Microsurgical Recovery of a Migrated Balloon from the Internal Carotid Artery of a Child

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A child developed a traumatic intrapetrous internal carotid aneurysm after a routine myringotomy. The aneurysm was treated by occlusion of the internal carotid artery by the detachable balloon technique. Unfortunately, both balloons migrated and ischemic sequelae resulted when one of the balloons became lodged in the bifurcation of the internal carotid artery. The balloon was successfully retrieved during an emergency microsurgical embolectomy, and the child's neurological deficit was reversed. The management of both the intrapetrous aneurysm and the balloon migration are discussed. (Neurosurgery 16:381-386, 1985)

Key words: Detachable balloon technique, Internal carotid artery occlusion, Intrapetrous aneurysm, Microsurgical embolectomy

INTRODUCTION

The technique of detachable balloon catheterization for the treatment of carotid-cavernous sinus fistulas was promoted by DeBrun et al. in 1978 (7). Since that time, it has become a widely used procedure for the management of carotidcavernous sinus fistulas and for the treatment of vertebral and extracranial fistulas, giant aneurysms, and other unclippable intracranial aneurysms. Reports of complications with the detachable balloon technique in children are limited. We report a nearly tragic complication when a balloon migrated distally, obstructing the internal carotid artery (ICA) bifurcation. The management of this complication is discussed in this communication.

CASE REPORT

A 4-year-old girl presented to her local hospital in January 1984 with hearing loss and was diagnosed to have bilateral serous otitis media. Bilateral myringotomies and the placement of tubes were planned. The procedure was performed in the left ear without difficulty but, when the myringotomy was done in the right ear, bright red blood flowed briskly from the middle ear cavity. The bleeding was stopped by packing the ear. When stabilized, the child was transported to the

Hospital for Sick Children in Toronto.

When examined in this hospital, she was alert and hemodynamically stable. The examination was normal except for a right conductive hearing loss and clotted blood seen bulging through the right myringotomy. Shortly after arrival, the patient bled spontaneously from the right ear. Approximately 100 ml of bright red blood poured out of her right ear. The bleeding was again stopped with packing.

A computed tomographic (CT) head scan revealed a presumed congenital defect in the bony septum that separates the right middle ear cleft from the right intrapetrous segment of the carotid canal (Fig. 1). There was also fluid in the middle ear. A cerebral angiogram demonstrated a 2.5-mm aneurysm of the proximal portion of the intrapetrous segment of the right ICA (Fig. 2). This aneurysm, which was bulging into the middle ear cleft through its deficient floor, was thought to be traumatic in origin, secondary to injury during the myringotomy. Good collateral flow was seen from left to right during right carotid compression.

Direct clipping of this traumatic aneurysm was not practical because of its inaccessible position in the petrous bone and, therefore, detachable balloon occlusion of the right ICA was planned.

Embolization

Under general anesthesia, the right ICA was catheterized utilizing the transfemoral route. The first detachable balloon (BD 1-mm miniballoon; Becton-Dickenson) was placed in the intrapetrous portion of the right ICA adjacent to the aneurysm neck (Fig. 3); however, when the balloon was detached, it migrated distally and became lodged in the ICA adjacent to the anterior clinoid process. A second balloon was placed proximal to the aneurysm in the ICA at the base of the skull (Fig. 4). Both balloon placements were checked with angiography. Angiography of the vertebral artery and of the left carotid artery was also performed to confirm that collateral circulation was patent from the posterior communicating artery and the anterior cerebral artery and that the distal balloon was situated just below the origin of the posterior communicating artery. The girl awoke from anesthesia neurologically normal.

Postembolization course

The patient was discharged from the hospital and remained well for 1 month, when she suddenly developed a left facial weakness. During the next 24 hours, the left arm and leg also became paretic. When examined, she had a dense left facial weakness and was just able to lift her left arm against gravity. She was unable to walk because of weakness in her left leg. No sensory deficit was detected. Reflexes were suppressed on the left side and the left toe was upgoing. A right middle cerebral artery (MCA) infarction was suspected.

Skull x-ray films showed that both balloons had migrated. The distal balloon had migrated further up the supraclinoid ICA and the proximal balloon had somehow moved proximally and laterally. The cerebral angiogram confirmed that both balloons had indeed wandered (Fig. 5). The distal balloon was located in the ICA bifurcation, bulging into the M-1 segment of the MCA, partially stenosing collateral flow from the anterior cerebral artery (ACA) to the MCA by about 95% (Fig. 6). This balloon was also occluding the anterior choroidal and posterior communicating arteries. The proximal balloon

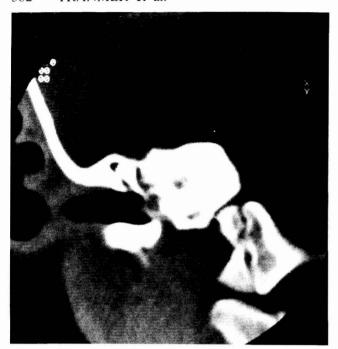


Fig. 1. CT head scan—detail of the right middle ear region. Dehiscence in the bony septum between the middle ear cleft and the carotid canal is indicated by the *arrow*.

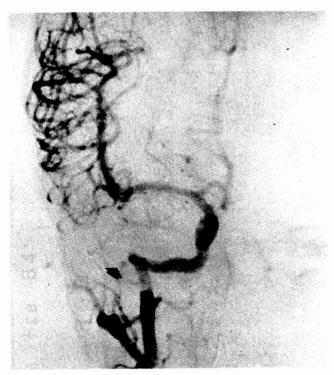


FIG. 2. Right internal carotid subtraction angiogram, anteroposterior view. The traumatic intrapetrous aneurysm is indicated by the *arrow*.

was now located in the internal maxillary artery. The angiogram also demonstrated multiple emboli in the distal MCA circulation. Fortunately, the intrapetrous ICA was thrombosed. A CT scan showed ischemia in the right MCA distribution.

It was concluded that the left hemiparesis was secondary to MCA ischemia resulting from balloon stenosis of the ICA



FIG. 3. Right carotid angiogram—anteroposterior view. The inflated balloon in the desired position in the ICA in the region of the aneurysm before detachment is indicated by the *open arrow*. The *black arrow* shows the inflated balloon bulging into the aneurysm.

bifurcation area. The patient was treated with anticoagulation and volume expansion for 36 hours while surgical therapy was planned. Minimal improvement occurred during this period.

Operation

Four days after her first ischemic symptom, a standard right pterional exposure of the right optic nerve and ICA was performed. After opening the anterior part of the sylvian fissure, we had good exposure of the entire supraclinoid ICA and the proximal ACA and MCA. Through the microscope, the balloon was visualized in the distal ICA, obstructing the posterior communicating and anterior choroidal arteries and bulging into the MCA. Minimal blood flowed from the A-1 segment of the ACA to the MCA past the tip of the balloon.

A temporary clip was placed on the posterior communicating artery and then a 2-mm arteriotomy was made in the ICA opposite the origin of the posterior communicating artery. Blood gushed from the arteriotomy and the balloon disappeared. It was believed that the balloon had been expelled from the ICA, and thus an attempt was made to suture the arteriotomy. It was necessary to occlude the ACA and the MCA temporarily. No flow was seen from the proximal ICA. There was great difficulty suturing the ICA, as the wall of the artery was friable and tore easily. After 30 minutes of MCA occlusion and unsuccessful closure of the arteriotomy, clips

were placed on the ICA proximal to the posterior communicating artery and proximal to the anterior choroidal artery. Another clip was placed on the posterior communicating artery. The balloon was found in the proximal ICA as the clips were being applied (Fig. 7). Good flow to the MCA and



FIG. 4. Right common carotid angiogram, anteroposterior view. Both balloons are in their final positions, trapping the aneurysm, after embolization. The distal balloon is in the ICA adjacent to the anterior clinoid process and the proximal balloon is in the ICA at the base of the skull.

also to the anterior choroidal artery from A-1 was visible at the conclusion of the operation.

Postoperative course

The patient regained consciousness in the recovery room, but showed only minimal improvement of the left hemiparesis. After 1 week, her deficits had improved significantly and she was able to use her left hand and walk with little difficulty. One month later, she was completely normal except for a mild left facial weakness. Three months after the em-

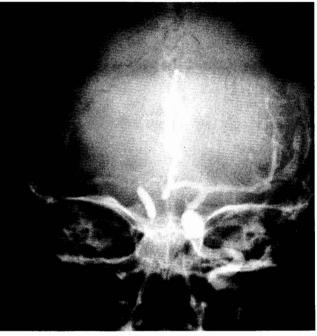


FIG. 6. Left internal carotid angiogram, anteroposterior view, after right cerebral infarction. The distal balloon is located in the supraclinoid ICA wedged into the ICA bifurcation. Collateral flow from the ACA to the MCA is significantly obstructed by the balloon.

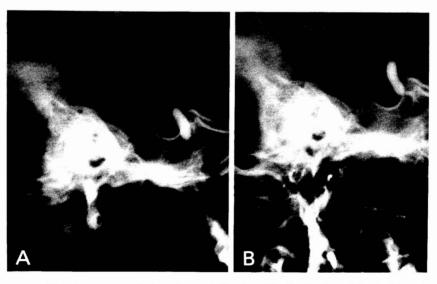


FIG. 5. A, right common carotid angiogram, lateral view, after embolization. The distal balloon is in the ICA adjacent to the anterior clinoid process and the proximal balloon is in the ICA at the base of the skull. B, right common carotid angiogram, lateral view, after right cerebral infarction. Both balloons migrated. The distal balloon wandered distally, up the supraclinoid ICA into the ICA bifurcation. The proximal balloon wandered down the ICA, up the ECA into the internal maxillary artery.

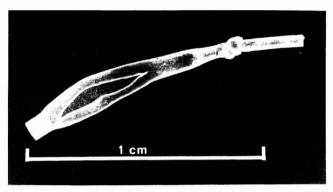


Fig. 7. Miniballoon after microsurgical retrieval from the ICA. The balloon was punctured intraoperatively.

bolectomy, the neurological examination was normal and a cerebral angiogram showed a thrombosed right ICA and excellent collateral flow through the anterior communicating artery to the right MCA.

DISCUSSION

We believe that this is the first report of detachable balloon occlusion of the ICA followed by microsurgical recovery of the migrated balloon in a child. Two previous reports described the intracranial recovery of migrated balloons in adults (6, 17). In these cases, the detachable balloon technique was used for the treatment of a carotid-cavernous sinus fistula and an ICA aneurysm. Our case is also unique because of the rare occurrence and our subsequent management of an intrapetrous ICA aneurysm.

The girl was born with a congenital defect in the bony lamella separating the middle ear cleft and the carotid canal. We believe that, during a routine myringotomy, the ICA was lacerated as it pouted into the middle ear cleft. Profuse hemorrhage was witnessed and a traumatic intrapetrous ICA aneurysm developed.

Aneurysms involving the petrous portion of the ICA are rare. Only 25 previous case reports were found in the literature (4, 11–13, 16, 19). The aneurysm usually presents as a middle ear mass producing hearing loss or as a spontaneous hemorrhage from the ear. It can be misdiagnosed as a glomus tumor and, in fact, several were biopsied, producing brisk arterial bleeding. The aneurysms can be true aneurysms or pseudoaneurysms (false aneurysms). Kecht reported that the bony septum separating the tympanic cavity from the carotid canal is often less than 0.5 mm thick (15), and Meyerson et al. suggested that there is a dehiscence rate of about 1% in this segment of the carotid canal (18). Therefore, this preexisting defect within the petrous bone will allow aneurysmal growth of an ICA defect.

The true aneurysms (congenital) are similar to the supraclinoid ICA aneurysms and originate at the origin of intrapetrous branches, usually the caroticotympanic branch. The majority of the reported aneurysms were described as having an unknown cause or as being of congenital origin.

False intrapetrous aneurysms have been reported after closed head injuries (5, 21), surgical procedures in the ear and mastoid area (1, 2, 22), and chronic mastoid and middle ear infections (2, 14, 24).

Intrapetrous aneurysms have been treated by a variety of methods, all having associated complications and not always satisfactory results. Conservative treatment (observation), although occasionally successful, leaves the patient with an unacceptable rebleed rate (14). Packing the middle ear with muscle is appropriate only in the older patient who is unable to tolerate carotid manipulation. Because of its location deep within the petrous bone, direct surgical attack on the aneurysm seems to be a difficult procedure, exposing the patient to possible serious complications. Despite this, Glassock described an interesting approach to an intrapetrous aneurysm through an infratemporal fossa route (12). He successfully resected an aneurysm, but exposed the patient to 30 minutes of carotid occlusion, sacrificed ipsilateral hearing, and sectioned the 7th nerve, although the nerve was later anastomosed.

The majority of the reported cases were treated by carotid occlusion by either carotid ligation or a trapping procedure (2, 20, 22). Only one patient sustained a permanent neurological deficit. The detachable balloon technique seemed to us to be the simplest and safest method of treating this girl's ICA aneurysm. A balloon placed adjacent to the aneurysm neck would effectively occlude the neck of the aneurysm and allow preservation of the supraclinoid ICA.

The detachable balloon technique, which was first described by Serbinenko in 1974 and was later introduced to the western world by DeBrun in 1978, has recently become a popular procedure in the treatment of carotid-cavernous sinus fistulas, giant aneurysms, and other unclippable intracranial aneurysms (7, 23). Although viewed as an effective and relatively simple procedure, this technique is not without complication. Barrow et al. described complications including shrinkage of positioned balloons, cranial nerve palsies, embolization from the catheter tip, and neck hematomas during attempts to obliterate carotid-cavernous sinus fistulas with detachable balloons (3). DeBrun reported his extensive experience using the detachable balloon technique for the management of carotid-cavernous sinus fistulas and giant aneurysms (7-9). The development of false aneurysms and cranial nerve palsies after balloon occlusion has been a significant problem. When treating giant aneurysms, it has been found that balloon occlusion of the parent artery rather than filling the aneurysm itself with balloons is the safest way to treat the aneurysm, even though it may be necessary to first perform an extracranial-intracranial (ECIC) arterial bypass.

We found only two previous publications describing distal migration of the detached balloon. Chalif presented a case in which a balloon embolized from a carotid-cavernous sinus fistula into the supraclinoid ICA (6). Langford described the migration of a balloon into the MCA after ICA occlusion for the treatment of an ICA aneurysm (17). In each case, ischemic sequelae followed the balloon migration and an emergency craniotomy was performed to remove the balloon.

The balloons that we used wandered alarmingly easily within the ICA. The first balloon migrated immediately after it had been detached and became lodged in the ICA adjacent to the anterior clinoid process. We were then forced to place a second balloon proximal to the aneurysm at the base of the skull. When the child returned 1 month later with an ischemic right hemisphere, we discovered that both balloons had migrated. The distal balloon had migrated further up the ICA into the ICA bifurcation, obstructing collateral flow from the ACA to the MCA. The other balloon migrated in a retrograde fashion down the ICA into the external carotid artery (ECA). Fortunately, the ICA aneurysm remained thrombosed after the balloon migrations.

Of prime importance is an explanation for the unacceptable migration of the balloons. In this patient, a 1-mm BD detachable silicone balloon inflated to a width of 4 mm with isotonic metrizamide was used. Although experience with balloon

embolization in the pediatric age group is limited, this size and type of balloon has been used. In our patient, the first balloon migrated immediately after detachment. Either deflation occurred at this point or the balloon had not originally been adequately inflated. The second alternative is more likely because the inflation of the balloon may not be ideal within the bony carotid canal. Alternatively, balloons can deflate when the wall of the balloon acts as a semipermeable membrane and allows concentration equilibration of the solution inside the balloon with surrounding blood. Isotonic metrizamide was used to inflate the balloon in this case. DeBrun recommends that the detachable balloons be inflated with a 100% polymerizing substance using a double-lumen catheter (10). This, he claims, ensures against balloon deflation and subsequent distal migration. The retrograde movement of the second balloon into the ECA is even more puzzling. It is more likely that it moved after the migration of the first balloon more distally.

It has become apparent that children can tolerate ICA occlusion far better than adults. Their collateral flow from the contralateral carotid and posterior circulation is almost always sufficient to perfuse the ipsilateral hemisphere. Rarely is a bypass procedure, such as an ECIC bypass, necessary. On the other hand, occlusion of one carotid system may place the child at additional future risk to the sequelae of such potential diseases as atherosclerotic carotid artery disease, cerebral aneurysms, and head and neck cancer.

When the balloon migrated into the ICA bifurcation, obstructing collateral flow from the right ACA to the right MCA, our patient gradually developed a left hemiparesis that was the result of ischemia in the distribution of the right MCA. Although anticoagulation and volume expansion did retard the progression of the stroke-in-evolution, we believed that the optimal treatment was an embolectomy of the balloon from the ICA bifurcation. Successful removal of the balloon would have allowed free flow from the ACA to the MCA and also would have removed a source of thromboembolism. Unfortunately, we were unable to reconstitute the ICA after the arteriotomy and retrieval of the balloon and were forced to sacrifice the ICA proximal to the anterior choroidal artery. We did succeed in reestablishing the collateral flow into the MCA and also the anterior choroidal artery.

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COMMENT

This communication is quite pertinent and important to the expanding field of interventional neurosurgery. It emphasizes the potential hazard in the application of detachable balloons for neurological disorders. The microsurgical technique for balloon removal and the attendant difficulties add significance to this case presentation.

The authors note the growing number of reports that advocate occlusion of surgically inaccessible aneurysms with detachable balloons. However, migration of balloons is constantly mentioned as an inherent risk of these procedures in

the treatment of the internal carotid artery. Comparison of the artery and balloon diameters on a roentgenogram is difficult; however, we suspect that the internal carotid artery diameter at the level of the balloon detachment closely approximated the maximal inflation of the miniballoon (4 to 5 mm). To occlude a vessel of 4 to 5 mm in diameter, a larger balloon is advisable, particularly if the balloon is inflated with contrast material. In other published cases of migrations of detachable balloons used for carotid artery aneurysms, a 1-mm-wide miniballoon was used.

DeBrun recommends inflating detachable balloons with silicone material, which polymerizes to form a solid, nondeformable mass (1). This technique should ensure more permanent placement. However, the double-lumen catheter required to fill the balloon totally with silicone fluid is larger and requires a significantly larger introducing cannula. This requirement obviates the universal applicability of this technique. The use of other polymerizing materials, such as hydroxyethylmethacrylate (hema), may make the use of detachable balloons safer (2).

We are of the opinion that detachable balloon occlusion of inaccessible internal carotid or vertebral artery lesions with optimal size balloons filled with polymerizing solid material will ultimately prove to be the method of choice for treatment. Currently, detachable balloons filled with contrast material have a high rate of therapeutic success, although the inherent risk of migration remains a problem. Therefore, in high risk situations, it is our recommendation that proximal occlusion of the internal carotid artery by a direct surgical approach be an option to prevent balloon migration.

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