New detachable balloon technique for traumatic carotid-cavernous sinus fistulae.

W Taki, H Handa, H Miyake, A Kobayashi, Y Yonekawa, K Yamamura, M Suzuki and Y Ikada

AJNR Am J Neuroradiol 1985, 6 (6) 961-964
http://www.ajnr.org/content/6/6/961.citation

New Detachable Balloon Technique for Traumatic Carotid–Cavernous Sinus Fistulae

Waro Taki,[1] Hajime Handa,[1] Hidenori Miyake,[1] Akira Kobayashi,[1] Yasuhiro Yonekawa,[1] Kunio Yamamura,[1] Masakazu Suzuki,[2] and Yoshito Ikada[2]

Recent advances in intravascular surgery have opened new horizons in the treatment of various cerebrovascular diseases. In particular, embolization using detachable balloon catheters is widely accepted as the treatment of choice in traumatic carotid-cavernous sinus fistulas (CCFs) [1–3]. However, a relatively large number of clinical trials have revealed that this technique sometimes fails to preserve the carotid blood flow [1]. Also, large balloons or multiple balloons occupying the cavernous sinus can cause cranial nerve palsies or delay recovery from preexisting palsies. In addition, incomplete occlusion of the fistulous opening sometimes produces a false aneurysm. For these reasons we have developed a new detachable balloon that completely occludes the fistulous opening rather than fills the cavernous sinus. The success of this approach in a case of a huge CCF is the subject of this report.

Technique

Our present technique is a modification of our detachable balloon technique with activated radiofrequency current [3–5]. With this technique, the balloon is attached to the silicone catheter by a polyvinyl alcohol tube that dissolves when heated, releasing the balloon. Heating is achieved with two ring-shaped copper electrodes, less than 1 mm apart, connected to two copper wires embedded in the silicone catheter. The new modification involves only the balloon and not the detaching mechanism. The new balloon is connected to a Silastic tube (1.0 mm in outer diameter, 3 mm in length) with a fine nylon thread (0.2 mm in outer diameter, 3 cm in length) (fig. 1A). To opacify the Silastic tube under fluoroscopy, stainless steel is embedded in the Silastic tube. Tantalum is attached to the balloon for the same purpose. The proper-sized balloon is chosen by considering the size of the fistulous opening. We currently use a balloon with an outer diameter of 0.6 mm.

Under local anesthesia, the common carotid artery is punctured and a sheath introducer is inserted. Through this sheath, the balloon catheter is introduced into the carotid artery. Inflation and deflation of the balloon with Amipaque is repeated while advancing the balloon catheter. After the leading Silastic rod enters the cavernous sinus, the balloon is again inflated within the internal carotid artery so that the nylon threads cross the orifice (fig. 1B). Under fluoroscopic control, the volume of the balloon is measured and adjusted to occlude the opening without causing severe stenosis in the internal carotid artery. The Amipaque is aspirated and the same volume of 2-hydroxyethylmethacrylate (HEMA) is injected to completely occlude the opening [5]. Considering the dead space of the catheter, we adopted the carotid route rather than the femoral route. In this new technique, we also used a catheter with a narrower lumen so that the dead space would be less than 0.02 ml. Viscosity of HEMA is low enough to pass into the balloon through this narrow lumen. After solidification of the balloon by HEMA, the balloon is detached from the catheter by applying a radiofrequency current. Since our method of detachment does not involve mechanical force, the balloon does not move. Immediately after detachment, the balloon is fixed at the opening by the sump effect between the internal carotid artery and the cavernous sinus, and the balloon becomes embedded in the clot that closes the fistula. Because this closure may negate the sump effect, causing the blood flow to carry the balloon into the distal internal carotid system, the Silastic tube embedded in the cavernous sinus functions as an anchoring system that keeps the balloon at the fistula orifice. After detachment, the catheter is removed and hemostasis is obtained at the arterial puncture site.

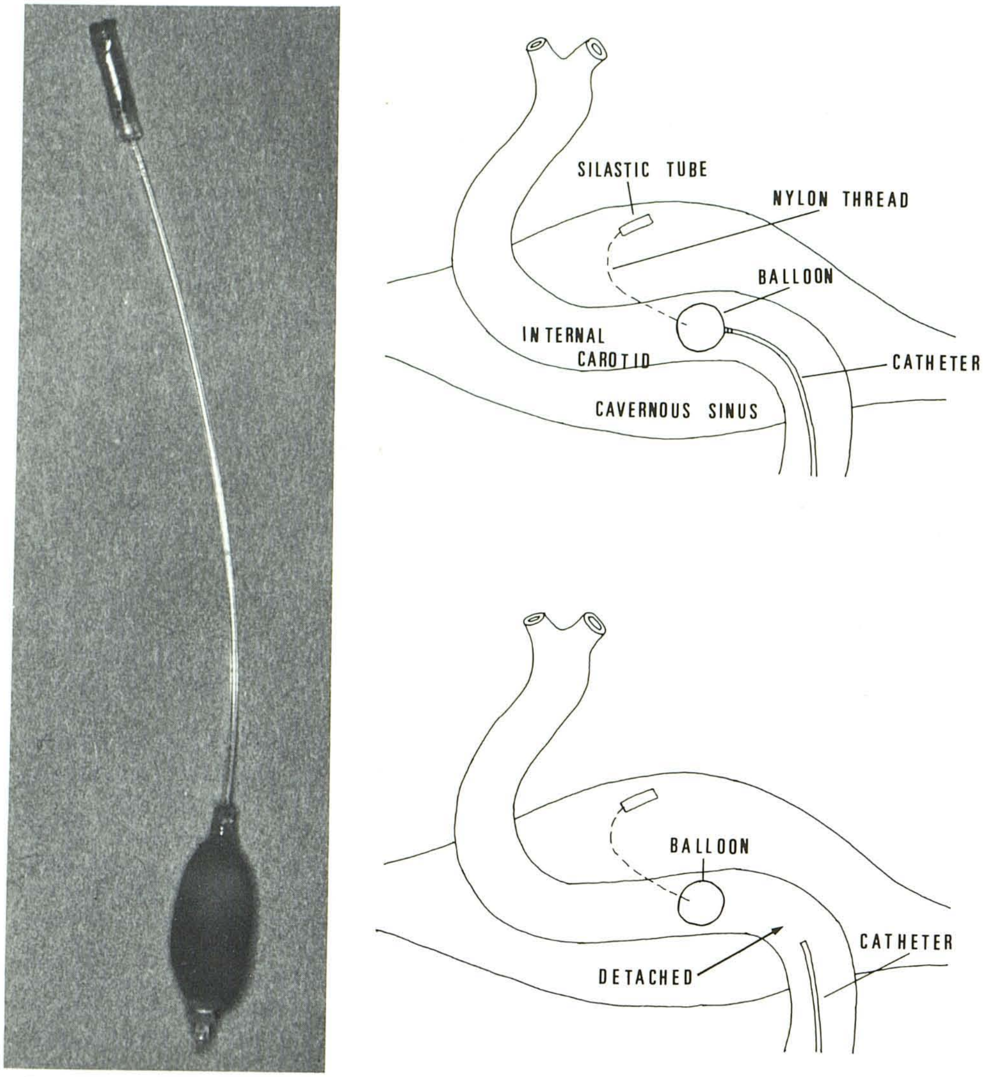
Representative Case Report

A 27-year-old man fell from a three-story building and was taken to a local hospital. He was drowsy and bleeding from the nose. Radiography demonstrated a fracture of the right frontal bone. Computed tomography (CT) revealed a subarachnoid and an intraventricular hemorrhage. Three days later he developed right third, fourth, and sixth nerve palsies. Six days later visual acuity began to deteriorate. Angiography 2 weeks after the accident revealed the right traumatic CCF. The patient had regained consciousness and was transferred to our hospital.

Received April 30, 1984; accepted after revision April 11, 1985.

[1] Department of Neurosurgery, Kyoto University Medical School, 54 Kawaharacho Shogoin, Sakyoku, Kyoto, Japan 606. Address reprint requests to W. Taki.
[2] Institute of Biomedical Material Research, Kyoto University Medical School, Kyoto, Japan 606.

AJNR **6:961–964, November/December 1985** 0195–6108/85/0606–0961 $00.00



A B

Fig. 1.—**A**, New detachable balloon catheter. Balloon was inflated with HEMA and detached from catheter. Nylon thread attached to tip of balloon is connected to Silastic rod, which anchors balloon. **B**, Schematic drawing of new modification technique.

On examination the patient was alert. Bilateral anosmia probably was caused by the initial head injury. A loud cranial bruit was audible, especially over the right eye. There was only light perception in the right eye; with the left eye, fingers could be counted at 50 cm. There were bitemporal hemianopia; right third, fourth, and sixth nerve palsies; and right exophthalmos. Radiography demonstrated right frontal and sphenoid bone fractures. CT showed a spherical and homogeneously enhanced mass in the suprasellar cistern with mild hydrocephalus. Angiography revealed a large CCF that was fed by the right internal carotid artery and drained by the pterygomaxillary plexus, the superior ophthalmic vein, and the contralateral inferior petrosal sinus (figs. 2A and 2B). The cavernous sinus protruded into the third ventricle.

The right common carotid artery was cannulated under local anesthesia. A 6 French sheath introducer was inserted in the right common carotid artery. Through this introducer, the detachable balloon catheter was inserted, and the Silastic tube and the balloon were advanced to the fistulous opening under fluoroscopic observation. After confirming that the Silastic tube had entered the cavernous sinus, the balloon was inflated with Amipaque. The balloon size was adjusted so as to completely occlude the fistulous opening, but not to cause substantial stenosis of the internal carotid artery. After confirming the volume needed to inflate the balloon (0.08 ml), the balloon was completely deflated, and the same volume of HEMA was injected into the balloon. After 4 min, the HEMA solidified and the balloon was instantaneously detached without changing its position (figs. 2C and 2D). Immediately after embolization, the bruit completely disappeared. The right exophthalmos disappeared within 4 hr. The ophthalmoplegia disappeared within 1 week. Visual acuity improved to become 1.0 on the right, 0.5 on the left. Angiography 1 week after embolization showed complete obliteration of the fistulous opening while the internal carotid artery remained intact. The patient was followed for 16 months, and there was no recurrence of symptoms. The patient returned to work.

Discussion

Detachable balloon catheter techniques have yielded good results in the treatment of traumatic CCFs, though conven-

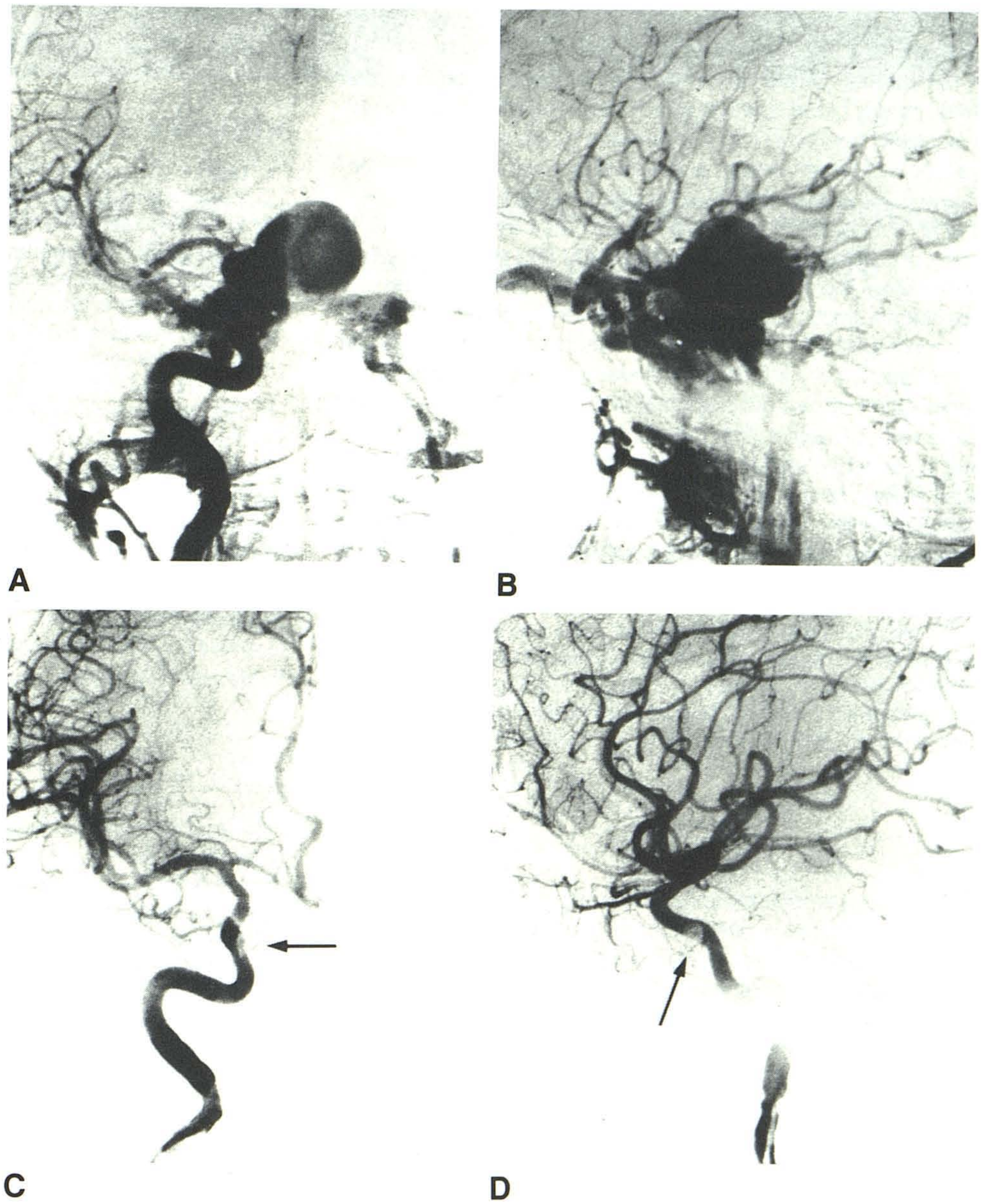


Fig. 2.—Anteroposterior (**A**) and lateral (**B**) angiograms before embolization. CCF was fed by right internal carotid artery. Draining veins comprise contralateral inferior petrosal sinus, superior division of ophthalmic vein, sphenoparietal vein, and pterygomaxillary plexus. **C** and **D**, After embolization. Balloon (*arrows*) was detached at fistulous opening. CCF was completely obliterated and internal carotid blood flow preserved.

tional techniques cannot always preserve the carotid blood flow. Debrun et al. [1] reported that carotid blood flow was preserved in 59% of their 54 cases of traumatic CCF. In attempting to occlude the cavernous sinus itself, the inflated balloon can also cause mechanical compression of the cranial nerves in the cavernous sinus; the third nerve is often disturbed. Debrun et al. reported that 20% of their patients exhibited transient ocular nerve palsy (either third or sixth nerve) postoperatively. It is not always possible to completely occlude the cavernous sinus; in some cases, the residual lumen results in formation of a false aneurysm, especially if the balloon is disproportionately small compared with the large cavernous sinus and if it is inflated only with contrast medium. Debrun et al. also reported that these aneurysms occurred in 44% of their patients.

Because of these disadvantages, we have developed a new technique, whereby the balloons are not detached within the cavernous sinus, but at the fistulous opening. Complete closure of the opening prevents the formation of false aneurysms and is expected to provide prompt recovery of associated cranial nerve palsies. In occluding the fistulous opening with the balloon, the problem is to prevent distal migration of the balloon into the intracranial artery. Anchoring the detached balloon to nearby tissue is a necessary step that we have attempted to do using a Silastic rod. This rod, which initially floats in the cavernous sinus after clot formation, may act as an anchor after adhering to the sinus wall. In our technique, the balloon is solidified with HEMA, eliminating balloon shrinkage and reopening of the fistula. Another problem is stenosis at the internal carotid artery. The average size of a fistulous opening is reported to be 3 mm. Theoretically, a 3 mm balloon may protrude into the carotid artery about 1.5 mm because the diameter of internal carotid artery in the cavernous sinus is about 3–4 mm. Although the balloon may cause stenosis in the internal carotid artery, the stenosis should be less than 50%; hence, blood flow would not be substantially decreased. Practically, however, it is not possible to expect that a 3 mm balloon will never create a stenosis greater than 50%, because the shape of the fistulous opening differs in each case, and an oval rather than the round balloon may be required. A more practical expectation is that there is a good chance of obliterating the fistulous opening by the balloon when the opening is small, without causing severe stenosis. This can be accomplished by close observation during fluoroscopic observation. This is how severe stenosis was avoided in our case. Although we did not measure blood flow, this can be done with a Doppler flow meter. Another potential complication is the embolization of fresh clot forming from the balloon base to the distal intracranial artery in the early postoperative days. In our experiment with dogs, the intravascular balloon was covered with endothelium within 30 days [3]. In future trials, a prophylactic antiplatelet aggregation medication, such as aspirin or Persantine, will be necessary for about 1 month.

REFERENCES

1. Debrun G, Lacour P, Viñuela F, Fox A, Drake CG, Caron JP. Treatment of 54 traumatic carotid-cavernous sinus fistulas. *J Neurosurg* **1981**;55:678–692
2. Kerber CW. Balloon catheter with a calibrated leak: new system for superselective angiography and occlusive catheter therapy. *Radiology* **1976**;120:547–550
3. Taki W, Handa H, Yonekawa Y, et al. Detachable balloon catheter systems for embolization of cerebrovascular lesions. *Neurol Med Chir* (Tokyo) **1981**;31:709–719
4. Taki W, Handa H, Yamagata S, Yonekawa Y, Iwata H, Ikada Y. The releasable balloon technique with activated high frequency electrical current. *Surg Neurol* **1980**;13:405–408
5. Taki W, Handa H, Yamagata S, Ishikawa M, Iwata H, Ikada Y. Radiopaque solidifying liquids for releasable balloon technique: a technical note. *Surg Neurol* **1980**;13:140–142