W.-Y. Cheng¹ S.-C. Chao¹ W.-H. Chen² C.-C. Shen¹

Minimally Invasive Keyhole Approach for Removal of a Migratory Balloon Complicated by Endovascular Embolization of a Carotid-Cavernous Fistula

Abstract

Purpose: This report presents our experience in using a minimally invasive keyhole approach to remove a migratory balloon in the cerebral artery in one patient. Case Report: A 19-year-old male suffered from carotid-cavernous fistula after craniofacial trauma two months previously. The patient received endovascular embolization of a carotid-cavernous fistula with detachable balloons. Unfortunately, migration of one balloon to the right middle cerebral artery (MCA) at the M1-M2 junction was noted after detaching the balloon during this procedure. Volume expansion, anticoagulation therapy and an emergency pterional keyhole approach with removal of the displaced balloon were performed successfully. Transient left hemiparesis due to temporary occlusion of the right middle cerebral artery by the balloon was promptly alleviated. There was no definite neurological sequel after the operation. Conclusions: Although detachable balloon embolization is the best initial treatment of direct carotid-cavernous fistulas, it is likely to migrate to downstream cerebral arteries. We recommend a minimally invasive pterional keyhole approach as a good alternative for treating such endovascular complications to improve outcome.

Key words

Carotid-cavernous fistula · keyhole · migratory balloon · pterion

Introduction

A carotid-cavernous fistula (CCF) is an aberrant vascular communication between the carotid artery system and the venous channels within the cavernous sinuses of the sphenoid. In 1985, Barrow and his colleagues formulated a classification system of CCF (type A, B, C, D) based on angiographic studies [1]. Direct type CCF (type A) is usually associated with trauma and the current standard therapy is endovascular detachable balloon occlusion [2]. Migration of balloon is one of the complications of detachable balloon embolization. Management of the migratory balloon includes volume expansion, anticoagulation therapy and embolectomy. For embolectomy, the traditional pterion craniotomy is frequently used. As an alternative we report here the case of a migratory balloon during the endovascular procedure that was successfully treated by the pterional keyhole approach. The advantages of the pterional keyhole approach for removal of the migratory balloon during anticoagulation therapy and possible complications of the detachable balloon technique are discussed.

Case Report

A 19-year-old man had presented with redness and proptosis of the right eye, double vision, and progressive deterioration in visual acuity after craniofacial trauma two months previously. Four-vessel cerebral angiography revealed a Barrow type A CCF.

Affiliation

¹Department of Neurosurgery, Taichung Veterans General Hospital, Taichung, Taiwan, R.O.C. ²Department of Radiology, Taichung Veterans General Hospital, Taichung, Taiwan, R.O.C.

Correspondence

Chinng-Chyi Shen, M.D. · Department of Neurosurgery · Taichung Veterans General Hospital · 160, Sec. 3, Taichung-Kang Road · Taichung · Taiwan · Republic of China · Tel./Fax: +886/4/23 74 12 18 · E-mail: ns@vghtc.gov.tw

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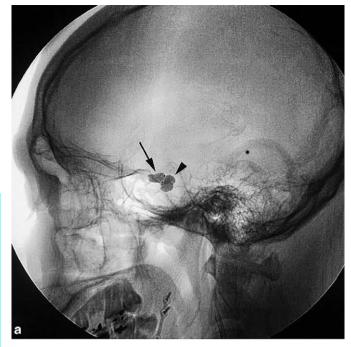




Fig. **1** Angiograms showing the locations of the detachable balloon embolization. **a** Gauge-7 (arrow) and gauge-9 (arrowhead) detachable balloons mounted with a 3F/2Fr microcatheter were placed into the right cavernous sinus through the carotid-cavernous fistula but complete occlusion of the fistula could not be achieved, suggestive of balloon trapping in the right internal carotid artery (proximal and distal locations of the fistula). **b** After detachment of the gauge-7 balloon, it deflated immediately. The shrunken balloon (arrow) flowed to and lodged in the right middle cerebral artery.

Initial treatment of the fistula was performed by detachable latex balloon (Acta Vascular System Inc., Paris, France) embolization. Unfortunately, just after detaching the last balloon (gauge 7), it deflated immediately (Fig. 1). The shrunken balloon flowed to and lodged in the right middle cerebral artery (MCA). The valve of the balloon did not function as usual and leakage of contrast media happened immediately after detachment. Shortly after-

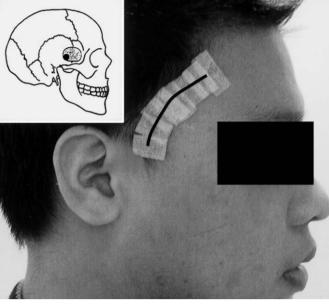


Fig. **2** Illustration of the pterional keyhole approach. An oblique skin incision (curved black line) about 5 cm in length was first made in the right frontotemporal region. A burr hole (inset, black dot) was made at the temporal base and a small craniotomy (inset, shadowed area) about 2 cm in diameter at the right pterional region just below the temporal line was performed.

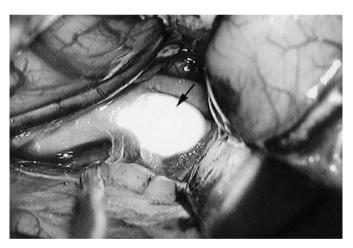


Fig. **3** A picture showing the displaced balloon trapped at the MI-M2 junction of the right middle cerebral artery.

ward, a follow-up angiogram showed a total obstruction of the right MCA at the MI-M2 junction. Progressive weakness of the left limbs was noted after the accident. A pterional keyhole approach with removal of the displaced balloon was then performed as an emergency operation and a sufficient volume supply to maintain cerebral perfusion as well as intravenous heparin were given during operation.

A curved incision of the scalp about 5 cm in length over the right frontotemporal region was made and a small craniotomy of about 2 cm in diameter in the right pterional region was performed (Fig. **2**) as we previously reported [3]. Frequent oozing of the operative field was noted. Under the microscope, microsurgical dissection was done to open the sylvian fissure and to identify the MCA at the MI-M2 junction. The displaced balloon





Fig. **5** Postoperative angiogram of the detachable balloon embolization. The right internal carotid artery was totally occluded with preservation of the right middle cerebral artery and anterior cerebral artery. Complete obliteration of the carotidcavernous fistula was also confirmed.

Fig. **4** Postoperative computed tomographic scan of the brain showed no definite infarction in the territory of the right middle cerebral artery.

was found (Fig. **3**) and the main trunk and branches of the MCA were temporarily clipped. The vessel was opened and the balloon was removed smoothly. A thrombus was also found at M2 and embolectomy was performed. Then the vessel from Ml to M2 was sutured with 10–0 nylon thread. After that, the blood flow of the MCA was measured with Doppler flowmetry to ensure its patency. The time spent from occlusion of the MCA to re-establishment of blood flow was about 2.5 hours. After operation, enoxaparin was given to the patient for two days. Postoperative computed tomography (CT) of the brain showed no definite infarction in the right MCA territory (Fig. **4**). Transient left hemiparesis due to the temporary occlusion of the right MCA by the migratory balloon was promptly alleviated.

Two weeks after the operation, another detachable balloon embolization was performed smoothly. One week after this embolization, the patient's orbital symptoms except for diplopia were resolved. Angiography confirmed the complete obliteration of the fistula (Fig. **5**). The follow-up magnetic resonance (MR) angiography revealed no evidence for recurrence of the fistula 3 months later.

Discussion

Occlusion of direct carotid-cavernous fistulas (CCFs) with the detachable balloons was first described by Serbinenko in 1974 [4]. Since then Debrun et al. have popularized their use for the treatment of direct CCFs [5]. Currently, several studies have shown that transarterial embolization of direct CCFs by detachable balloons is the best option for initial treatment [6–8]. Although this technique can be performed with minimal risks, there are potential complications.

The most common complication is oculomotor nerve palsy. Debrun et al. reported that oculomotor nerve palsy occurred in 20% of 54 patients with traumatic carotid-cavernous fistulas treated with detachable balloons and the occurrence rate was 16% in the series reported by Tsai et al. [9]. Lewis et al. reported complications associated with this procedure, including cerebral infarction, intracerebral hemorrhage, loss of vision, transient cerebral ischemia and pseudoaneurysm formation [10]. Lee et al. reported that a ruptured balloon lodged in the cavernous sinus [11] and Peeters et al. also reported rupture of the balloon during the embolization procedure [12]. The balloon may deflate prematurely and become lodged in the carotid artery or its branch [9]. In our case, the balloon deflated immediately just after it was detached. The shrunken balloon then flowed to and lodged in the right MCA. Thus, migration of balloon may be also a complication of detachable balloon embolization. Most of the patients with migratory balloons were complicated with cerebral infarction and/or mortality after the endovascular procedure [10]. Only a few cases of migratory balloon during endovascular embolization were successfully treated by a traditional pterion craniotomy and embolectomy [13-15]. In the present case, the migratory balloon was also successfully removed by a minimally invasive pterion keyhole approach.

The keyhole concept is defined by two principles including widening of the intracranial optical field with increased distance from the keyhole and visualization of the contralateral structures. Perneczky proposed the concept of keyhole surgery and the supraorbital keyhole approach for aneurysm clipping or tumor removal. We modified the method as a pterional keyhole approach in which a small craniotomy of about 2 cm in diameter was made in the pterional region [3]. The advantages of our method are minimal brain retraction, minimal surgical trauma, better cosmetic results, easy approach, less approach-related surgical morbidity and shortened hospitalization. From March 1999 to December 2004, we have gained experienced in this minimally invasive approach to treat anterior cranial base lesions such as pituitary adenomas, cavernous neurilemmomas,

cavernous hemangiomas, metastatic adenocarcinomas, gliomas, interpeduncular lipomas and intracranial aneurysms (data unpublished). In the present case, we also used this minimally invasive approach to remove the migratory balloon in the MCA. This keyhole approach can avoid large craniotomy-related intracranial hemorrhage, especially in patients under heparinization during endovascular procedures or other operations. Swann et al. reported a case of MCA embolism by a detachable balloon treated with embolectomy [13]. They spent about 3 hours from occurrence of embolism to re-establishment of blood flow by reopening a recent craniotomy. They thought that patient outcome was related to the degree of cerebral ischemia and time interval to re-establish the blood flow, and that it appeared difficult to re-establish the blood flow by embolectomy within 3 hours of vessel occlusion [13]. In our case, we only required 2.5 hours by the keyhole approach. We think that it is more timesaving than a traditional craniotomy with similar or even better improvement of clinical outcome. The authors consider that in selected groups of patients the pterional keyhole approach is a valuable alternative to the traditional pterion approach.

Conclusion

Although detachable balloon embolization is the best initial treatment of direct carotid-cavernous fistulas, there are potential complications. We report a case of a migratory balloon as a complication of detachable balloon embolization for the treatment of a direct carotid-cavernous fistula. The displaced migratory balloon was removed smoothly by the pterional keyhole approach. We recommend this minimally invasive approach as a good choice for treating such endovascular complications to improve outcome.

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