Rupture of aneurysms following balloon embolization

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Three cases of complex aneurysms are presented in which balloon embolization therapy was associated with subsequent aneurysmal rupture, causing subarachnoid hemorrhage in two cases and a carotid-cavernous fistula in one. Two of these patients were treated directly by balloon embolization following surgical exploration. The third patient developed the fistula during postembolization volume expansion and heparinization.

KEY WORDS • aneurysm • embolization • balloon catheter

In North America, balloon embolization therapy of intracranial aneurysms is usually reserved for aneurysms of which the necks cannot be clipped directly for various reasons. These include aneurysms judged to be inaccessible, aneurysms with thick and sclerotic necks, or complex aneurysms giving rise to major branches or important perforating vessels. Endovascular detachable-balloon therapy of aneurysms may be accomplished by occlusion of the parent vessel1,2 or by insertion of a balloon into the aneurysm, sparing the parent artery and surrounding branches.3-6,8,9

This communication details complications in three cases where aneurysmal rupture occurred following direct balloon occlusion of the aneurysm (Cases 1 and 2) or the inadvertent migration of a balloon into the aneurysm after attempted parent vessel occlusion (Case 3).

Embolization Technique

In these cases, the interventional therapy and angiographic examination were carried out by the transfemoral arterial route. Systemic anticoagulation was accomplished with a 2000-U heparin bolus and multiple continuous infusions of 3000 U/500 cc saline (approximately 1000 to 2000 U/hr). Debrun latex balloons with an internal self-sealing valve were placed on No. 2.2 French Tracker catheters and detached by gentle traction.4 Balloon volume was 0.5 to 2.0 ml. Prior to detachment of the balloons, the iohexol contrast material was exchanged for precatalyzed 5-hydroxyethyl methacrylate (HEMA),3,4,6 a liquid hydrophilic polymer that solidifies and hardens in about 45 minutes and remains permanently solidified within the balloon.6 Heparinization was reversed prior to removal of the femoral artery catheter.

Case Reports

Case 1

This 51-year-old hypertensive women suffered a subarachnoid hemorrhage (SAH) on February 7, 1988. Arteriography demonstrated bilateral proximal carotid aneurysms. The patient was admitted to our facility 7 days later, and repeat arteriography showed bilateral paracranial aneurysms. The aneurysm on the left side had an angiographic lumen of 17 mm and a broad fusiform origin with a multilobulated shape (Fig. 1a). The patient underwent a left craniotomy on February 16, with the finding of a partially thrombosed giant aneurysm. The lateral portion of this giant aneurysm was clipped with three tandem Sugita clips (Fig. 1b), but its medial aspect was not excluded from the circulation because of a thick sclerotic neck.

On March 2, a Debrun No. 7 detachable balloon was uneventfully inserted and inflated, obliterating the remaining base of the left carotid artery aneurysm (Fig. 1c). The HEMA was exchanged uneventfully and the balloon was detached, occluding the aneurysm lumen

* Goldvalve balloon manufactured by Ingenor, Paris, France; Tracker catheters manufactured by Target Therapeutics, San Jose, California.

† HEMA manufactured by Polysciences Inc., Warrington, Pennsylvania.
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FIG. 1. Case 1. a: Left carotid angiogram, anteroposterior projection, showing a large ruptured carotid aneurysm with fusiform origin from the carotid artery. b: Postoperative angiogram. Three aneurysm clips are discernible (arrows) and the medial aspect of the aneurysm still fills. c: Postembolization angiogram showing the aneurysm lumen occluded with a single detachable balloon (small arrows). A small remnant of residual neck (curved arrow) can be seen filling prior to reversal of heparin. d: Postembolization plain radiograph demonstrating the balloon in relation to the aneurysm clips.

FIG. 2. Case 1. a: Plain radiograph 2 days postembolization showing that the balloon has shifted medially and superiorly outside the original limits of the aneurysm. b: Angiogram following hemorrhage. The aneurysm lumen is seen to be refilling and the balloon was migrated medially and superiorly outside the original limits of the aneurysm wall. c: Angiogram 6 months following stenosis established with a Selverstone clamp showing almost complete obliteration of the aneurysm.

Postoperatively, she recovered consciousness but exhibited a right upper-extremity drift, confusion, and speech disturbance. Gradual improvement over several weeks ensued but her course was complicated by sepsis, pneumothorax from a subclavian central venous line insertion complication, and hydrocephalus requiring shunting. Arteriography prior to discharge and 6 months postoperatively showed obliteration of the left internal carotid artery aneurysm (Fig. 2c) and diminished flow through the left internal carotid artery. The patient's neurological status at her 6-month follow-up examination showed a persistent mild memory disturbance and a minimal speech deficit. Her hemiparesis had resolved.

Case 2

This 63-year-old woman complained of blurring of vision in her left eye for 2 months prior to admission. Magnetic resonance (MR) imaging and angiography showed a left cavernous carotid artery aneurysm (Fig. 3a). Her medical history was remarkable for SAH in 1972 from rupture of a right carotid ophthalmic artery aneurysm. This had been treated by occlusion of the right internal carotid artery in the neck. On admission, her examination showed that visual acuity in the left eye had decreased to 20/200 and in the right eye to 20/40. Otherwise, her history and examination were unremarkable.

On September 2, 1987, the patient was treated by transfemoral intravascular placement of three Debrun...
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No. 9 balloons (Fig. 3b) into the aneurysm. Contrast material was exchanged for HEMA uneventfully. The postembolization angiogram, performed while the patient was still heparinized, showed nearly complete occlusion of the aneurysm and preservation of the carotid artery (Fig. 3c). Several hours after the procedure, the patient developed signs of left hemispheric ischemia which were thought to be secondary to embolization of thrombus from the neck of the aneurysm. Her status improved with aggressive volume expansion and heparinization. Four days following the procedure, she developed a bruit, and angiography demonstrated a carotid-cavernous fistula (Fig. 3d). An attempt to embolize the fistula was unsuccessful. Over the course of the next week, a cavernous sinus syndrome with progressive third then fourth cranial nerve involvement, proptosis, and chemosis developed despite reversal of heparin and intermittent carotid artery compressive therapy. An extracerebral-intracerebral bypass procedure was carried out, and subsequently balloon occlusion of the internal carotid artery was performed. The bruit and cavernous sinus syndrome resolved over the next several weeks.

Case 3

This 50-year-old man developed persistent nausea and vomiting about 3 months prior to presentation. Medical investigations culminated in cranial imaging with CT and then MR studies. An enhancing mass lesion anterior to and compressing the medulla was found. Angiography proved this lesion to be a vertebrobasilar junction aneurysm (Fig. 4a and b). On January 11, 1989, an attempt to clip the aneurysm directly was abandoned because the neck was broad and sclerotic and a large anterior inferior cerebellar artery arose from the proximal sac. Instead, the right vertebral artery was occluded distal to the origin of the posterior inferior cerebellar artery (PICA). Postoperatively, the patient was neurologically well.

On the 1st postoperative day, the patient, who was alert and oriented, was taken to the angiography suite and the left vertebral artery was occluded with a short Debrun No. 15 balloon distal to the PICA in order to avoid occluding the numerous perforators along this segment of artery. After 30 minutes of successful temporary occlusion in the awake patient, the contrast
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FIG. 4. Case 3.  a and b: Right (a) and left (b) vertebral artery angiograms, anteroposterior projection, showing a giant 3-cm aneurysm apparently arising from the right vertebrobasilar junction. The posterior inferior cerebellar artery (PICA) is seen proximal to the origin of the aneurysm bilaterally (arrows).  c and d: Left vertebral artery angiograms, early (c) and late (d) phases, after surgical clipping of the right vertebral artery distal to the PICA and after the embolization procedure. The silver clip within the balloon tip is seen in two different positions (arrows) within the aneurysm lumen, demonstrating that the balloon was freely floating within the aneurysm.  e: Left vertebral angiogram after aneurysm rupture. The silver clip in the balloon is clearly seen outside the aneurysm lumen (arrow).

material in the balloon was exchanged for HEMA using a vent tube. After the control HEMA on the bench had hardened, the balloon was detached. During detachment, the balloon presumably elongated, rebounded, and was propelled distally, and the artery was reopened. Postoperative angiography showed the balloon to be freely moving within the aneurysm (Fig. 4c and d). With the knowledge that the patient was able to tolerate distal bilateral vertebral occlusion, surgical clipping of the vertebral distal to the PICA was planned. Unfortunately, 48 hours after the balloon had slipped into the aneurysm and before this procedure could be scheduled, he suffered a massive SAH. Angiography and CT at that time showed that the balloon had migrated outside the lumen of the aneurysm (Fig. 4e). The patient was immediately taken back to the operating room where he underwent evacuation of the blood clot anterior to the medulla and clipping of the contralateral vertebral artery. He remained in poor condition after the SAH and died several weeks later.

\[\text{Vent tube manufactured by Interventional Therapeutics, San Francisco, California.}\]

Discussion

The techniques of intravascular navigation and balloon occlusion of intracranial aneurysms used in these three cases are representative of current technology. The potential of these methods to lead to rupture of an aneurysm is recognized, and hopefully the techniques can be modified with this complication in mind. These three cases are the only instances of aneurysm rupture following balloon treatment of aneurysms in our institutional experience, which has reached 120 aneurysms treated by detachable balloons since 1978. Much of our experience has been published previously.1,2 Because of the variety of aneurysms treated with detachable balloons, and the different techniques that have evolved over the years, it is considered that a relative risk cannot be usefully obtained from these three cases.

In Case 1, the patient had had a recent SAH prior to the balloon embolization attempt. She had also undergone a major intracranial procedure with manipulation of the aneurysm during placement of the aneurysm clips, as well as reduction of the intracranial pressure and a relative increase in the transmural pressure across the aneurysm wall. Following balloon exclusion of the aneurysm from the circulation, the patient suffered a
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large SAH. Several explanations for this occurrence are possible. One is that the aneurysm was not completely excluded from the circulation. There was a remnant of neck and proximal sac left in continuity with the cerebral circulation and this allowed a portion of the aneurysm to remain subject to arterial pressure with subsequent rupture. Alternatively, the balloon, the proximal portion of which continued to be subject to intraarterial pressure, may have transmitted pressure to the aneurysm sac, contributing to aneurysmal rupture. A combination of these events is likely. It is of interest that, at subsequent angiography, the aneurysmal dome was visualized and the balloon was lodged half in and half out of the aneurysm, plugging the acute tear, thus both causing the rupture and possibly saving the patient from massive intracranial hemorrhage and death.

In Case 2, the patient's clinical status several hours after successful balloon occlusion of the aneurysm indicated cerebral dysfunction, possibly from thromboembolism or impaired flow through the preserved but narrowed carotid artery. The decision to give the patient heparin and increase the intravascular volume was thought to be appropriate in order to prevent further cerebral ischemia. The patient tolerated this treatment for several days, with neurological recovery, but developed a carotid-cavernous fistula from rupture of the intracavernous aneurysm. The decision to induce mild hypertension and heparinize the patient in spite of the pressure of the balloon in the aneurysm as well as pressure on the aneurysm dome exerted by the projecting silver clips, presumably enhanced the risk of fistula development. Debrun No. 9 detachable balloons (and some others) have a small protrusion (Fig. 3b) containing the silver marker clip that projects from the distal part of the balloon. This small projection may play a role in puncturing an aneurysm. Heparin will prevent thrombus from forming around intraluminal balloons, and will therefore impede the major goal of aneurysm balloon therapy: complete aneurysmal obliteration by balloon and clot. In addition, the introduction of balloons into the aneurysm undoubtedly causes trauma to the aneurysm wall. This intimal trauma combined with heparinization and increased carotid flow by volume expansion may have contributed to rupture of the aneurysm.

In the final case, aneurysm rupture occurred after craniotomy, surgical clipping of the right vertebral artery, and attempted balloon occlusion of the left vertebral artery. The balloon moving and swirling within the aneurysm may impart forces sufficient to rupture the thin-walled sac. Alternatively, the free-floating balloon may have temporarily occluded the aneurysm outflow, causing an increase in intra-aneurysmal pressure and rupture. Subsequently, the balloon was seen to be located outside the aneurysm itself, probably propelled there by blood escaping through the site of rupture.

These cases suggest some caution. A recently ruptured aneurysm is subject to some mechanical increased risk of hemorrhage from the pressure of a balloon within it. The treatment regimen of an embolic ischemic event following balloon embolization of an aneurysm must be balanced with the possible risk of heparinization and volume expansion preventing aneurysm thrombosis. The placement of balloons within an aneurysm induces potential aneurysmal wall trauma coupled with possible pressure from the protruding balloon tip containing a metallic marker. Finally, when a balloon becomes loose within an aneurysm, expeditious definitive surgical therapy should be planned to eliminate the risk of aneurysm rupture due to repeated trauma of the aneurysm wall by the baffling balloon.

References

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