

(CASE REPORT)



High-flow direct carotid-cavernous fistula following craniofacial trauma: endovascular management and clinical outcome

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Abstract

Background: Direct carotid-cavernous fistulas (CCFs) are uncommon but potentially devastating vascular lesions resulting from an abnormal communication between the intracavernous internal carotid artery and the cavernous sinus. Most direct CCFs are traumatic and may lead to progressive visual impairment, cranial nerve dysfunction, and intracranial complications if left untreated.

Case Description: We report the case of a 25-year-old man who developed a high-flow direct carotid-cavernous fistula following craniofacial trauma secondary to physical assault. Clinical examination revealed pulsatile left-sided exophthalmos, orbital bruit, conjunctival congestion, eyelid edema, and severe visual impairment with visual acuity limited to 1/10. Cerebro-orbital computed tomography and digital subtraction angiography confirmed a Barrow type A direct carotid-cavernous fistula arising from the C3 segment of the left internal carotid artery. Endovascular embolization using detachable platinum coils achieved complete angiographic occlusion of the fistula. At six-month follow-up, visual acuity improved to 8/10 with marked regression of orbital symptoms.

Conclusion: Early diagnosis and prompt endovascular intervention remain the cornerstone of management for high-flow traumatic carotid-cavernous fistulas. Endovascular embolization offers excellent angiographic and functional outcomes while minimizing treatment-related morbidity.

Keywords: Carotid-cavernous fistula; Craniofacial trauma; Endovascular embolization; Digital subtraction angiography; Visual outcome; Barrow classification

1. Introduction

Carotid-cavernous fistulas (CCFs) are pathological arteriovenous communications established between the carotid arterial circulation and the cavernous sinus. According to the Barrow classification, direct fistulas (Type A) correspond to a direct communication between the intracavernous segment of the internal carotid artery and the cavernous sinus and are typically characterized by high-flow hemodynamics. Traumatic injuries account for the majority of these lesions and are usually associated with skull base fractures or severe craniofacial trauma.

The abnormal shunting of arterial blood into the cavernous sinus leads to venous hypertension within the orbital venous system, resulting in characteristic ophthalmological manifestations including pulsatile exophthalmos, chemosis, conjunctival arterialization, ocular bruit, and progressive visual deterioration. Delayed diagnosis may expose patients

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to severe complications such as irreversible visual loss, intracranial hemorrhage, cortical venous reflux, and cerebral ischemia.

Digital subtraction angiography remains the gold standard for diagnosis, providing detailed characterization of the fistulous point, venous drainage patterns, and collateral cerebral circulation. Over the past decades, advances in endovascular techniques have revolutionized the management of these lesions, replacing surgical approaches in most cases. [1–5]

We report a case of a high-flow direct post-traumatic carotid-cavernous fistula successfully treated by endovascular embolization, highlighting the diagnostic workup, technical aspects of treatment, and favorable clinical outcome.

2. Case presentation

A 25-year-old male with a history of tobacco and alcohol consumption was admitted following a cranio-orbital trauma sustained during physical assault. Initial neurological examination revealed a conscious patient with a Glasgow Coma Scale score of 15/15 and no focal neurological deficit.

Physical examination demonstrated marked bilateral periorbital ecchymosis predominating on the left side, significant eyelid edema, conjunctival congestion, audible orbital bruit, and grade II pulsatile axial exophthalmos. Visual acuity assessment revealed severe impairment of the affected eye, limited to 1/10. No cranial nerve palsy was identified at admission.

Cerebro-orbital computed tomography demonstrated extensive orbital soft tissue infiltration associated with a superior orbital hematoma. Enlargement of the left cavernous sinus and dilatation of both superior and inferior ophthalmic veins were observed, strongly suggesting the presence of a carotid-cavernous fistula. No intracranial hemorrhage or associated cerebral parenchymal lesion was detected.

Subsequent digital subtraction angiography confirmed a high-flow direct carotid-cavernous fistula arising from the C3 segment of the left internal carotid artery. Venous drainage occurred predominantly through the superior ophthalmic vein anteriorly, with extension toward the contralateral cavernous sinus and posterior drainage through the superior petrosal sinus. Based on angiographic findings, the lesion was classified as a Barrow Type A fistula.



Figure 1 Initial clinical presentation showing bilateral periorbital ecchymosis and left pulsatile exophthalmos

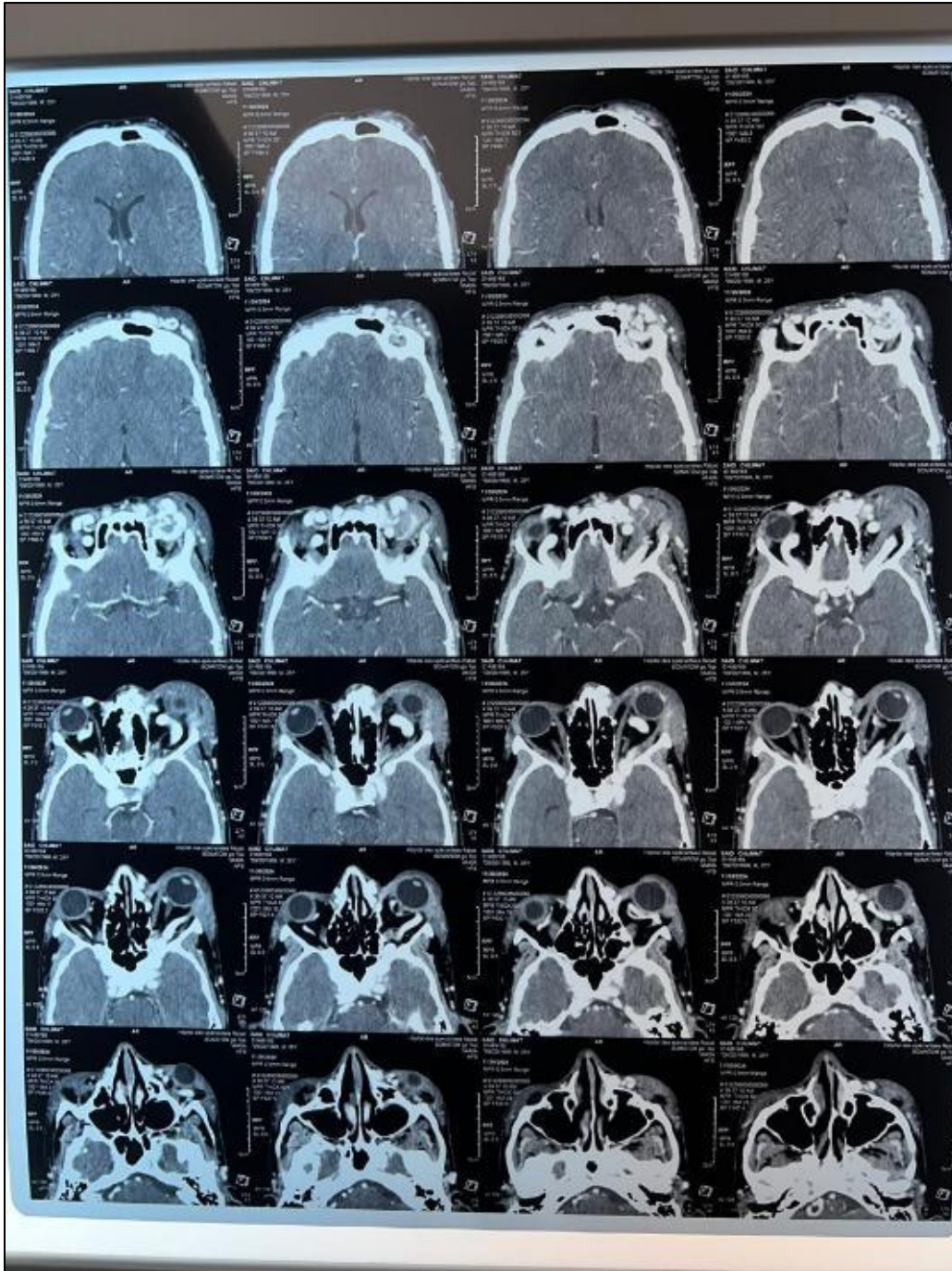


Figure 2 Preoperative cerebro-orbital CT scan demonstrating enlargement of the cavernous sinus and dilatation of the superior ophthalmic vein

2.1. Endovascular management

Considering the progressive visual impairment and the high-flow nature of the lesion, endovascular treatment was undertaken under general anesthesia.

Following bilateral transfemoral vascular access, selective catheterization of both carotid systems and the left vertebral artery was performed. Angiographic evaluation demonstrated a markedly enlarged left internal carotid artery supplying a high-flow fistulous communication at the cavernous segment. Complete diversion of arterial flow toward the venous compartment resulted in absent opacification of the supraclinoid segment of the ipsilateral internal carotid artery.

Careful assessment of collateral cerebral circulation demonstrated adequate compensation through the anterior and posterior communicating arteries. This finding was essential for treatment planning and confirmed the feasibility of therapeutic sacrifice of the diseased carotid segment if required.

A coaxial endovascular system composed of guiding catheters, microcatheters, and microwires was advanced to the fistulous compartment. Initial embolization targeted the venous pouch and cavernous sinus using detachable platinum coils. A total of 309 cm of coils were deployed during the first stage of the procedure.

Residual arteriovenous shunting persisted after the initial embolization, necessitating a complementary embolization strategy. Additional catheterization of the distal intracranial circulation allowed deployment of a further 92 cm of detachable coils. This resulted in complete exclusion of the fistulous communication and therapeutic occlusion of the affected internal carotid artery.

Final angiographic control demonstrated complete disappearance of pathological venous drainage, absence of residual shunting, and satisfactory cerebral perfusion through collateral circulation supplied by the contralateral carotid and vertebrobasilar systems via the circle of Willis. [3,4,8,12]



Figure 3 Digital subtraction angiography demonstrating a high-flow direct carotid-cavernous fistula arising from the cavernous segment of the left internal carotid artery



Figure 4 Intraoperative fluoroscopic image showing coil deployment within the cavernous sinus and fistulous pouch

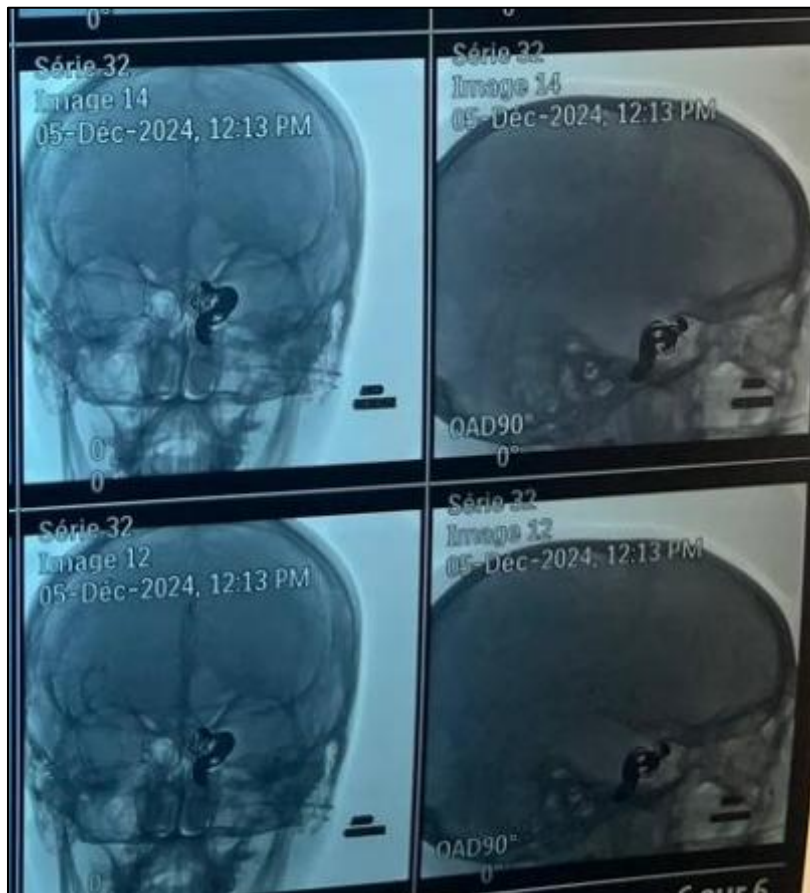


Figure 5 Final angiographic control demonstrating complete occlusion of the fistula and disappearance of abnormal venous drainage

2.2. OUTCOME AND FOLLOW-UP

The postoperative course was uneventful, with no ischemic or hemorrhagic complications. Early clinical improvement was observed, including progressive regression of orbital congestion, eyelid edema, exophthalmos, and disappearance of the orbital bruit.

At 2 weeks follow-up, the patient exhibited substantial functional recovery. Visual acuity improved from 1/10 preoperatively to 8/10. Clinical examination confirmed near-complete resolution of the ophthalmological manifestations. No recurrence of the fistula was detected clinically, and the patient remained neurologically intact.

The combination of complete angiographic occlusion and significant visual recovery was considered an excellent therapeutic outcome.



Figure 6 2weeks postoperative follow-up demonstrating marked regression of orbital manifestations and significant visual recovery

3. Discussion

Traumatic direct carotid-cavernous fistulas represent the most frequent subtype of CCFs and typically result from disruption of the intracavernous internal carotid artery. Although relatively uncommon, they constitute a neurovascular emergency because of the potential for irreversible visual loss and life-threatening neurological complications.

The clinical presentation of direct CCFs is largely determined by venous hypertension within the orbital circulation.

Pulsatile exophthalmos, conjunctival arterialization, chemosis, ocular bruit, and visual impairment represent the hallmark manifestations. The presence of this characteristic constellation of symptoms in a patient with recent craniofacial trauma should immediately raise suspicion of a carotid-cavernous fistula.

Computed tomography and CT angiography provide valuable initial diagnostic information by demonstrating indirect signs such as cavernous sinus enlargement and dilatation of the superior ophthalmic vein. Nevertheless, digital subtraction angiography remains indispensable because it provides definitive diagnosis and simultaneously enables therapeutic intervention. [4-7,10,13-15]

Endovascular therapy has become the treatment of choice owing to its high success rates and low morbidity profile. Contemporary therapeutic options include detachable balloons, platinum coils, liquid embolic agents, covered stents, and flow-diverting devices. The choice of technique depends on fistula anatomy, venous drainage pattern, and preservation of the parent artery.

In the present case, extensive collateral circulation through the circle of Willis allowed complete therapeutic occlusion of the affected internal carotid artery without neurological sequelae. The favorable visual recovery observed during follow-up emphasizes the importance of timely intervention before irreversible optic nerve damage occurs.

Our findings are consistent with previously published series reporting angiographic cure rates exceeding 90% following endovascular treatment of direct traumatic carotid-cavernous fistulas. [11,12,15]

4. Conclusion

High-flow direct carotid-cavernous fistulas remain a rare but potentially devastating consequence of craniofacial trauma. Early recognition of characteristic clinical features, combined with appropriate vascular imaging, is essential for establishing the diagnosis.

Endovascular embolization provides a safe and effective treatment modality, allowing definitive fistula occlusion and significant functional recovery. The present case further illustrates the pivotal role of endovascular therapy in achieving excellent angiographic and visual outcomes.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Ethical approval was done.

Statement of informed consent

"Informed consent was obtained from all individual participants included in the study."

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