Retrospective study on the endovascular embolization for traumatic carotid cavernous fistula

CHEN Li-zhao 陈立朝*, XU Min-hui 许民辉, YANG Dong-hong 杨东虹, ZOU Yong-wen 邹咏文 and ZHANG Yun-dong 张云东

【Abstract】Objective: To retrospectively analyze 95 cases of traumatic carotid cavernous fistula treated by endovascular embolization.

Methods: From January 1994 to December 2008, 95 patients with traumatic carotid cavernous fistula were treated in our hospital. All patients received selective cerebral angiography through femoral artery catheterization. Accordingly, 89 cases were treated by detachable balloon embolization, 5 by platinum microcoils and 1 by covered-stent, respectively.

Results: In the study, 61 cases achieved successful balloon embolization at the first time. Fifty-six cases had multiple balloons due to the big fistula. Nine cases received balloon embolization twice. But among the 5 patients treated with platinum microcoils, one developed slight brainstem ischemia. After operation the patient had hemiparesis and swallow difficulty, but gradually recovered 3 months later. No neurological deficits were observed in other cases. All the cases recovered. Eighty-five cases were followed up for 1-15 years and no recurrence was found.

Conclusions: The endovascular embolization for traumatic carotid cavernous fistula is minimally invasive, safe, effective and reliable. The detachable balloon embolization is the first choice in the treatment of TCCF.

Key words: Wounds and injuries; Carotid-cavernous sinus fistula; Embolization, therapeutic; Ballon occlusion

Traumatic carotid cavernous fistula (TCCF) refers to a vascular disease, i.e. skull fractures caused by trauma bring damage to internal carotid artery and its branches and cavernous sinus, and produce an abnormal passage between hyperbaric cervical arterial system and hypobaric carotid cavernous sinus system. As a consequence of high-flow diversion, the majority of blood flow in TCCF goes reversely to the superior ophthalmic vein and superficial middle cerebral vein, and is quickly diverted to the inferior petrosal sinus and petrosal vein. Reverse blood flow can cause neurological and eye symptoms, such as cranial nerve palsy or intracranial hematoma occasionally. There are some changes in cerebrovascular haemodynamics of TCCF because of arterial steal phenomenon and shunting flow to the venous system.

Despite the advancement in endovascular techniques in the previous decades, it is recognized worldwide that detachable balloon embolization is the first choice for the treatment of TCCF. From April 1994 to May 2008, a total of 95 TCCF patients were treated by endovascular embolization in our hospital and the outcome was satisfactory.

METHODS

General data
From January 1994 to December 2008, we treated 95 patients with TCCFs in our hospital, including 61 males and 34 females, aged from 11-72 years (mean 37 years). The time from injury to admission into hospital ranged from 6 days to 2 years. There were 68 patients injured in car accidents, 11 falling injury, 9 blunt injury and 5 microtrauma. As for the clinical manifestations, all 95 cases had sustained intracranial vascular murmur in orbital auscultation; 79 cases had pulsating exophthalmos, conjunctival hyperemia and ocular movement disorders; 82 cases had eyelid edema and ectropion, and decreased visual acuity; one patient had blindness.
Angiography

A total of 95 cases received selective cerebral angiography through femoral artery catheterization. The anteroposterior films showed that contrast agent in carotid cavernous fistula was sponge-like in 94 cases, among which 6 cases showed contralateral cavernous sinus image via intercavernous sinuses. On lateral view, 94 cases showed venous drainage through the thickened ophthalmic veins, including 18 cases accompanied by the drainage via cortical vein and petrosal sinus. Due to ipsilateral internal carotid artery occlusion, one patient had the vertebral artery angiography through the primitive trigeminal arteries, which revealed the fistula. There were 90 patients with one fistula and 3 with two fistulas. Two patients had the fistula in internal carotid artery, with external carotid artery connected with cavernous sinus.

Embolization

Local anesthesia was performed routinely. But uncooperative patients and children underwent general anesthesia. Intravenous heparin saline was continuously used for 1000 U per hour.

According to Seldinger’s method, puncture the femoral artery and insert 8F catheter sheath. Seventy patients were treated with detachable balloon embolization. The tube was inserted into internal carotid artery at C2 segment by femoral artery catheterization, and the Magic-BD catheter pre-loaded with a detachable balloon (Magic-BD balloon, BALT Co, France) was inserted to the carotid-cavernous fistula. Fill the balloon with low concentration contrast agent (Omnipague, 180 mg/ml) and then perform angiography through the three-connecting pipe to investigate whether the fistula was completely occluded. Keep adjusting the position of balloon until it got into the sinus, then inflate the balloon. Release the balloon after the angiography confirmed the occlusion of TCCF and the non-obstruction of carotid artery. Because the fistula was too small or too big, 19 cases required internal carotid artery occlusion. Before the occlusion, blood pressure was decreased (mean arterial blood pressure dropped to 70-80 mm Hg). Under that condition, perform the occlusion experiment, i.e. fill the balloon for 30 minutes to check whether the neurological deficits exist, meanwhile perform contralateral femoral artery catheterization and the angiography of contralateral internal carotid artery and vertebral artery to investigate the compensation of the anterior and posterior communicating arteries. If the cross-filling is good, it indicates that the result of occlusion test is negative, so you can release the balloon and add a protective balloon beneath.

If the patient had a small fistula or two fistulas or fistula in carotid artery connected with cavernous sinus, balloon embolization was difficult to apply. Instead, platinum micro-coils were used for embolization in 5 cases. The tube was guided into the internal carotid artery or vertebral artery at C2 segment. Under the guidance of microwire, the pinnacle of micro-catheter entered the cavernous sinus via the fistula. Then remove the microwire. The angiogram through micro-catheter confirmed the diagnosis of TCCF, so platinum microcoils was put into sinus for embolization until cavernous sinus fistula was completely occluded.

A patient had two small fistulas and both were located in horizontal part of cavernous sinus in the internal carotid artery, so detachable balloon embolization was unfeasible. A covered stent was used to close the fistula. The tubes was guided into internal carotid artery at C2 segment, then the exchange guide wire (length: 300 cm, diameter:0.36 mm or 0.014 inch) was inserted into the coronary micro-catheter. The micro-catheter went across the lesion to reach the distal ends of fistula. According to the size of lesion and internal carotid artery, along the exchange guide wire, 4 mm × 19 mm Jostent coronary covered stent covered the fistula. The multi-angle angiogram was taken to ensure that the fistula had been completely covered and the balloon-expandable covered stent was put in the lesion, adhering to the vessel wall.

Postoperative treatment

All patients had rest in bed for 48 to 72 hours after operation. Patients with internal carotid artery occlusion underwent vasodilative treatment for postoperative one week. Patients treated by micro-coil embolization took heparin for 3 to 5 days. The patients who had successful stent placement were given heparin for 3 days, anti-platelet therapy from preoperative 3 days to postoperative 6 months, oral clopidogrel (75 mg/d) and aspirin (300 mg/d).
RESULTS

In the study, 61 cases achieved successful balloon embolization at the first time. Fifty-six cases had multiple balloons due to the big fistula. Nine cases received embolization twice and succeed, with the internal carotid artery unobstructed. Nineteen patients received detachable balloon embolization of internal carotid artery. Five TCCF patients were treated with platinum microcoils and the embolization was successful at the first time. Intracranial vascular murmur disappeared immediately after operation, and exophthalmos vanished 7 days to 2 months later. One patient experienced mild limb paralysis and dysphagia 6 hours after a successful Guglielmi detachable coil (GDC) embolization, which might be caused by vascular thrombosis of brain stem resulting from the thrombosis and detachment of artery wall. The patient received anticoagulative and vasodilative therapy and gradually recovered three months later. No symptoms of nervous system dysfunction were found in other cases. Eighty-five patients were followed up for 1-14 years and no recurrence was observed.

DISCUSSION

Diagnosis of TCCF

Based on the case history of cerebral injury and clinical manifestation, doctors can diagnose TCCF by cerebral angiography. The clinical manifestations are as follows: pulsating exophthalmos, vascular murmur, eyeball conjunctival congestion, edema and valgus, limited eye movement, decreased visual acuity, epistaxis and so on. The definite diagnosis of TCCF can be made by cerebral angiography. The main concern of angiography is to investigate Willis ring collateral circulation, location and size of fistula, blood supply of internal and external carotid arteries, steal phenomenon and venous drainage.1-11

Endovascular treatment1-3

Endovascular treatment aims to protect eyesight, eliminate murmur, retract eyeball and prevent cerebral ischemia or bleeding. The treatment principle is to occlude the fistula and keep internal carotid artery unobstructed.

Detachable balloon  Currenty, it is recognized that detachable balloon embolization is the first choice for TCCF.1-7 This method has many advantages of being simple, easy to operate, minimally invasive, painless, effective and reliable with less complications. It can not only occlude the fistula, but also keep internal carotid artery unobstructed. However, in some cases, premature leakage of contrast agent in balloon after embolization makes the balloon smaller and displaced, at that time sinus thrombosis has not yet formed, so the fistula is recanalized. Besides, in skull fracture, bone fragments within sinus can easily pierce into the balloon, leading to fistula recurrence.

Most cases received two or more than two balloons for embolization. Some patients had single balloon embolization, but recurred, which can be cured with another balloon embolization. In this study, 70 cases had detachable balloon embolization, among which 61 cases had successful balloon embolization at the first time (56 cases received several balloons because the fistula was relatively big), 9 cases achieved successful balloon occlusion at the second time and retained the internal carotid artery unobstructed. Among the 9 cases, 2 had fistula recanalization after embolization, and 1 had balloon rupture on the day of embolization, then the artery was successfully occluded after re-embolization. Six cases had re-embolization 1 week later because fistula had not been completely occluded. If the fistula is big and several balloons have been inserted, but the fistula is not yet completely occluded, do not conduct balloon embolization until contrast agent in balloon overflows and space in cavernous sinus increases one week later. Avoid occluding internal carotid artery. However, in the cases of too big or too small or low-flow fistula, internal carotid artery should be occluded.

In the study, 19 patients had internal carotid artery occlusion. Among them, in 6 cases, the fistula was not completely occluded because it was large and several balloons were inserted in the first embolization. The retreatment could not retain the internal carotid artery unobstructed. And in the other 13 cases, the balloon can not enter the cavernous sinus because fistula was too small. Before the occlusion, blood pressure was decreased (mean arterial blood pressure dropped to 70-80 mm Hg). Then fill the balloon for 30 minutes to check whether the neurological deficits exist, meanwhile perform contralateral femoral artery catheterization and angiography of contralateral carotid artery and vertebral...
artery to investigate the compensation of the anterior and posterior communicating arteries. If the cross-filling is good, it indicates that the result of occlusion test is negative, then release the balloon and add a protective balloon to prevent the shrink and displacement of balloon and recanalization of fistula. The following signs indicate good cross-filling compensation: (1) blood supply to the affected side was via the anterior and posterior communicating arteries; (2) after embolization, internal carotid artery angiography showed that the venous phase appeared on both sides at the same time and the extension at affected side was no more than 1.5 seconds; (3) omocclusion experiments, blood pressure was decreased by 20-30 mm Hg and the patients had no neurological dysfunction; (4) during the occlusion experiment, EEG and other tests demonstrated no abnormality. In addition, operate gently to prevent the automatical withdraw of balloon. Do not insert or remove the catheter when the balloon is fully filled, otherwise, it will cause the detachment of balloon. In the low-flow fistula, the detached balloon may enter the intracranial artery and cause embolism.

Micro-coils In most cases, patients can be cured by simple detachable balloon occlusion of fistula or occlusion of fistula and internal carotid artery. However, detachable balloon embolization is not feasible under the following circumstances: (1) internal carotid artery has been occluded, the blood supply of TCCF is from anterior and posterior communicating artery or external carotid artery branches and each blood vessel is not large enough to pass a detachable balloon; (2) carotid artery has been occluded and it is hard for a balloon to reach fistula by venous approach; (3) internal carotid artery is seriously injured and the fistula is large, cavernous sinus is significantly dilated, separation structure is complex, gap between balloons exists, the fistula can not be completely occluded by balloons; and (4) small fistula with small blood flow, so a balloon can not enter the cavernous sinus. Micro-coils have better compliance and can fully fill the cavity of cavernous sinus near fistula so as to occlude the fistula. The micro-coil embolization is preferred for small TCCF which balloon can not enter. In our study, 5 cases treated with the micro-coil embolization had small fistula and low blood flow. The fistula was partially occluded by balloons or the carotid artery was closed. The blood flow velocity in arteriovenous fistula was less than that of common TCCF.

Covered stent. For the cases who are hard to undergo balloon embolization, such as large or small fistula or fistula recurrence after detachable balloon embolization, covered stent is recommended to close the fistula and reconstruct the fistula artery. The release of stent can occlude the perforating branches of brain from affected artery or collateral arteries, so it can only be applied for the arteries without key collateral arterial branches. Moreover, covered stent has low compliance and is less migratory. Until now, covered stents are designed for coronary arteries and no brain-specific stents are available. During operation, make sure that the stent is in the accurate place and aderent to vessel wall, and avoid the complications such as cerebral vascular perforation, dissection, etc. In this study, one patient had two small fistulas located in the horizontal part of cavernous sinus of internal carotid artery, so it was difficult to apply balloon embolization. We used 4 mm×19 mm Jostent coronary covered stent to occlude the fistula successfully and no complications occurred.

NBCA method n-butyl-cyanoacrylate (NBCA) has high technical requirement and potential risk of thrombosis. Doctors should strictly control the concentration, dosage and injection rate of NBCA during the process. Therefore, it is not recommended for routine treatment. The indications for NBCA are as follows: (1) special separation types of cavernous sinus with multiple recurrence, and (2) slow blood flow in fistula.

Ophthalmic vein approach and superior and inferior petrosal sinus approach Ophthalmic vein approach is generally applied for cavernous sinus fistula, mostly treated by ophthalmic vein drainage. Case history is usually more than 3 months when ophthalmic vein has been arterialized. Superior and inferior petrosal sinus approach is generally applied for the cavernous sinus fistula, mostly treated by the drainage of superior and inferior petrosal sinus before the fistula occlusion. Avoid damaging superior and inferior petrosal sinus, otherwise, it may increase the venous pressure and aggravate exophthalmos or divert flow into intravenous cortex, leading to intracranial hemorrhage. Micro-coil embolization is often adopted for venous approach.
Cavernous sinus fistula requiring emergency treatment  The patients should be given emergency treatment if TCCF is accompanied by the following symptoms:1-7 (1) nose bleeding, which may stop by oppressing ipsilateral carotid artery, but massive hemorrhage of nose can be life-threatening; (2) acute visual impairment, which is caused by acute ocular hypertension and congestion; (3) intracranial hematoma, which may be caused by the blood flow into subdura in rupture of cavernous sinus wall or caused by venous rupture in the cortex drainage on the basis of primary brain contusion. The intracranial hematoma combined with cavernous sinus fistula may occur repeatedly and affect the patient’s prognosis.

REFERENCES


(Received August 12, 2009)  
Edited by LIU Jun-lan