Therapeutic Embolization for Vascular Trauma of the Head and Neck

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Therapeutic embolization is an effective and relatively safe method for managing many cases of head and neck trauma. In the last 5 years, 78 traumatic vascular lesions—10 arterial transections and 68 arteriovenous fistula—were treated by intravascular embolization at four medical centers. Selection of embolic materials is discussed and different types of lesions are illustrated. Treatment was successful in every instance. Complications were limited to one case of cerebral infarction and two cases of temporary oculomotor weakness. The indications for embolization have widened beyond life-threatening hemorrhage alone, and continued improvement in techniques and embolic agents should see an increased use of this form of treatment.

Traumatic vascular injuries of the head and neck include vessel transection and laceration, false aneurysm formation, and arteriovenous fistula. Such injuries may result from either closed or penetrating trauma and their presentation can be either immediate or delayed. In the past, management of these injuries had consisted mostly of surgery or observation. In many instances surgical treatment is efficacious, but in others the location of the injury may make surgery difficult or unacceptably dangerous. In such circumstances we have used therapeutic embolization techniques as an adjunct to facilitate surgery or as the definitive treatment. Our experience in treating 78 patients with traumatic vascular lesions of the head and neck over the past 5 years forms the basis of this report.

Many of the patients were bleeding actively at the time of angiography, and this has been one of the most common indications for embolization therapy in the past. The indications for vascular occlusive techniques are widening, however, and patients with other lesions such as arteriovenous fistulas and false aneurysms have been treated increasingly with these methods. Complex injuries with combinations of bleeding, fistulas, and false aneurysms may be particularly suitable for embolization therapy. The specific lesions treated in this series are summarized in table 1. Ten involved major vessel transection; the rest were arteriovenous fistulas, the most common involving the caverous sinus.

Materials and Methods

The techniques of vascular occlusive therapy have been described elsewhere [1–8]. A number of different materials have been used successfully for vessel occlusion. The materials that we have used include particulate emboli and balloon catheters. For particulate emboli, we prefer polyvinyl alcohol foam (PVA, Unipoint, Ind., High Point, NC), Gelfoam (Upjohn, Kalamazoo, MI), or barium-impregnated Silastic spheres (American Heyer-Schulte Corp., Goleta, CA). The balloon catheters used have been both fixed and detachable. In early cases, a fixed balloon (Edwards Labs., Santa Ana, CA) was used. More recently, we have used a detachable Silastic balloon catheter system [3]. The choice of agent varies with different lesions, as no one agent is optimal for all lesions. We have chosen to categorize this series into groups based on the vessel size and type of injury. This, in turn, helps to determine the choice of agents used for embolization. The groups include small or

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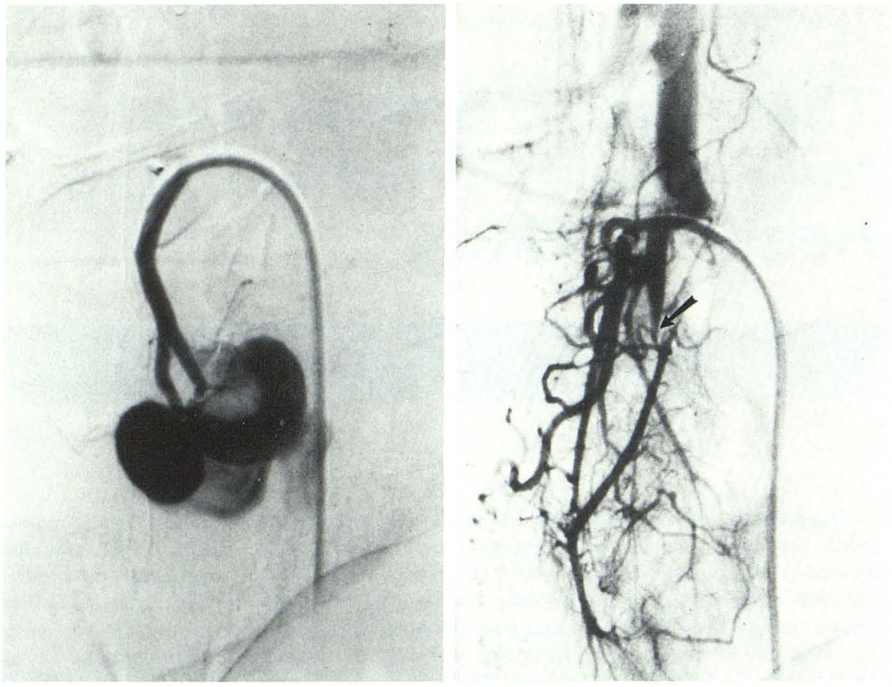

A B

Fig. 1.—Case 1. Small vessel laceration. **A**, Lobulated false aneurysm of left superior thyroid artery with small incidental fistula to jugular vein. **B**, Occlusion of aneurysm (*arrow*) with sparing of nearby branches after PVA foam embolization.

TABLE 1: **Embolization for Head and Neck Trauma over 5 Years**

Reason for Embolization	No.
Internal carotid-cavernous sinus fistula	51
Internal carotid-jugular fistula	1
Internal carotid transection/laceration	4
Middle cerebral artery transection	1
External carotid-cavernous fistula	3
External carotid-jugular fistula	2
External carotid branch transection	5
Meningeal arteriovenous fistula	8
Vertebral arteriovenous fistula	3
Total	78

large vessel lacerations and small or large vessel arteriovenous fistulas. Patients with complex injuries are classified under the more clinically significant injury at the time of the procedure.

Representative Case Reports

Case 1

A 32-year-old man suffered a stab wound in the left neck. Upon arrival at the hospital the patient was spitting up copious amounts of blood and there was an expanding cervical hematoma with impending compromise of the airway. An emergency angiogram showed extravasation of contrast material from a branch of the left superior thyroid artery into a false aneurysm, which in turn fed into an arteriovenous fistula draining into the jugular vein (fig. 1A).

The tip of the 5 French angiographic catheter was positioned near the site of the fistula. Because of the short distance from the catheter tip to the fistula and the desire for permanent occlusion, PVA foam was selected for embolization. It has been our experience that this agent shows more of a tendency to lodge proximally in an artery than Gelfoam or Silastic spheres. An occlusion that is too proximal may allow continued patency of the artery via collaterals beyond the site of occlusion. This would negate the effect of embolization, and the collateral vessels themselves might be of such size and geometry that further embolization through them would be impossible. The short distance from catheter tip to injury site and the small size of the artery in this case were ideal for PVA foam.

The fistula and false aneurysm were easily occluded with 1 mm PVA foam particles injected through the angiographic catheter. There was no occlusion of nearby vessels (fig. 1B). The patient underwent an uneventful recovery and no surgery was performed.

Case 2

A 40-year-old man received a closed head injury. Ten weeks later he noted onset of decreased vision and diplopia bilaterally with an intracranial bruit. Carotid angiography was performed and bilateral external carotid-cavernous fistulas were demonstrated (fig. 2A). Embolization of both external carotid arteries was accomplished using about 60 1 mm Silastic spheres (fig. 2B). Within 3 days of the embolization, all the symptoms had resolved.

Silastic spheres were chosen in this case because of the need for an embolus with the potential to travel for some distance from the catheter tip without becoming lodged en route to the fistula. In our experience, spheres have been more effective in this setting than Gelfoam or PVA foam.

Case 3

A 30-year-old man was shot in the right medial orbit and developed massive epistaxis while being transported to the hospital. The patient was found comatose with a dense right hemiplegia and

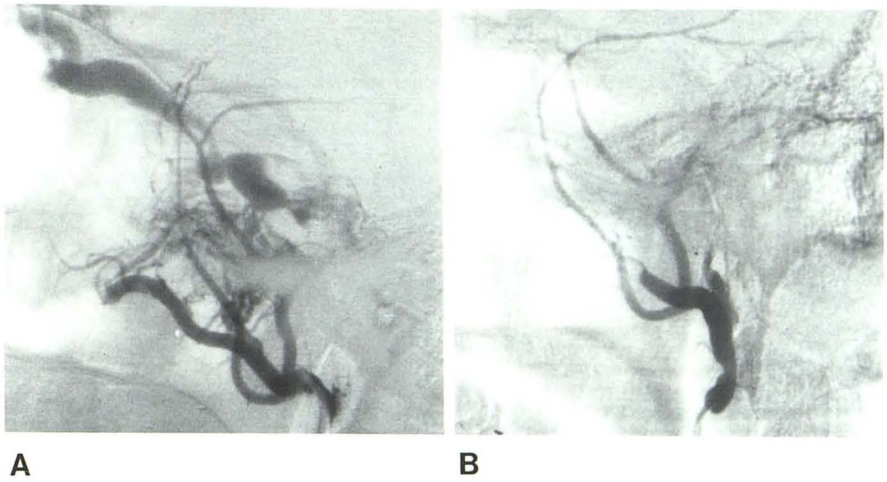

Fig. 2.—Case 2. Small vessel arteriovenous fistula. **A**, External carotid to cavernous sinus fistula, left-sided injection. **B**, Closure of fistula after embolization with Silastic spheres. Similar result was obtained on right side.

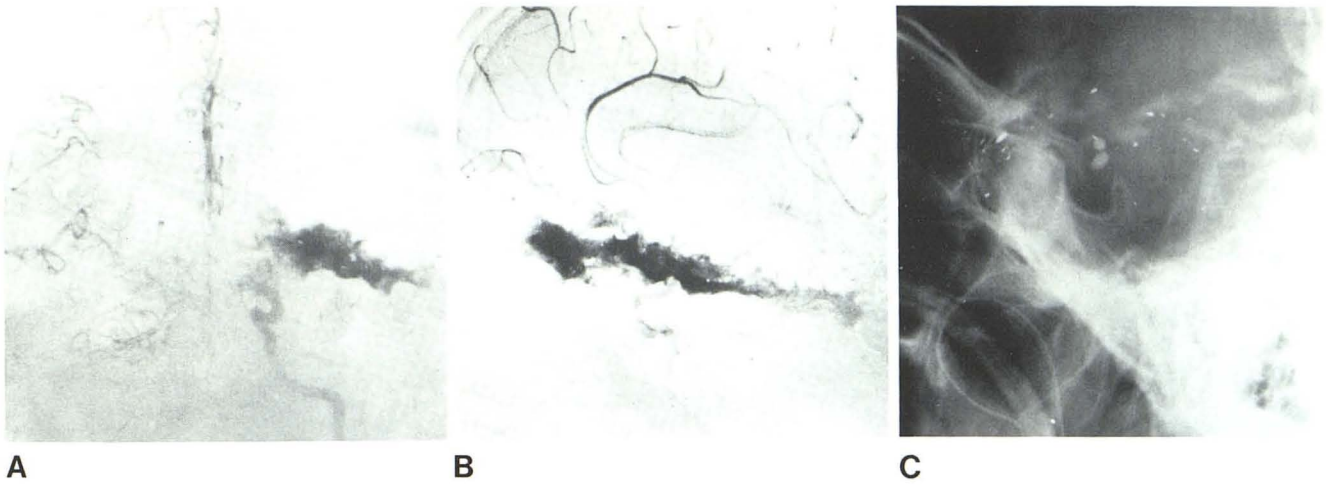

Fig. 3.—Case 3. Large vessel laceration. Frontal (**A**) and lateral (**B**) projections. Left middle cerebral artery transection with extravasation through bullet tract. **C**, Plain film. Two detachable balloons in place in proximal left middle cerebral artery. Hemorrhage stopped; some extravasation remains from preembolization injections.

ophthalmoplegias involving right cranial nerves III, IV, and VI. He was rapidly transfused and treated with nasal packs.

A skull series revealed that the bullet had entered the right ethmoid sinus anteriorly and exited the left sphenoid sinus to lodge in the left posterior temporal area. An arteriogram was obtained which revealed a transection of the left middle cerebral artery and extravasation of contrast material into the bullet tract and out through the sphenoid sinus (figs. 3A and 3B).

Due to continued arterial hemorrhage and deteriorating neurologic status, an emergency embolization of the left middle cerebral artery was performed with two detachable balloons (fig. 3C).

Although the hemorrhage was stopped, the patient continued to deteriorate as a result of the massive brain injury and subsequently died.

Case 4

A 22-year-old man suffered a closed head injury in an automobile accident. Signs of a carotid-cavernous fistula developed soon thereafter. The right eye showed proptosis and chemosis and there was an intracranial bruit. A cerebral angiogram (fig. 4A) documented the right internal carotid-cavernous fistula. Vision in the right eye began to deteriorate and extraocular muscle palsy developed. It was decided to treat the fistula by use of an inflatable and detachable balloon. Two balloons were placed through the fistula in the cavernous sinus. Flow through the fistula was markedly slowed and at follow-up angiography 2 weeks later the fistula was closed (figs. 4B and 4C). Vision and ocular movements returned to normal.

This case demonstrates treatment of a large vessel fistula. Inflatable and detachable balloons are ideal for such a situation. They are controllable and have an expansibility greater than other emboli. The balloon can be controlled before detachment by flow direction and mechanical manipulation of the coaxial catheter system. This makes precise embolus placement possible. The expansile characteristics of balloons offer the advantage of a large embolus without requiring a large catheter and arteriotomy for delivery.

Case 5

A 28-year-old man sustained a gunshot wound to his left eye. He was comatose with a severe orbital injury. A cranial computed tomographic (CT) scan showed subarachnoid hemorrhage but was

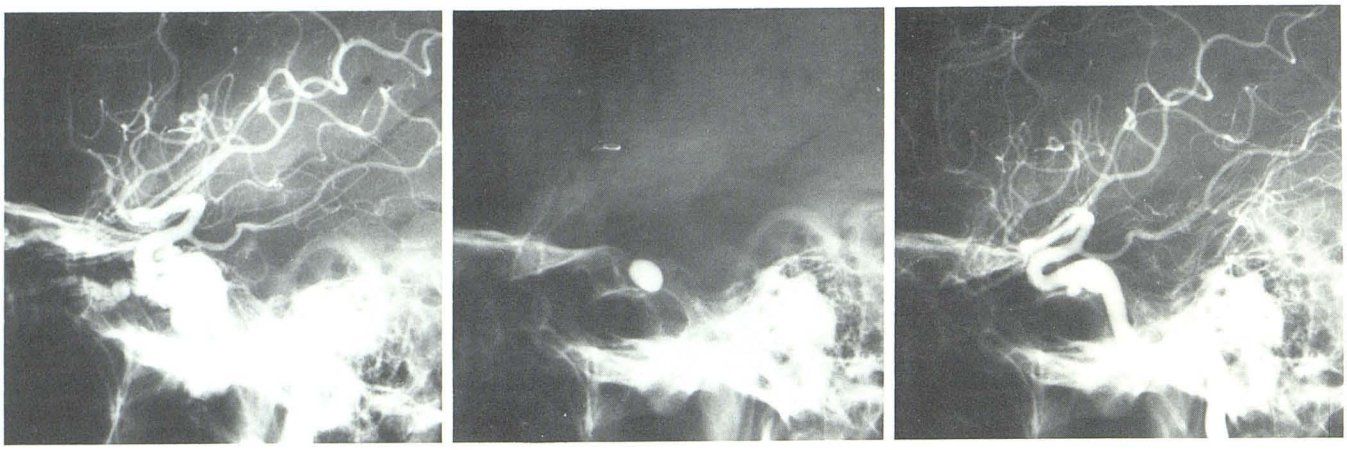

Fig. 4.—Case 4. Large vessel arteriovenous fistula. **A**, Right internal carotid to cavernous sinus fistula. **B**, Detachable balloon in place. **C**, Fistula is closed and internal carotid is patent. Small false aneurysm.

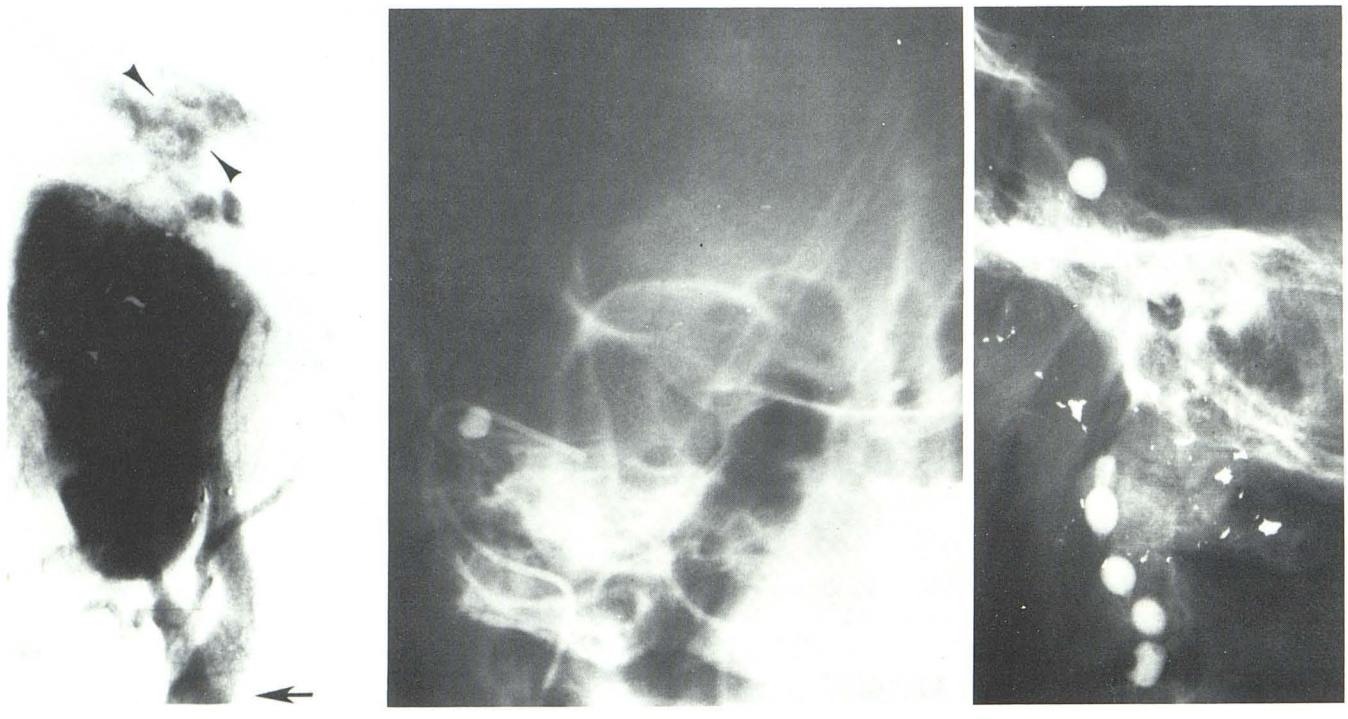

Fig. 5.—Case 5. Large vessel laceration and arteriovenous fistula. **A**, Lateral view of high cervical carotid preembolization. Large false aneurysm of left internal carotid artery and a carotid-cavernous fistula (*arrowheads*). Carotid bifurcation (*arrow*) at bottom of film. Carotid to jugular fistula also present. **B**, Dislodged detachable balloon in right transverse sinus with 5 French catheter in sinus preparatory to snaring and withdrawal of balloon. **C**, Final result with trapping of carotid-cavernous fistula by two upper balloons and carotid-jugular fistula by four lower balloons.

otherwise negative. His condition rapidly deteriorated and cerebral angiography was performed.

The angiogram showed a complex vascular injury (fig. 5A). There was a large traumatic aneurysm of the left internal carotid artery and an internal carotid-cavernous fistula. In addition, there was a left internal carotid-jugular fistula. The jugular vein was occluded distal to the fistula and the fistulized left jugular venous flow was therefore reversed through the transverse sinuses and out the right jugular vein. His rapid deterioration was thought to be due to increased intracranial pressure secondary to the impaired and arterialized cerebral venous drainage.

An emergency embolization was attempted to close the carotid-jugular fistula. A detachable balloon was placed in the fistula, but the balloon was quickly dislodged by the high flow and stopped in

the right transverse sinus. This result could have been catastrophic because it further compromised the already abnormal cerebral venous outflow. It was considered imperative to remove the balloon. This was accomplished by manipulation with a J guide wire via a percutaneous right jugular approach (fig. 5B). The balloon was snared and withdrawn into the right jugular vein where it was percutaneously punctured and allowed to pass into the lung. Subsequently, the carotid-cavernous and carotid-jugular fistulas were treated by trapping with detachable balloons (fig. 5C). After this the patient made a slow recovery.

This rather complex case involved large vessel laceration with pseudoaneurysm formation and fistulas. The carotid-jugular fistula was thought to be contributing to the patient's clinical deterioration and a prompt and complete occlusion of the fistula was needed. Inflatable and detachable balloons were considered more likely than smaller particulate emboli to effect rapid closure in vessels of this size.

Discussion

Embolization therapy for traumatic vascular lesions has a number of advantages over more conventional methods of treatment. It can be performed in conjunction with the initial angiographic workup, thus saving time in patients with life-threatening lesions. It can be used to treat lesions whose anatomic location makes them unsuitable for surgical treatment. Morbidity after embolization is usually less than with surgery and, although there are definite risks of embolization therapy, if carefully performed, it is a safe procedure.

The choice of embolic agents used in this series is based on our own early experience and has been fairly consistent since that time. This does not imply that agents other than the ones used might not have been used successfully in any given case, however, results with these agents have been satisfactory thus far. Our approach to the choice of embolic agents is that small vessel lacerations and fistulas at a distance from the catheter tip are treated initially with Silastic spheres of 1 or 1.5 mm size. If this does not effect closure of the injured vessel or fistula, larger pieces of moist PVA foam are injected. As mentioned in case 1, PVA foam in our experience has shown a tendency to become lodged more proximally in arteries than Silastic spheres, perhaps due to its more irregular surface with a tendency for particles to clump together. Therefore, when the catheter can be placed very near the injury site PVA foam may be used as the initial agent. Gelfoam alone is used instead of PVA foam only in those instances where temporary occlusion is acceptable, as there is evidence that recanalization can occur soon after embolization when Gelfoam is used [9].

For the large vessel arterial injuries that have involved vertebral, common carotid, internal carotid, or middle cerebral arteries, we have used Silastic balloon catheters [7]. These have been almost entirely detachable balloons of 2 mm to 2 cm in diameter when inflated. In cases of arteriovenous fistula the balloons are preferably placed in the fistula without compromise of the arterial lumen. When this is not possible the fistula is trapped by placing a balloon distally and then proximally on the arterial side. If the safety of arterial occlusion is questioned the artery may be temporarily occluded with the balloon before detachment and the patient observed for ischemic symptoms. If there are none, the balloon is then detached. Almost all of the balloon embolizations have been performed with the patients anticoagulated to decrease the risks of unwanted embolization distal to the lesion. When the patient is actively bleeding the value of anticoagulation may have to be weighed against the risk of hemorrhage.

If a large-bore catheter can be placed close to a large vessel lesion, an effective closure might be obtained by injecting large pieces of sponge or Gelfoam. This technique could be used in treating large vessel lacerations, but offers little advantage over balloons and is less desirable for large vessel fistulas because of the risk of proximal occlusion with continued fistula patency via collaterals. Also, the lack of control over a large particulate embolus when it is injected compared with balloon placement before detachment is a distinct disadvantage. The maneuverability of balloons offers the best chance for precise embolus placement, which is necessary to close fistulas.

The clinical presentation of patients with head and neck trauma receiving embolization therapy is variable. Acute hemorrhage is a frequent indication for embolization therapy in general, and it is also an important presentation in head and neck trauma. However, hemorrhage alone has not been the dominant indication for treatment in our experience, and we have seen more patients with arteriovenous fistulas than with hemorrhage. The arteriovenous fistulas are usually managed electively because symptoms develop gradually as the fistula increases and there is usually no immediate threat to life. An exception to this is seen in case 5 where increased intracranial pressure due to arterialization of an obstructed cerebral venous outflow was causing acute neurologic deterioration. A carotid-cavernous fistula may also require emergency embolization if vision is deteriorating or cerebral ischemic changes develop.

Complications of embolization in our series were limited to one patient who developed a cerebral infarction from thrombi, which formed on a detachable balloon during its placement in a carotid-cavernous fistula. This patient was not anticoagulated because of previous life-threatening epistaxis related to the carotid injury. Two patients developed third nerve palsies after treatment of carotid-cavernous fistulas but responded to exercise and extraocular muscle-shortening procedures, the only subsequent surgery required. The procedures have otherwise been free of any permanent sequelae and all patients received a total cure of their vascular lesions.

REFERENCES

1. Athanasoulis CA. Therapeutic applications of angiography: medical progress, part 1. *N Engl J Med* **1980**;302:1117–1125
2. Athanasoulis CA. Therapeutic applications of angiography: medical progress, part 2. *N Engl J Med* **1980**;302:1174–1179
3. Berenstein A, Kricheff II. Catheter and material selection for transarterial embolization: technical considerations. I. Catheter. *Radiology* **1979**;132:610–630
4. Berenstein A, Kricheff II. Catheter and material selection for transarterial embolization: technical consideration. II. Materials. *Radiology* **1979**;132:631–639
5. Debrun G, Lacour P, Caron JP, et al. Detachable balloon and

calibrated leak balloon techniques in the treatment of cerebral vascular lesions. *J Neurosurg* **1978**;49:635

6. Hieshima GB, Mehringer CM, Grinnell VS, Hasso AN, Siegel NH, Pribram HFW. Emergency occlusive techniques. *Surg Neurol* **1978**;9:293–302
7. Hieshima GB, Grinnell VS, Mehringer CM. A detachable balloon for therapeutic transcatheter occlusions. *Radiology* **1981**;138:227–228
8. Serbinenko FA. Balloon catheterization and occlusion of major cerebral vessels. *J Neurosurg* **1974**;42:125
9. Vlahos L, Benakis V, Dimakakos P, Dimopoulos C, Pontifex G. A comparative study of degree of arterial recanalization in kidney of dogs following transcatheter embolization with eight different materials. *Eur Urol* **1980**;6:180–185