Endovascular Modalities for the Treatment of Cavernous Sinus Arteriovenous Fistulas: A Single-Center Experience

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Background: Cavernous sinus (CS) fistulas are classified into traumatic and spontaneous. Traumatic carotid–cavernous fistulas (CCFs) are usually direct internal carotid artery (ICA) high-flow fistulas; whereas spontaneous CCFs are usually dural, low-flow fistulas and generally possess less severe symptoms than direct carotid–cavernous fistulas. *Methods:* This study involved 34 patients who were classified into 2 groups: Group A included 26 patients with direct carotid–cavernous fistula; and Group B included 8 patients with indirect dural cavernous fistula. All patients had ocular manifestations. One patient had subarachnoid hemorrhage. Coils were used alone in 19 cases of direct fistula and in 1 case of dural fistulas. Coils and Onyx (Covidien, Mansfield, MA, USA) were used in 7 cases of direct fistula and in 2 cases of dural fistulas. Onyx alone was used to treat 5 cases with dural fistulas but none of the cases with direct fistulas. Covered stents and coils were used in 2 cases of direct fistulas. *Results:* All patients in both groups showed full recovery of their clinical signs and symptoms. Only 1 procedure-related complication was observed (3%) in which a patient had an embolic event and trigeminal dysesthesia as a result of Onyx reflux through external carotid artery–ICA anastomosis. *Conclusion:* Coils are superior solid embolic agents used for the treatment of direct high-flow fistulas, while Onyx is more valuable in dural low-flow CCF. Onyx shortens the procedure time and decreases procedure cost. Onyx injection inside the CS proper through the transarterial or transvenous route may be safer than Onyx injected inside dural arteries supplying the CS. However, more cases are needed to determine this. **Key Words:** Carotid–cavernous fistula—cavernous sinus—Onyx—covered stent—coil—exophthalmos.

Introduction

Carotid–cavernous fistulas (CCFs) are uncommon vascular lesions. CCFs can be classified as direct (involving the internal carotid artery) or indirect (involving a dural branch). The direct type is usually traumatic and high flow, whereas the indirect type (also termed dural fistula) is usually spontaneous and low flow. The classification of CCF as direct versus dural might be better since the emphasis is on the vascular anatomy pertinent to treatment.

Direct carotid–cavernous fistulas (TCCFs) involve 2 disease processes: one is acute, rapidly progressive, and caused by trauma; the second is the less common ruptured intracavernous internal carotid artery (ICA) aneurysm into the cavernous sinus (CS) leading to a TCCF. Traumatic CCFs are rare complications of blunt and penetrating skull injuries that account for only .2%-.3% of craniofacial trauma.[1] The cause is a tear in the ICA leading to abnormal communication between the ICA and the CS.[2-4] They are classified as high-flow fistulas and, according to Barrows classification, they are Type A fistulas.[2,5-7] The shunting of blood at arterial pressure from the ICA to the CS causes an increase in the venous pressure in the CS and its tributaries, especially the superior

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ophthalmic vein (SOV), leading to a classical triad seen in traumatic CCF cases; this triad includes pulsatile exophthalmos, orbital bruit, and conjunctival injection.[7-11]

Dural carotid–cavernous fistulas (DCCFs) occur spontaneously without previous trauma and have more insidious onset than direct fistulas, and symptoms are similar to those of TCCF but less in severity. Ocular manifestations included increased intraocular pressure, eye redness, proptosis, cranial nerve palsies, diplopia, and orbital bruit.[7,9,11,12] DCCFs represent 10%-15% of all intracranial vascular malformations.[13-16] We present this series aiming at discussing the different techniques that can be used in treating TCCF and DCCFs, with special emphasis on the use of Onyx.

Patients and Methods

This study involved analysis of data from all patients, who were managed for CS fistulas from 2006 to 2015. The patients were classified into 2 groups: Group A, which included patients with TCCFs; and Group B, which included patients with DCCFs.

Group A included 26 patients with TCCF (21 males and 4 females). The patients' ages ranged between 4 and 53 years with a mean of 24.20 years. All patients had ocular manifestations that consisted of orbital signs (proptosis, chemosis, and conjunctival hypervascularity) and eye movement abnormalities. Patient 9 presented by subarachnoid hemorrhage from a ruptured CS varix, and he was the only patient in the series to present by hemorrhage.

The patients' symptoms were unusually long standing, and the duration of symptoms varied from 1 week to 84 months with a mean of 9.52 months. All the patients had a previous history of road traffic accidents except for 4 patients, 2 of whom developed the fistula after iatrogenic injury of the ICA during an ear, nose, and throat surgical procedure and endoscopic pituitary surgery. Another patient suffered from penetrating eye injury. The last case had ruptured ICA aneurysm into the CS (Table 1).

Group B included 8 patients (5 females and 3 males). Their ages ranged between 42 and 60 years with a mean of 52 years, and the duration of symptoms ranged between 3 months and 2 years. Patients had ocular manifestations that consisted of orbital signs (proptosis, chemosis, and conjunctival hypervascularity) and eye movement abnormalities. However, ocular manifestations were less severe than those in the TCCF group. Obvious proptosis was noted in all but 2 cases (Table 2).

Because the patients' symptoms were unacceptable and persistent; conservative treatment did not satisfy them and they requested interventional treatment aiming for cure because their fistulas did not close spontaneously. Symptoms were bilateral in 2 out of the 7 patients. One patient had previous treatment attempt by coiling at another institute that failed to occlude the fistula and symptoms persisted (patient 31) (Table 2).

Radiological Evaluation

Patients were evaluated by computed tomography, magnetic resonance imaging, cerebral angiography, and balloon occlusion test (BOT) in some cases. Diagnostic cerebral angiography was interpreted in terms of evaluating the side, type, and flow rate of the fistula, the adequacy of the collateral circulation to withstand ICA sacrifice (in cases of TCCF), the pattern of venous drainage of the fistula, and the best route to approach the fistula.

The exact location of the fistulous rent within the ICA is quite difficult to determine in cases of TCCF. Allcock test, which is done during cerebral diagnostic angiography procedure by manual compression of the injured ICA in the neck while doing vertebral injection aiming to reverse the flow in the ICA through the posterior communicating (P-com) artery that may help to delineate the upper boundary of the fistulas rent (Allcock maneuver).[17] Slow injection technique of the injured ICA during selective angiography can also help to delineate the lower boundary of the fistula.

In cases of DCCF; the exact shunting point in the dura is easy to be evaluated on external carotid artery (ECA) angiography in an antroposterior view. Evaluation of the venous system is necessary to detect and predict the shift of the venous drainage pressure to a dangerous outflow pathway during or before embolization (cortical or superior petrosal sinus (SPS)).

BOT

The technique for BOT was published elsewhere in the literature.[18,19] The main technical difference between doing BOT for aneurysms or other vascular pathologies and TCCF is that the balloon must be positioned to cover the fistula rent, so as to prevent retrograde flow into the fistula that can elicit arterial steal and can lead to false interpretation of the test.[4]

Follow-up

The patients were followed up for a period between 6 months and 5 years. Follow up is done by clinical examination by a neurosurgeon, an ophthalmologist and by radiological investigations via computed tomography angiography, magnetic resonance imaging angiography, or conventional catheter angiography.

Results

Approach Routes and Procedures

Group A

TCCFs are approached all through the transarterial route. The transvenous access has to be prepared if covered stents were to be used, so if the stent failed to occlude the fistula, the transvenous embolization route could be accessed to