Transarterial Embolization of Direct Carotid Cavernous Fistulas with the Double-balloon Technique

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Summary

Treatment of direct carotid cavernous fistulas (CCF) has progressed from surgical ligation to surgical trapping to endovascular techniques. Endovascular therapies are advantageous as they allow for occlusion of the fistula whilst preserving flow in the parent carotid artery. However, technical difficulties are not uncommon and occur when the fistulous orifice is too small or when the inflated balloon in the cavernous sinus retracts to the carotid artery. Both circumstances may lead to technical failure or an unplanned sacrifice of the parent internal carotid artery (ICA).

Here we describe a double-balloon technique used in the embolization of CCF in four patients that were successfully treated with complete immediate occlusion whilst preserving the parent ICA.

Introduction

Direct carotid-cavernous fistulae (CCF) are high-flow shunts between the cavernous portion of the internal carotid artery (ICA) and the cavernous sinus (CS). They are mostly caused by traumatic laceration of the ICA or rupture of a preexisting aneurysm in the cavernous segment of the ICA. The most serious complications of CCF are those associated with venous hypertension transmitted either to the eye or the brain, depending on the available

route of venous drainage. In recent years, the preferred treatment for CCF involves transarterial embolization of the fistula with a detachable balloon that preserves the ICA. This can be risky or even impossible in some situations. Higashida and colleagues¹ reported preservation of the parent artery in 88% of patients with CCF treated using detachable balloons. Other authors have described a need for parent artery occlusion is as many as 20% of cases^{2,3}. Procedure failure may occur if the fistulous orifice is too small to allow entry, the inflated balloon is retracted from the cavernous sinus in to the carotid artery, or sharp margins from bony fragments or foreign bodies rupture the balloon during inflation⁴.

In this article, we report our experience of transarterial embolization of CCF using a double-balloon technique that may have an increased success rate and also allow preservation of blood flow in the parent ICA.

Materials and Method

Thirteen patients with CCF were treated in our department between June and December 2006. Out of these, four patients were treated successfully with the balloon protection technique. Patient demographics and the procedure technique are summarized in the table 1. Those patients (two male and two female, age 33-72 years) who presented with symptoms relating to traumatic CCF formation following head in-

Figure 1 33-year-old-male (case 3 in table) with a left CCF following a car accident. A) Lateral projection of left ICA arteriogram shows direct type CCF with no filling of the intradural segment of the ICA. Note prominent ophthalmic, petrosal and pterygoid venous drainage. B) Lateral projection of left ICA arteriogram during embolization of fistula with the balloon protection technique. The detachable balloon, marked by a broad arrow, is for embolization. The wire-directed temporary occlusion balloon catheter, marked by a thinner arrow, is for temporary inflation inside the carotid artery as a protective balloon for the purpose of stabilizing the placement of the detachable embolization balloon at the time of detachment. C) Lateral projection of left ICA arteriogram immediately after embolization demonstrates resolution of the fistula whilst preserving a parent carotid artery. Note that the detachable balloon remains inside the cavernous sinus. D) Lateral projection of left ICA 3 months following embolization demonstrating no recurrent fistula or pseudoaneurysm formation. The detachable balloon is deflated.

jury were treated with the balloon protection technique as standard detachable balloon methods failed to occlude the fistula (GVB, Minvasys, France). In our experience, there are two main reasons for employing the protection balloon technique. The first, as encountered in

cases 1, 2 and 4, is when the fistulous orifice is too small to allow entry of the balloon. In this situation, a partially inflated detachable balloon can either only partly enter the fistula or not at all. When anchored at the orifice, it could not be traversed through fistula in to the ve-

Table 1 Patient demographics, fistula characteristics, outcomes and results at follow-up.

	Case 1	Case 2	Case 3	Case 4
Sex/age (y)	F/61	M/72	M/33	F/50
Presentation	Proptosis, bruit	Chemosis, proptosis, diplopia	Diplopia, bruit	Proptosis, bruit
Venous Drainage	Ophthalmic, petrous	Ophthalmic, petrous, contralateral CS, cerebral veins	Ophthalmic, petrous, contralateral CS, pterygoid	Ophthalmic, petrous, contralateral CS, superficial veins
Reason for protection balloon	Small fistula	Small fistula	Retraction of balloon	Small fistula
Initial outcome	Cure	Cure	Cure	Small residual fistulous flow
Angiographic Follow-up time (mo)/result	3/ Cure	0.5/ Balloon migration, treat with stent graft, cure	3/ Cure	0.5/ Pseudoaneurysm
Total follow-up length (mo)	18	18	12	13

nous site by blood flow alone. The second reason for using the protection balloon, as in case 3, is to prevent retraction of the balloon into the parent ICA. This often occurs when a large fistula is combined with a small CS.

In our patients, we employ a wire-directed temporary occlusion balloon catheter (Sentry-15 balloon, Target therapeutics, Fremont, CA) as a protective balloon that can stabilize the placement of the detachable embolization balloon at the time of detachment, or as a device that can compress the detachable balloon and pass through the fistulous orifice into the CS. We used a 7 French Shuttle 90 cm Flexor Tuohy-Borst Introducer set (Cook, Bloomington, IN) as the guiding catheter.

The patient is fully heparinized during the procedure with an initial 3000 unit intravenous bolus followed by a continuous background infusion (1000 U heparin in 1000mL normal saline). Firstly, a wire-directed balloon catheter was introduced into the ICA as the protection balloon, just distal to the orifice of fistula. A second, detachable balloon was then introduced in to the CS and used as the embolization balloon.

The protection balloon was directed towards the defect in the ICA, and once there, the detachable balloon was inflated to close the fistu-

la. The protection balloon is then maximally inflated within the ICA. In this way, when traction is placed on the implantable device for balloon detachment, it cannot migrate in to the parent ICA (see figure). If the fistulous orifice is too small to allow the embolization balloon to pass, the protection balloon can be partially inflated to compress the detachable balloon into the fistulous tract.

Results

Out of four patients with CCF, complete fistula closure with preservation of the ICA was achieved in 3 patients, as demonstrated on immediate postembolization angiograms. A small residual fistulous flow was noted in the remaining patient, and spontaneous thrombosis of the fistula was confirmed on repeat angiogram 2 weeks later. However, an asymptomatic small false sac or pseudoaneurysm was detected at the same time in the cavernous ICA. Another patient who suffered from recurrent symptoms attributed to a recurrent fistula 2 weeks after embolization (due to balloon migration) was successfully treated with stent graft placement. All patients had complete resolution of symptoms at 12-18 months follow-up, and repeat angiographies were therefore not performed.

Discussion

Since the use of balloons was described by Debrun and colleagues⁵ and Serbinenko⁶, a method for closure of the CCF with preservation of the parent artery has emerged. Transarterial balloon embolization is currently the gold standard treatment for most CCF, but technical difficulties are not uncommon. The size of the fistula and the CS are important factors affecting the technical success rate. The fistula should be smaller than an inflated balloon but large enough to allow passage of a deflated or partially inflated balloon. The CS should be large enough to accommodate an inflated balloon or balloons.

Failure often occurs when the fistula orifice is too small to allow entry, or when a large fistula is combined with a small CS allowing retraction of the inflated balloon to the ICA⁷. Both circumstances may lead to technical failure or unplanned sacrifice of the parent ICA. Several special techniques have been developed for these special circumstances including stent-assisted coil placement⁸, embolization with the Guglielmi detachable coil⁴, n-butyl-2-cyanoacrylate⁹ or even stent grafts^{10,11}.

The double-balloon technique is particularly useful in two specific situations: when the fistula orifice or flow is too small to allow passage of a deflated or partially inflated balloon and when the width of the CS is less than the fistula opening. When the fistula orifice is too small or the flow through the fistula is too slow, a detachable embolization balloon may not easily traverse the fistula on blood flow alone. In this situation, it is usually not easy to embolize the fistula and preserve ICA flow with a detachable balloon from an arterial approach without using a special technique. In the double-balloon technique, a protection balloon temporarily occludes the ICA distal to the orifice of the fistula, and facilitates the passage of the detachable embolization balloon through the fistula and in to the CS. However, the balloon protection technique may also fail if the fistula is extremely small. When the width of the CS is smaller than the opening of the fistula, inflation of the balloon on the venous side (CS) may push the balloon back in to the ICA. By using the balloon protection technique, the detachable embolization balloon can be inflated inside the CS to a size larger than the diameter of the opening of the fistula whilst the protection

balloon is temporarily inflated within the ICA. Given that the inflated detachable balloon is larger than the fistula, it will remain inside the CS even after the protection balloon has been removed. However, when the fistula is too large or the CS is too small, this technique may not always work. When balloon protection technique has failed in the above two situations, other techniques have been described including embolization with the Guglielmi detachable coil, n-butyl-2-cyanoacrylate, stent graft^{10,11} or transvenous embolization through the inferior petrosal sinus or the ophthalmic vein^{12,13}.

Teng and colleagues¹⁴ first reported a series of patients with CCF that could not be treated with a standard single balloon technique but required a double-balloon technique instead. In their patients, a second detachable balloon was used as the protection balloon, but we employed a wire-directed balloon catheter instead. This has several advantages. Firstly, there is no risk of premature detachment. Premature detachment of the inflated detachable balloon may result in occlusion of the ICA and subsequent cerebral infarction. Secondly, the wire-directed balloon catheter is more flexible, has greater luminal integrity, is more maneuverable and can generate more force than the detachable balloon. Thirdly, with the 0.010 inch guidewire, this balloon provides greater stability when inflated. Moreover, given that the balloon is longwise designed, it provides a larger protection area and reduces the risk of over inflation and rupture of the ICA.

Conclusions

As described above, the double-balloon technique for transarterial embolization of CCF is a feasible method that increases the embolization rate whilst also allowing for preservation of the parent ICAs. This technique is particularly useful when the fistula orifice is too small to allow passage of the detachable balloon or when the width of the CS is less than the opening of the fistula so that the inflated balloon may be erroneously retracted into the carotid artery.

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References

- 1 Higashida RT, Halbach VV et Al: Interventional neurovascular treatment of traumatic and vertebral lesions: results in 234 cases. *Am J Roentgenol* 153: 577-582, 1989.
- 2 Debrun G, Vinuela F et Al: Indications for treatment and classification of 132 carotid-cavernous fistulas. *Neurosurgery* 22: 285-289, 1988.
- 3 Lewis A, Tomsick TA et Al: Management of 100 consecutive direct carotid cavernous fistulas: results of treatment with detachable balloons. *Neurosurgery* 36: 239-244, 1995.
- 4 Topi S, Seppo S et Al: Transarterial embolization of a direct carotid cavernous fistula with guglielmi detachable coils. *Am J Neuroradiol* 18: 519-523, 1997.
- 5 Debrun G, Lacour P et Al: Detachable balloon and calibrated-leak balloon techniques in the treatment of cerebral vascular lesions. *J Neurosurg* 49: 635-649, 1978.
- 6 Serbinenko FA: Balloon catheterization and occlusion of major cerebral vessels. *J Neurosurg* 41: 125-145, 1974.
- 7 Graeb DA, Robertson WD et Al: Avoiding intraarterial balloon detachment in the treatment of posttraumatic carotid-cavernous fistulae with detachable balloons. *Am J Neuroradiol* 6: 602-605, 1985.
- 8 Fanny EM, Richard PK et Al: Endovascular treatment of high-flow carotid cavernous fistula by stent-assisted coil placement. *Am J Neuroradiol* 26: 1399-1404, 2005.
- 9 Luo CB, Teng MMH et Al: Transarterial balloon-assisted n-butyl-2-cyanoacrylate embolization of direct carotid cavernous fistulas. *Am J Neuroradiol* 27: 1535-1540, 2006.
- 10 Gomez F, Escobar W et Al: Treatment of carotid cavernous fistulas using covered stent: Midterm results in seven patients. *Am J Neuroradiol* 28: 1762-1768, 2007.
- 11 La Tessa G, Pasqualetto L et Al: Traumatic Carotid Cavernous Fistula: Failure of Endovascular Treatment with Two Stent-Grafts. *Interventional Neuroradiology* 11: 369-375, 2005.
- 12 Uflacker R, Lima S et Al: Carotid-cavernous fistulas: Embolization through the superior ophthalmic vein approach. *Radiology* 159: 175-179, 1986.
- 13 Halbach VV, Higashida RT et Al: Transvenous embolization of direct carotid cavernous fistulas. *Am J Neuroradiol* 9: 741-747, 1988.
- 14 Teng MMH, Chang CY et Al: Double-balloon technique for embolization of carotid cavernous fistulas. *Am J Neuroradiol* 21: 1753-1756, 2000.

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