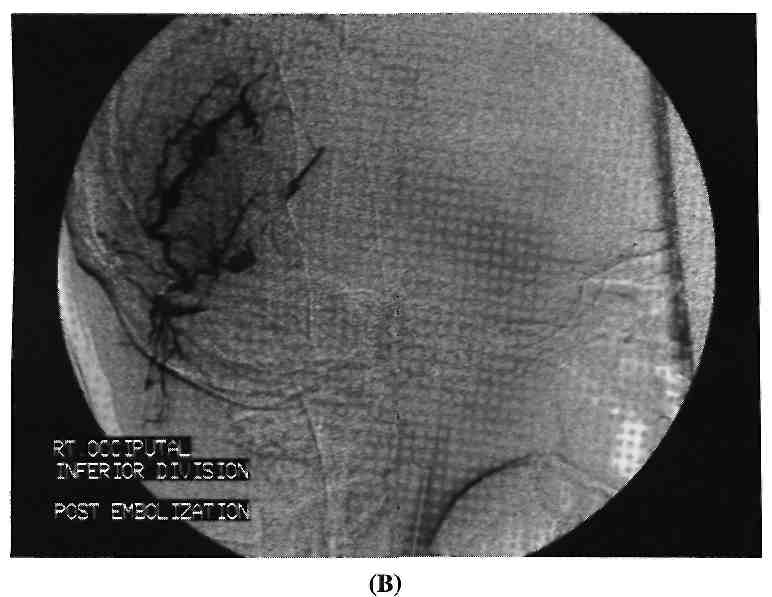
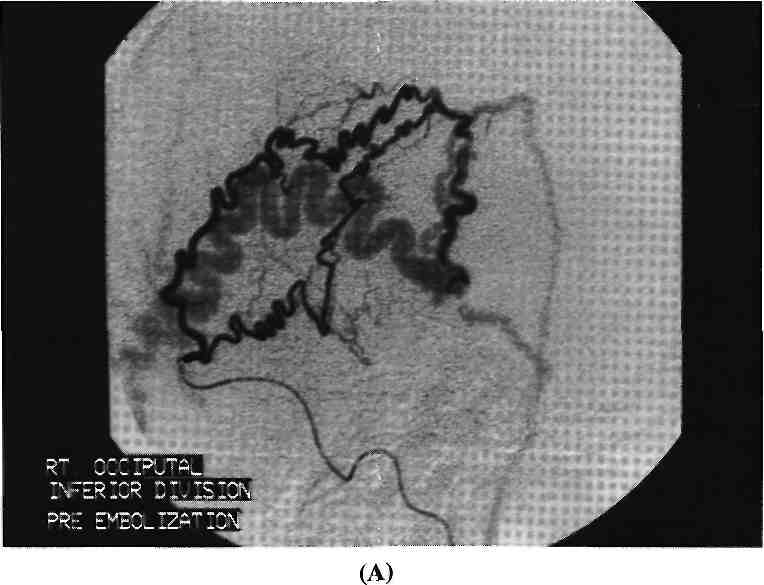
1. most common - traumatic laceration of vessels (esp. GSW – routine CTA for all GSW patients on day 10-12; if retained bullet gives obscuring artefacts – then angiography)
2. aneurysm
3. angiodysplasia

* treated via **endovascular approach** (balloons, PVA, liquid agents, coils).

Traumatic AV fistula:

*A.* Superselective arteriogram of a. occipitalis - two prominent branches draining directly to markedly dilated draining vein.

*B.* Arteriogram after embolization with PVA microparticles and coils - nonfilling of draining vein.



Bibliography for ch. “Head Trauma” → follow this [link >>](http://www.neurosurgeryresident.net/TrH.%20Head%20trauma\TrH.%20Bibliography.pdf)

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